

NFPA® 99

2012 Edition

HEALTH CARE FACILITIES CODE

Including all Gas & Vacuum
System Requirements



Documents

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NFPA® 99

Health Care Facilities Code

2012 Edition

This edition of NFPA 99, *Health Care Facilities Code*, was prepared by the Technical Committees on Electrical Systems, Fundamentals, Health Care Emergency Management and Security, Hyperbaric and Hypobaric Facilities, Mechanical Systems, Medical Equipment, and Piping Systems, released by the Technical Correlating Committee on Health Care Facilities, and acted on by NFPA at its June Association Technical Meeting held June 12–15, 2011, in Boston, MA. It was issued by the Standards Council on August 11, 2011, with an effective date of August 31, 2011, and supersedes all previous editions.

Tentative interim amendments (TIAs) to Chapters 8 and 9 were issued on August 11, 2011. Additional TIAs have been attached to the back of the document following the index. For further information on tentative interim amendments, see Section 5 of the NFPA Regulations Governing Committee Projects available at: <http://www.nfpa.org/assets/files/PDF/CodesStandards/TIAErrataFI/TIAREgs.pdf>

This edition of NFPA 99 was approved as an American National Standard on August 31, 2011.

Origin and Development of NFPA 99

The idea for this document grew as the number of documents under the original NFPA Committee on Hospitals grew. By the end of 1980, there existed 12 documents on a variety of subjects, 11 directly addressing fire-related problems in and about health care facilities. These documents covered health care emergency preparedness, inhalation anesthetics, respiratory therapy, laboratories in health-related institutions, hyperbaric facilities, hypobaric facilities, inhalation anesthetics in ambulatory care facilities, home use of respiratory therapy, medical-surgical vacuum systems in hospitals, essential electrical systems for health care facilities, safe use of electricity in patient care areas of health care facilities, and safe use of high-frequency electricity in health care facilities.

A history on the documents that covered these topics can be found in the “Origin and Development of NFPA 99” in the 1984 edition of NFPA 99.

What was then the Health Care Facilities Correlating Committee reviewed the matter beginning in late 1979 and concluded that combining all the documents under its jurisdiction would be beneficial to those who used those documents, for the following reasons:

- (1) The referenced documents were being revised independently of each other. Combining all the individual documents into one document would place all of them on the same revision cycle.
- (2) It would place in one unit many documents that referenced each other.
- (3) It would be an easier and more complete reference for the various users of the document (e.g., hospital engineers, medical personnel, designers and architects, and the various types of enforcing authorities).

To learn if this proposal was desired or desirable to users of the individual documents, the Committee issued a request for public comments in the spring of 1981, asking whether purchasers of the individual documents utilized more than one document in the course of their activities and whether combining these individual documents would be beneficial. Seventy-five percent of responses supported such a proposal, with 90 percent of health care facilities and organizations supportive of it. Based on this support, the Correlating Committee proceeded with plans to combine all the documents under its jurisdiction into one document.

In January, 1982, a compilation of the latest edition of each of the 12 individual documents under the jurisdiction of the Correlating Committee was published. It was designated NFPA 99, *Health Care Facilities Code*. The Correlating Committee also entered the document into the revision cycle reporting to the 1983 Fall Meeting for the purpose of formally adopting the document.

For the 1984 edition of NFPA 99, in addition to technical changes, administrative and organizational changes were made.

For the 1987 edition of NFPA 99, the third and final step in the process of combining the previous individual documents took place — that of integrating the content of these individual documents into a cohesive document. In addition, there were again technical changes made. The 1987 edition also saw the incorporation of NFPA 56F, *Standard on Nonflammable Medical Piped Gas Systems*, into NFPA 99.

For the 1990 edition of NFPA 99, some structural changes were made and some modifiers were added to make it easier to determine where requirements are applicable. Technical changes made included the following: correlation with NFPA 101®, *Life Safety Code*®; changes for compressed medical air systems on the use of gas-powered medical devices operating at a gauge pressure of 200 psi, and piped gas systems in general; changes in leakage current limits for patient care electrical appliances; clarification that patient care areas and wet locations are mutually exclusive; and further guidance on the effects of a disaster on staff.

For the 1993 edition of NFPA 99 there were further efforts to make the document more user-friendly (e.g., placing all “recommended” guidance either in notes or in the appendix). Significant technical changes included the following: adding requirements and recommendations to further prevent or minimize fires in operating rooms; making major changes to requirements in Chapter 4 for installing, testing, inspecting, verifying, and maintaining nonflammable medical piped gas systems; adding new sections on dental compressed air and dental vacuum requirements in Chapter 4; changing leakage current limits of patient care-related electrical appliances to correlate more closely with an international document on the subject; revising laboratory requirements to correlate more closely with NFPA 45, *Standard for Laboratories Using Chemicals*; changing essential electrical system requirements in ambulatory health care clinics and medical/dental offices; and extensively revising hyperbaric chamber requirements (Chapter 19).

For the 1996 edition of NFPA 99, further changes to make the document more user-friendly were made. These included restructuring Chapters 3 and 4 so that all requirements for a Type 1, 2, or 3 essential electrical system, or a Level 1, 2, 3, or 4 piped gas or vacuum system, were contained in one section.

Other technical changes included the following:

- (1) Moving requirements on flammable anesthetizing locations and the use of flammable inhalation anesthetics to a new Appendix 2
- (2) Upgrading the subject of emergency preparedness from guidance to a new chapter containing requirements
- (3) Adding a new chapter (Chapter 18) on home health care
- (4) Revising Section 1-1 to reflect the intent that NFPA 99 applies only to facilities treating human beings
- (5) In Chapter 3, revising load testing requirements for emergency generators to reference NFPA 110, *Standard for Emergency and Standby Power Systems*, and revising emergency lighting criteria for operating rooms
- (6) In Chapter 4, revising requirements for medical compressed air systems, dental compressed air systems, waste anesthetic gas disposal systems, and dental piped gas/vacuum systems; adding a new section on “headwall units” (“manufactured assemblies”); and clarifying and moving requirements for transfilling containers of liquid oxygen to Chapter 8
- (7) In Chapter 8, adding requirements for storage rooms containing cylinders and containers totaling less than 3000 ft³
- (8) In Chapters 12 to 17, revising criteria for gas and vacuum systems
- (9) In Chapter 19, in addition to many technical changes, adding criteria for mobile hyperbaric facilities

For the 1999 edition, significant technical and structural changes included the following:

- (1) Chapters 13, 14, and 15 (on ambulatory health care centers, clinics, and medical/dental offices, respectively) were replaced completely by new Chapter 13 covering health care facilities other than hospitals, nursing homes, and limited care facilities as defined in Chapter 2.
- (2) Requirements for Level 2 gas and vacuum systems were developed (Section 4.4 in Chapter 4).
- (3) Subsections 12.3.4, 16.3.4, and 7.3.4 were revised to correlate with the two significant changes in (1) and (2).
- (4) In Chapter 3, load testing requirements for emergency power supplies of the essential electrical system were changed through reference, and the testing interval (“monthly”) was reworded to be more responsive to needs of health care facilities.
- (5) Clarification of transfer switches and branches of the emergency system was made.
- (6) Clarification on the use of emergency power supplies other than for emergency power was made in 3.4.1.1.5.
- (7) Paragraph 4.3.1.2, Distribution Requirements for Level 1 Gas Systems, was completely revised and restructured.
- (8) Chapter 4 was made more user-friendly by reducing the number of internal cross-references between Sections 4.3 and 4.5.
- (9) The order of installation and testing requirements for piped gas and vacuum systems was revised.
- (10) Emphasis on emergency preparedness was made in Chapter 11 and its appendix material.
- (11) Chapter 19, “Hyperbaric Facilities,” was extensively revised in the areas of electrical wiring, air quality, ventilation lighting, equipment, communication, and safety management.
- (12) A new chapter (Chapter 20) on freestanding birthing centers was added.

The 2002 edition included format and technical revisions. The *Manual of Style for NFPA Technical Committee Documents*, April 2000 edition, was applied to this document, resulting in changes to its structure and format. Introductory material in Chapter 1 was formatted for consistency among all NFPA documents. Referenced publications that apply to the document were relocated from the last chapter to Chapter 2, resulting in the renumbering of chapters. Informational references remained in the last annex. Appendices were designated as annexes. Definitions in Chapter 3 were

reviewed for consistency with definitions in other NFPA documents, were systematically aligned, and were individually numbered. Paragraph structuring was revised with the intent of one mandatory requirement per section, subsection, or paragraph. Information that often accompanied many of the requirements was moved to Annex A, Explanatory Material. Exceptions were deleted or rephrased in mandatory text, unless the exception represented an allowance or required alternate procedure to a general rule when limited specified conditions exist. The reformatted appearance and structure provided continuity among NFPA documents, clarity of mandatory text, and greater ease in locating specific mandatory text.

The document scope and individual chapter scopes defining the intent of each chapter and document as a whole were located in Chapter 1.

The occupancy Chapters 13–21 stated what is required, while Chapters 4–12 prescribed how those requirements are achieved. Each chapter began with a section explaining applicability. Information concerning the nature of hazards was moved to Annex B. Annexes A and C retained explanatory information, and Annexes 1 and 2 became Annexes D and E. Informational references were in Annex F.

The changes in Chapter 4, Electrical Systems, addressed electrical wiring, transfer switches, inspection, and application.

Chapter 5 on Piping Systems was realigned so that Level 1 requirements were found in Section 5.1, and concurrently Level 2 in Section 5.2 and Level 3 in Section 5.3. Level 4 associated with laboratories was deleted, with requirements realigned in Chapter 11 on laboratories. Definitions were developed for vacuum systems and Levels 1, 2, and 3 gas systems in Chapter 3. Revisions were made to compressed gas cylinder identification and restraint; valve venting; ventilation of storage rooms; alarms; connection of the electrical supply for central supply systems with the essential electrical system; allowance of a three-way full port ball valve to isolate one branch or component; provisions for a monitored and audible low-content alarm on the surge gas while brazing; the allowance of medical air systems for application with human respiration; and deletion of 20-year-old appendix information.

Gas Delivery, Chapter 8, included a new section on the storage of compressed gas cylinders in patient care areas.

Chapter 11, Laboratories, clarified the structural protection of exits, and intent of portable fire extinguishers. Revisions were made concerning flammable and combustible liquids handling requirements.

An increased focus on the total process of maintaining services during a disaster, mitigating damage from a disaster, and recovery from a disaster was reflected in Chapter 12, Emergency Management. Annexed security program information was expanded.

Chapter 20, Hyperbaric Facilities, contained revised emergency depressurization requirements, safety director responsibilities, and emergency procedure performance.

The changes made to the 2005 edition were mainly for clarity and were editorial in nature. In Chapter 3, the definitions for medical gas, patient medical gas, and medical support gas were modified to differentiate between the different types of gases.

In Chapter 4, the requirements for switches and receptacles in anesthetizing locations were moved to Chapter 13, Hospital Requirements. The extracted material from NFPA 110, *Standard for Emergency and Standby Power Systems*, was updated.

In Chapter 5, the requirements for construction materials for filters, dryers, regulators, vacuum pumps, and after-coolers were changed to allow the manufacturers to choose the materials.

A centralized computer was allowed to be used in lieu of one of the master alarms. Cylinders were allowed to be fitted with a means to slow the initial opening pressure. The requirement to individually secure the cylinders was changed to no longer require the cylinders to be secured individually. Two new methods for making joints were added to the requirements. Stainless steel tubing was added as an approved material for vacuum systems. The requirement to braze a joint within 1 hour after cleaning was changed to 8 hours. Vacuum joints were required to be leak tested, and operational pressure testing was permitted to be conducted with the source gas.

Chapters 6, 7, 8, 9, 10, and 11 underwent minor changes for clarity or for editorial reasons.

Chapter 12 was revised to update the techniques used in emergency management in health care facilities.

In Chapters 13, 14, 15, 16, 17, 18, and 19 editorial corrections were made.

Chapter 20 was revised to include requirements for heating and ventilation changes in the chamber. Additional restrictions to the types of materials that are allowed in the chamber were added.

The 2012 edition went through a major overhaul. The premise of an occupancy-based document was modified to become a risk-based document. NFPA 99 was changed to a “code” instead of a “standard” to reflect how the document is used and adopted.

The administration of health care continues to change. NFPA 99 has changed to reflect how health care is delivered. The risk to the patient does not change for a given procedure. If the procedure is performed in a doctor’s office versus a hospital, the risk remains the same. Therefore, NFPA 99 eliminated the occupancy chapters and has gone to a risk-based approach. New Chapter 4 outlines the parameters for this approach. The Code now reflects the risk to the patient in defined categories of risk.

Chapter 5, Gas and Vacuum Systems, went through some editorial changes as well as adding new material on the testing and maintenance of gas and vacuum systems. In addition, the administrative details for care, maintenance, and handling of cylinders moved to chapters under the responsibility of the new Technical Committee on Medical Equipment.

There are several new chapters. There are new chapters on Information Technology and Communications Systems for Health Care Facilities; Plumbing; Heating, Ventilation, and Air Conditioning; Security Management; and Features of Fire Protection. Many of these systems were not addressed by NFPA 99. These are important systems and protection features in health care and needed to be addressed. The Technical Committees on Gas Delivery Equipment and the Technical Committee on Electrical Equipment were combined into a single Technical Committee on Medical Equipment. The hyperbaric chapter had relatively minor changes for clarity.



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Committee Scope: This Committee shall have primary responsibility for documents that contain criteria for safeguarding patients and health care personnel in the delivery of health care services within health care facilities: a) from fire, explosion, electrical, and related hazards resulting either from the use of anesthetic agents, medical gas equipment, electrical apparatus, and high frequency electricity, or from internal or external incidents that disrupt normal patient care; b) from fire and explosion hazards associated with laboratory practices; c) in connection with the use of hyperbaric and hypobaric facilities for medical purposes; d) through performance, maintenance and testing criteria for electrical systems, both normal and essential; and e) through performance, maintenance and testing, and installation criteria: for vacuum systems for medical or surgical purpose, and for medical gas systems.

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Committee Scope: This Committee shall have primary responsibility for documents or portions of documents covering the framework for emergency management and security of health care facilities proportionate to the risk of the patient and health care staff. This Committee shall have primary responsibility for the elements of planning over a continuum from minor incidences to catastrophic events, including: management controls, mitigation practices, incident response, continuity of services, recovery, stored capacity, staff training, and program evaluation.

Technical Committee on Hyperbaric and Hypobaric Facilities (HEA-HYP)

Robert B. Sheffield, Chair
International ATMO, Inc., TX [U]

Michael W. Allen, Life Support Technologies Group Inc., PA [U]
Peter Atkinson, Townsville Hospital, Australia [C]
Rep. Hyperbaric Technicians & Nurses Association Inc.
Richard C. Barry, Diversified Clinical Services, FL [SE]
James Bell, Intermountain Health Care, UT [U]
W. Robert Bryant, Perry Baromedical Corporation, TX [M]
Mario Caruso, Comprehensive Healthcare Solutions, Inc., FL [SE]
Keith Ferrari, Praxair, NC [M]
Angela M. Fuqua, Chubb Group Insurance Companies, TX [I]
William C. Gearhart, University of Maryland Medical Systems, MD [U]

W. T. Gurnée, OxyHeal Health Group, CA [M]
Barry E. Newton, Wendell Hull & Associates, Inc., NM [SE]
Stephen D. Reimers, Reimers Systems, Inc., VA [M]
Rachael Sheets, The Linde Group, NJ [IM]
John M. Skinner, Medical Equipment Technology, Inc., GA [IM]
Deepak Talati, Sechrist Industries, Inc., CA [M]
Harry G. Vincent, Baromedical Nurses Association, LA [C]
Wilbur T. Workman, Undersea & Hyperbaric Medical Society, TX [U]

Alternates

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Richard P. Bielen, NFPA Staff Liaison

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents or portions of documents covering the construction, installation, testing, performance, and maintenance of hyperbaric and hypobaric facilities for safeguarding staff and occupants of chambers.

Technical Committee on Mechanical Systems (HEA-MEC)

Roger W. Lautz, Chair
Affiliated Engineers, Inc., WI [SE]

Kimberly A. Barker, Siemens Building Technologies, Inc., IL [M]
Christopher Bernecker, H. T. Lyons, Inc., PA [IM]
Gordon D. Burrill, Teegor Consulting Inc., Canada [U]
Rep. Canadian Healthcare Engineering Society
Robert J. Dubiel, Luther Midelfort Mayo Health, WI [U]
Keith Ferrari, Praxair, NC [M]
Ronald E. Galloway, Moses Cone Health System, NC [U]

Phil Gioia, Mazzetti & Associates Inc., OR [SE]
Charles Seyffer, Camfil Farr, NY [M]
Michael P. Sheerin, TLC Engineering for Architecture, FL [SE]
Michael Soper, Phoenix Controls Corporation, MA [M]
Allan David Volz, OSF HealthCare System, IL [U]

Richard P. Bielen, NFPA Staff Liaison

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This committee shall have primary responsibility for documents or portions of documents covering the performance, operations, testing, maintenance, and failure management criteria for air quality, temperature, humidity, critical space pressure relationships, water and waste water, and their associated systems.



Technical Committee on Medical Equipment (HEA-MED)

Alan Lipschultz, Chair

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Rep. Association for the Advancement of Medical Instrumentation

Michael E. Brousseau, Intertek Testing Services, MA [RT]
Susan E. Dorsch, Orange Park, FL [SE]
Robert J. Dubiel, Luther Midelfort Mayo Health, WI [U]
Keith Ferrari, Praxair, NC [M]
Rep. Compressed Gas Association
William C. Fettes, Airgas, Inc., KS [IM]
Gerald R. Goodman, Texas Woman's University, TX [SE]
Harvey Kostinsky, ECRI Institute, PA [RT]

Joseph P. Murnane, Jr., Underwriters Laboratories Inc., NY [RT]
Ezra R. Safdie, U.S. Department of Veterans Affairs, CA [U]
Lawrence S. Sandler, Bonita Springs, FL [SE]
W. Thomas Schipper, Lakewood, CA [U]
Rep. American Society for Healthcare Engineering
Robert M. Sutter, B&R Compliance Associates, PA [SE]

Alternates

Gary L. Bean, Air Products & Chemicals, Inc., GA [M]
(Alt. to K. Ferrari)
Barry E. Brown, Airgas, Inc., GA [IM]
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(Alt. to W. T. Schipper)
Mike W. Schmidt, Strategic Device Compliance Services, OH [M]
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Nonvoting

Saul Aronow, Auburndale, MA [SE]
(Member Emeritus)

Richard P. Bielen, NFPA Staff Liaison

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This committee shall have primary responsibility for documents or portions of documents covering the maintenance, performance, and testing of electrical medical equipment and portable patient-related gas equipment for the purpose of safeguarding patients and health care personnel within patient care areas of health care facilities from the hazards of fire, explosion, electricity, nonionizing radiation, heat, and electrical interference.

Technical Committee on Piping Systems (HEA-PIP)

David B. Mohile, Chair

Medical Engineering Services, Inc., VA [SE]

Mark W. Allen, Beacon Medaes, SC [M]
Grant A. Anderson, Bard, Rao & Athanas Consulting Engineers, LLC, MA [SE]
David L. Brittain, ProVac, OH [M]
Jan Ehrenwerth, Yale University, CT [C]
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Keith Ferrari, Praxair, NC [M]
Rep. Compressed Gas Association
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Michael Frankel, Utility Systems Consultants, FL [SE]
Rep. American Society of Plumbing Engineers
Ed Golla, TRI/Air Testing, TX [RT]
James L. Lucas, Tri-Tech Medical Inc., OH [M]
Edward J. Lyczko, The Cleveland Clinic, OH [U]
Jeffery F. McBride, Red Lion Medgas Consultants, Inc., DE [SE]
Donald R. McIlroy, Providence Health System, OR [U]
Jerry L. McManus, National ITC Corporation, LA [L]
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Olen L. Pruitt, University of Alabama at Birmingham, AL [U]
Rep. American Society for Healthcare Engineering
E. Daniel Shoemaker, Midmark Corporation, AZ [M]
Ronald M. Smidt, Carolinas HealthCare System, NC [U]
Rep. NFPA Health Care Section
Russell C. Thomason, U.S. Army Corps of Engineers, VA [U]
J. Richard Wagner, J. Richard Wagner, PE, LLC, MD [IM]
Rep. Mechanical Contractors Association of America, Inc.
Jonathan C. Willard, Certified Medical Gas Services, NH [SE]
Wayne T. Wozniak, American Dental Association, IL [U]

Alternates

Gary L. Bean, Air Products & Chemicals, Inc.,
GA [M]

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Chad E. Beebe, American Society for Healthcare
Engineering, WA [U]

(Alt. to O. L. Pruitt)

Barry E. Brown, Airgas, Inc.,
GA [IM]

(Alt. to W. C. Fettes)

David D. Eastman, Metro Detroit Plumbing Industry
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(Alt. to T. J. Mraulak)

P. L. Fan, Arlington Heights, IL [U]

(Alt. to W. T. Wozniak)

Michael T. Massey, National ITC Corporation, CA [L]

(Alt. to J. L. McManus)

Christopher Swayze, The Sherman Engineering
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(Alt. to M. W. Allen)

Richard P. Bielen, NFPA Staff Liaison

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents or portions of documents covering the performance, maintenance, installation, and testing of medical and dental related gas piping systems and medical and dental related vacuum piping systems.



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Health Care Facilities Code

2012 Edition

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Changes to the content of this code have not been marked by vertical rules and deletion bullets due to the fact that the entire document has undergone restructuring.

A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex D. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced publications can be found in Chapter 2 and Annex D.

Chapter 1 Administration

1.1 Scope.

1.1.1 The scope of this code is to establish minimum criteria as follows in 1.1.2 through 1.1.13.

1.1.2 Fundamentals. Chapter 4 establishes criteria for levels of health care services or systems based on risk to the patients, staff, or visitors in health care facilities.

1.1.3 Gas and Vacuum Systems.

1.1.3.1 Chapter 5 covers the performance, maintenance, installation, and testing of the following:

- (1) Nonflammable medical gas systems with operating pressures below a gauge pressure of 2068 kPa (300 psi)
- (2) Vacuum systems in health care facilities
- (3) Waste anesthetic gas disposal (WAGD) systems, also referred to as scavenging
- (4) Manufactured assemblies that are intended for connection to the medical gas, vacuum, or WAGD systems (also referred to as scavenging)

1.1.3.2 Requirements for portable compressed gas systems are covered in Chapter 11.

1.1.4 Electrical Systems.

1.1.4.1 Chapter 6 covers the performance, maintenance, and testing of electrical systems (both normal and essential) in health care facilities.

1.1.4.2 The following areas are not addressed in this code, but are addressed in other NFPA documents:

- (1) Specific requirements for wiring and installation of equipment are covered in *NFPA 70, National Electrical Code*.

- (2) Requirements for illumination and identification of means of egress in health care facilities are covered in *NFPA 101, Life Safety Code*.
- (3) Requirements for installation, testing, and maintenance of fire protection signaling systems are covered in *NFPA 72, National Fire Alarm and Signaling Code*.
- (4) Requirements for installation of fire pumps are covered in *NFPA 20, Standard for the Installation of Stationary Pumps for Fire Protection*, except that the alternate source of power are permitted to be the essential electrical system.
- (5) Requirements for installation of stationary engines and gas turbines are covered in *NFPA 37, Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*.

1.1.5 Information Technology and Communications Systems. Chapter 7 covers the performance, maintenance, and testing of information technology and communications systems in health care facilities.

1.1.6 Plumbing. Chapter 8 covers the performance, maintenance, and testing of plumbing systems in health care facilities.

1.1.7 HVAC Systems. Chapter 9 covers the performance, maintenance, and testing of heating, cooling, and ventilating in health care facilities.

1.1.8 Electrical Equipment. Chapter 10 covers the performance, maintenance, and testing of electrical equipment in health care facilities.

1.1.9 Gas Equipment. Chapter 11 covers the performance, maintenance, and testing of gas equipment in health care facilities.

1.1.10* Emergency Management. Chapter 12 establishes criteria for emergency management in the development of a program for effective disaster preparedness, response, mitigation, and recovery in health care facilities.

1.1.11 Security Management. Chapter 13 covers the performance, maintenance, and testing of security equipment and systems in health care facilities.

1.1.12* Hyperbaric Facilities. Chapter 14 covers the recognition of, and protection against, hazards of an electrical, explosive, or implosive nature, as well as fire hazards associated with hyperbaric chambers and associated facilities that are used, or intended to be used, for medical applications and experimental procedures at gauge pressures from 0 kPa to 690 kPa (0 psi to 100 psi).

1.1.13 Features of Fire Protection. Chapter 15 covers the performance, maintenance, and testing of fire protection equipment in health care facilities.

1.2 Purpose. The purpose of this code is to provide minimum requirements for the installation, inspection, testing, maintenance, performance, and safe practices for facilities, material, equipment, and appliances, including other hazards associated with the primary hazards.

1.3 Application.

1.3.1 This code shall apply to all health care facilities other than home care.

1.3.1.1 This document is intended for use by those persons involved in the design, construction, inspection, and operation of health care facilities and in the design, manufacture, and testing of appliances and equipment used in patient care rooms of health care facilities.

1.3.2 Construction and equipment requirements shall be applied only to new construction and new equipment, except as modified in individual chapters.

1.3.2.1 Only the altered, renovated, or modernized portion of an existing system or individual component shall be required to meet the installation and equipment requirements stated in this code.

1.3.2.2 If the alteration, renovation, or modernization adversely impacts the existing performance requirements of a system or component, additional upgrading shall be required.

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

1.3.3 Policies.

1.3.3.1 The health care organization shall ensure that policies are established and maintained that permit the attending physician to satisfy the emergency needs of any patient that supersede the requirements of this code.

1.3.3.2 Each such special use shall be clearly documented and reviewed to attempt to have future similar needs met within the requirements of this code.

1.3.4 Patient Care Rooms.

1.3.4.1 The governing body of the facility or its designee shall establish the following areas in accordance with the type of patient care anticipated and with the following definitions of the classification (*see definition of patient care room in Chapter 3*):

- (1) Critical care rooms
- (2) General care rooms
- (3) Basic care rooms
- (4) Support rooms

1.3.4.2 Anesthesia. It shall be the responsibility of the governing body of the health care organization to designate anesthetizing locations.

1.3.4.3 Wet Procedure Locations. It shall be the responsibility of the governing body of the health care organization to designate wet procedure locations.

1.4 Equivalency.

1.4.1 Nothing in this code is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety to those prescribed by this code. Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency. The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

1.4.2 Alternative systems, methods, or devices approved as equivalent by the authority having jurisdiction shall be recognized as being in compliance with this code.

1.4.3 The authority having jurisdiction shall be permitted to grant exceptions to this code.

1.5* Units. Primary units will be trade units, and secondary units will be the conversion.

1.6 Code Adoption Requirements.

1.6.1 The effective date of application of any provision of this document is not determined by the National Fire Protection

Association. All questions related to applicability shall be directed to the authority having jurisdiction.

1.6.2 Enforcement. This code shall be administered and enforced by the authority having jurisdiction. (*See Annex C for a sample wording for enabling legislation.*)

Chapter 2 Referenced Publications

2.1* General. The documents or portions thereof listed in this chapter are referenced within this code and shall be considered part of the requirements of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 10, *Standard for Portable Fire Extinguishers*, 2010 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2010 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2010 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2010 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2011 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2012 edition.

NFPA 31, *Standard for the Installation of Oil-Burning Equipment*, 2011 edition.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 2010 edition.

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 2011 edition.

NFPA 54, *National Fuel Gas Code*, 2012 edition.

NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, 2010 edition.

NFPA 58, *Liquefied Petroleum Gas Code*, 2011 edition.

NFPA 70®, *National Electrical Code®*, 2011 edition.

NFPA 72®, *National Fire Alarm and Signaling Code*, 2010 edition.

NFPA 82, *Standard on Incinerators and Waste and Linen Handling Systems and Equipment*, 2009 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, 2012 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*, 2010 edition.

NFPA 92, *Standard for Smoke Control Systems*, 2012 edition.

NFPA 99, *Health Care Facilities Code*, 2012 edition.

NFPA 99B, *Standard for Hypobaric Facilities*, 2010 edition.

NFPA 101®, *Life Safety Code®*, 2012 edition.

NFPA 101A, *Guide on Alternative Approaches to Life Safety*, 2010 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems*, 2010 edition.

NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems*, 2010 edition.

NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*, 2010 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, 2008 edition.

NFPA 286, *Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth*, 2011 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, 2012 edition.

NFPA 1600®, *Standard on Disaster/Emergency Management and Business Continuity Programs*, 2010 edition.

NFPA 5000®, *Building Construction and Safety Code®*, 2012 edition.



2.3 Other Publications.

2.3.1 ANSI Publications. American National Standards Institute, Inc., 22 West 43rd Street, 4th Floor, New York, NY 10036.

ANSI C84.1, *Electric Power Systems and Equipment — Voltage Ratings*, 1995.

ANSI Z136.3, *Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources*, 2011.

ANSI/NEMA WD 6, *Wiring Devices — Dimensional Requirements*, 2002.

ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*, 2010.

ANSI/AAMI ES 60601-1, *Medical Electrical Equipment*, 2005.

2.3.2 ASHRAE Publications. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329-2305

ASHRAE 170, *Ventilation of Health Care Facilities*, 2008.

ASHRAE 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*, 2010.

ASHRAE Guideline 0, *The Commissioning Process*, 2005.

ASHRAE Guideline 1.1, *HVAC&R Technical Requirements for The Commissioning Process*, 2007.

2.3.3 ASME Publications. American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

ASME A.17.1, *Safety Code for Elevators and Escalators*, 2010.

ASME A.17.3, *Safety Code for Existing Elevators and Escalators*, 2008.

ASME B1.20.1, *Pipe Threads, General Purpose, Inch*, 2001.

ASME B16.22, *Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings*, 2001.

ASME B16.26, *Cast Copper Alloy Fittings for Flared Copper Tubes*, 2006.

ANSI/ASME B16.50, *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*, 2001.

ASME B31.3, *Pressure Process Piping*, 2002.

ASME B40.100, *Pressure Gauges and Gauge Attachments*, 1998.

ASME *Boiler and Pressure Vessel Code*, Sections VIII and IX, 2001.

ANSI/ASME PVHO-1, *Safety Standard for Pressure Vessels for Human Occupancy*, 1990

2.3.4 ASSE Publications. American Society of Sanitary Engineering, 901 Canterbury Road, Suite A, Westlake, OH 44145-1480.

ASSE 6010, *Professional Qualification Standard for Medical Gas Systems Installers*, 2001.

ASSE 6030, *Professional Qualification Standard for Medical Gas Systems Verifiers*, 2001.

ASSE 6040, *Professional Qualification Standard for Medical Gas Maintenance Personnel*, 2001.

2.3.5 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM B 32, *Standard Specification for Solder Metal*, 1996.

ASTM B 88, *Standard Specification for Seamless Copper Water Tube*, 2002.

ASTM B 280, *Standard Specification for Seamless Copper Tubing for Air Conditioning and Refrigeration Field Service*, 2002.

ASTM B 819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems*, 2000.

ASTM B 828, *Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings*, 2002.

ASTM D 5, *Standard Test Method for Penetration of Bituminous Materials*, 1997.

ASTM D 1785, *Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120*, 2006.

ASTM D 2466, *Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40*, 2006.

ASTM D 2467, *Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80*, 2006.

ASTM D 2672, *Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement*, 2010.

ASTM D 2846, *Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems*, 2009b.

ASTM D 2863, *Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index) (ANSI D2863)*, 1997.

ASTM E 84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 2010.

ASTM E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, 1998.

ASTM F 438, *Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chlorinated) (CPVC) Plastic Pipe Fittings, Schedule 40*, 2009.

ASTM F 439, *Standard Specification for Chlorinated Poly (Vinyl Chlorinated) (CPVC) Plastic Pipe Fittings, Schedule 80*, 2009.

ASTM F 441, *Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80*, 2009.

ASTM F 493, *Solvent Cements for CPVC Pipe and Fittings*, 2004.

2.3.6 AWS Publications. American Welding Society, 550 NW LeJeune Road, Miami, FL 33126.

ANSI/AWS A5.8, *Specification for Filler Metals for Brazing and Braze Welding*, 1992.

AWS B2.2, *Standard for Brazing Procedure and Performance Qualification*, 1991.

2.3.7 BICSI Publications. BICSI, 8610 Hidden River Parkway, Tampa, FL 33637-1000.

Telecommunications Distribution Methods Manual, 11th edition, 2006.

The BICSI Information Transport Systems (ITS) Dictionary, 3rd edition.

2.3.8 CDA Publications. Copper Development Association Inc., 260 Madison Avenue, New York, NY 10016.

Copper Tube Handbook, 2010.

2.3.9 CGA Publications. Compressed Gas Association, 4221 Walney Road, 5th Floor, Chantilly, VA 20151-2923.

CGA C-4, *Method of Marking Portable Compressed Gas Containers to Identify the Material Contained*, 1954.

CGA C-7, *Guide to the Preparation of Precautionary Labeling and Marking of Compressed Gas Containers*, 2004.

CGA G-4, *Oxygen*, 2008.

CGA G-4.1, *Cleaning Equipment for Oxygen Service*, 2009.

CGA G-6.1, *Standard for Insulated Carbon Dioxide Systems at Consumer Sites*, 2005.

CGA G-6.5, *Standard for Small, Stationary, Insulated Carbon Dioxide Supply Systems*, 2007.

CGA G-8.1, *Standard for Nitrous Oxide Systems at Consumer Sites*, 2007.

CGA M-1, *Guide for Medical Gas Installations at Consumer Sites*, 2007.

CGA O2-DIR, *Directory of Cleaning Agents for Oxygen Service*, Edition 4.

CGA P-2.5, *Transfilling of High Pressure Gaseous Oxygen to be Used for Respiration*, 2007.

CGA P-2.6, *Transfilling of Liquid Oxygen to be Used for Respiration*, 2008.

CGA P-2.7, *Guide for the Safe Storage, Handling, and Use of Portable Liquid Oxygen Systems in Healthcare Facilities*, 2008.

CGA P-18, *Standard for Bulk Inert Gas Systems at Consumer Sites*, 2006.

CGA V-1, *Compressed Gas Association Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections* (ANSI B57.1), 2005.

CGA V-5, *Diameter-Index Safety System (Noninterchangeable Low Pressure Connections for Medical Gas Applications)*, 2008.

CGA V-6, *Standard Cryogenic Liquid Transfer Connection*, 2008.

2.3.10 CSA Publications. Canadian Standards Association, 5060 Spectrum Way, Mississauga, ON, L4W 5N6, Canada.

CSA C22.2 No. 0.3, *Test Methods for Electrical Wires and Cables*, 2009.

2.3.11 IEC Publications. International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, CH-1211 Geneva 20, Switzerland.

IEC 60601-1-2, *Medical Electrical Equipment — Part 1-2: General Requirements for Safety — Collateral Standard: Electromagnetic Compatibility — Requirements and Tests*, 2004.

2.3.12 ISA Publications. Instrumentation, Systems, and Automation Society (ISA), 67 Alexander Drive, Research Triangle Park, NC 27709.

ANSI/ISA S-7.0.01, *Quality Standard for Instrument Air*, 1996.

RP 12.6, *Installation of Intrinsically Safe Systems in Hazardous Locations*, 1995.

2.3.13 MSS Publications. Manufacturer's Standardization Society of the Valve and Fittings Industry, Inc., 127 Park Street NE, Vienna, VA 22180.

SP-58, *Pipe Hangers and Supports — Materials, Design, Manufacture, Selection, Application and Installation*, 2009

2.3.14 TC Publications. Transport Canada, 330 Sparks Street, Ottawa, ON, K1A/0N5, Canada.

Transportation of Dangerous Goods Regulations.

2.3.15 TIA Publications. Telecommunications Industry Association, 2500 Wilson Boulevard, Suite 300, Arlington, VA 22201.

TIA/EIA 568-B, *Commercial Building Telecommunications Cabling Standard*, 2003.

TIA/EIA 606-A, *Administration Standard for Commercial Telecommunications Infrastructure*, 2002.

2.3.16 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 263, *Standard for Fire Test of Building Construction and Materials*, 2003.

UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*, 2008.

UL 1685, *Standard for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables*, 2007.

2.3.17 U.S. Government Publications. Document Automation and Production Service (DAPS), Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, www.dodssp.daps.mil.

21 USC 9, United States Food, Drug, and Cosmetic Act.

U.S. Government Commercial Standard 223-59, *Casters, Wheels, and Glides for Hospital Equipment*.

2.3.18 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

CSA C22.2 No. 0.3-M, *Test Methods for Electrical Wires and Cables*, 2009.

2.4 References for Extracts in Mandatory Sections.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2010 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2012 edition.

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 2011 edition.

NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, 2010 edition.

NFPA 70®, *National Electrical Code®*, 2011 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, 2012 edition.

NFPA 99B, *Standard for Hypobaric Facilities*, 2010 edition.

NFPA 101®, *Life Safety Code®*, 2012 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems*, 2010 edition.

NFPA 1670, *Standard on Operations and Training for Technical Search and Rescue Incidents*, 2009 edition.

NFPA 5000®, *Building Construction and Safety Code®*, 2012 edition.



Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this code. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3* Code. A standard that is an extensive compilation of provisions covering broad subject matter or that is suitable for adoption into law independently of other codes and standards.

3.2.4 Guide. A document that is advisory or informative in nature and that contains only nonmandatory provisions. A guide may contain mandatory statements such as when a guide can be used, but the document as a whole is not suitable for adoption into law.

3.2.5 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3.2.6* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.2.7 Shall. Indicates a mandatory requirement.

3.2.8 Should. Indicates a recommendation or that which is advised but not required.

3.2.9 Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix or annex, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

3.3 General Definitions.

3.3.1 ACFM. Actual cubic feet per minute. (PIP)

3.3.2 Adiabatic Heating. The heating of a gas caused by its compression. (HYP)

3.3.3 Aerosol. An intimate mixture of a liquid or a solid in a gas; the liquid or solid, called the dispersed phase, is uniformly distributed in a finely divided state throughout the gas, which is the continuous phase or dispersing medium. (MED)

3.3.4 Alarm System.

3.3.4.1 Area Alarm System. A warning system within an area of use that provides continuous visible and audible surveillance of Category 1 and Category 2 medical gas and vacuum systems. (PIP)

3.3.4.2 Category 3 Alarm System. A warning system within an area of use that provides continuous visible and audible surveillance of Category 3 medical gas systems. (PIP)

3.3.4.3 Local Alarm System. A warning system that provides continuous visible and audible surveillance of medical gas and vacuum system source equipment at the equipment site. (PIP)

3.3.4.4 Master Alarm System. A warning system that monitors 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. (PIP)

3.3.5 Alternate Power Source. One or more generator sets, or battery systems where permitted, intended to provide power during the interruption of the normal electrical service; or the public utility electrical service intended to provide power during interruption of service normally provided by the generating facilities on the premises. (ELS)

3.3.6 Ambulatory Health Care Center. A building or portion thereof used to provide services or treatment simultaneously to four or more patients that (1) provides, on an outpatient basis, treatment for patients that renders the patients incapable of taking action for self-preservation under emergency conditions without the assistance of others; or (2) provides, on an outpatient basis, anesthesia that renders the patients incapable of taking action for self-preservation under emergency conditions without the assistance of others. (FUN)

3.3.7 Ampacity. The current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating. (ELS)

3.3.8 Anesthetic. As used in this code, applies to any inhalational agent used to produce sedation, analgesia, or general anesthesia. (MED)

3.3.9* Anesthetizing Location. Any area of a facility that has been designated to be used for the administration of general anesthesia. (MED)

3.3.10 Anoxia. A state of markedly inadequate oxygenation of the tissues and blood, of more marked degree than hypoxia. (HYP)

3.3.11 Appliance. Utilization equipment, generally other than industrial, normally built in standardized sizes or types, that is installed or connected as a unit to perform one or more functions. (MED)

3.3.12* Applicator. A means of applying high-frequency energy to a patient other than by an electrically conductive connection. (MED)

3.3.13 Area of Administration. Any point within a room within 4.3 m (15 ft) of oxygen equipment or an enclosure containing or intended to contain an oxygen-enriched atmosphere. (MED)

3.3.14* Atmosphere. The pressure exerted by, and gaseous composition of, an environment. (HYP)

3.3.14.1 Ambient Atmosphere. The pressure and composition of the environment surrounding a chamber. (HYP)

3.3.14.2 Atmosphere Absolute (ATA). The pressure of the earth's atmosphere, 760.0 mmHg, 101.325 kPa, or 14.7 psia. Two ATA = two atmospheres. (See also 3.3.14, *Atmosphere*.) (HYP)

3.3.14.3* Atmosphere of Increased Burning Rate. Any atmosphere containing a percentage of oxygen or oxygen and nitrous oxide greater than the quotient of 23.45 divided by the square root of the total pressure in atmospheres. (HYP)

3.3.14.4 Chamber Atmosphere. The environment inside a chamber. (HYP)

3.3.15 Automatic. Providing a function without the necessity of human intervention. (ELS)

3.3.16 Bathrooms. An area including a basin with one or more of the following: a toilet, a tub, or a shower. (FUN)

3.3.17 Battery-Powered Lighting Units. Individual unit equipment for backup illumination consisting of a rechargeable battery, battery-charging means, provisions for one or more lamps mounted on the equipment, or with terminals for remote lamps, or both, and relaying device arranged to energize the lamps automatically upon failure of the supply to the unit equipment. [70, 2011] (ELS)

3.3.18 Bends. Decompression sickness; caisson worker's disease. (HYP)

3.3.19 Branch Circuit. The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s). [70, 2011] (ELS)

3.3.20 Branch Line. See 3.3.144, Piping.

3.3.21 Bulk System. An assembly of equipment, such as storage containers, pressure regulators, pressure relief devices, vaporizers, manifolds, and interconnecting piping, that terminates at the source valve of oxygen or 1452 kg (3200 lb) of nitrous oxide, including unconnected reserves on the site. (PIP)

3.3.21.1 Bulk Inert Gas System. An assembly of equipment consisting of, but not limited to, storage containers, pressure regulators, pressure relief devices, vaporizers, manifolds, and piping, with a storage capacity of more than 20,000 ft³ (scf) (566 m³) of inert gas including unconnected reserves on hand at the site. The bulk system terminates at the point where the gas supply, at service pressure, first enters the supply line. The containers are either stationary or movable, and the source gas is stored as a compressed gas or cryogenic fluid. (PIP)

3.3.21.2 Bulk Nitrous Oxide System. An assembly of equipment as described in the definition of *bulk oxygen system* that has a storage capacity of more than 1452 kg (3200 lb) [approximately 793 m³ (28,000 ft³) (at normal temperature and pressure)] of nitrous oxide. (PIP)

3.3.21.3* Bulk Oxygen System. An assembly of equipment such as oxygen storage containers, pressure regulators, pressure relief devices, vaporizers, manifolds, and interconnecting piping that has a storage capacity of more than 566 m³ (20,000 ft³) of oxygen (at normal temperature and pressure), including unconnected reserves on hand at the site. (PIP)

3.3.22 Category 3 Drive Gas System. An assembly of component parts including, but not limited to, the source, pressure and operating controls, filters and purification equipment, valves, alarm warning systems, alarm wiring, gauges, and a network of piping and suitable outlets that produces and distrib-

utes compressed air from cylinders, compressed air from compressors, or nitrogen from cylinders less than 1100 kPa gauge (less than 160 psi gauge) to power devices (hand pieces, syringes, cleaning devices, delivery system chairs, and so forth) as a power source. The system includes the compressor intakes and ends with the service outlet where the user connects their clinical equipment. (PIP)

3.3.23 Category 3 Vacuum System. A Category 3 vacuum distribution system that can be either a wet system designed to remove liquids, air-gas, or solids from the treated area; or a dry system designed to trap liquid and solids before the service inlet and to accommodate air-gas only through the service inlet. (PIP)

3.3.24 Cold Room. A refrigerated area large enough for personnel to enter.

3.3.25 Combustible. Capable of undergoing combustion. (MED)

3.3.26* Combustible Liquid. Any liquid that was a closed-cup flash point at or above 37.8°C (100°F). Combustible liquids are classified as follows: (a) Class II liquid. Any liquid that has a flash point at or above 37.8°C (100°F) and below 60°C (140°F); (b) Class IIIA liquid. Any liquid that has a flash point at or above 60°C (140°F) and below 93°C (200°F); (c) Class IIIB liquid. Any liquid that has a flash point at or above 93°C (200°F).

3.3.27* Combustion. A chemical process of oxidation that occurs at a rate fast enough to produce heat and usually light in the form of either a glow or flame. [5000, 2012] (HYP)

3.3.28 Compact Storage. Storage on solid shelves not exceeding 0.9 m (36 in.) in total depth, arranged as part of a compact storage module, with no more than 0.76 m (30 in.) between shelves vertically and with no internal vertical flue spaces other than those between individual shelving sections. [13, 2010] (FUN)

3.3.29 Container. A low-pressure, vacuum-insulated vessel containing gases in liquid form. (MED)

3.3.29.1 Liquid Oxygen Ambulatory Container. A container used for liquid oxygen not exceeding 1.5 L (0.396 gal) specifically designed for use as a medical device as defined by 21 USC Chapter 9, the United States Food, Drug and Cosmetic Act, that is intended for portable therapeutic use and to be filled from its companion base unit, which is a liquid oxygen home care container. (MED)

3.3.29.2 Liquid Oxygen Base Reservoir Container. A container used for liquid oxygen not exceeding 60 L (15.8 gal) specifically designed for use as a medical device as defined by 21 USC Chapter 9, the United States Food, Drug and Cosmetic Act, that is intended to deliver gaseous oxygen for therapeutic use, transfilling, or both. (MED)

3.3.29.3 Liquid Oxygen Home Care Container. A container used for liquid oxygen not exceeding 60 L (15.8 gal) specifically designed for use as a medical device as defined by 21 USC Chapter 9, the United States Food, Drug and Cosmetic Act, that is intended to deliver gaseous oxygen for therapeutic use in a home environment. (MED)

3.3.29.4 Liquid Oxygen Portable Container. A container used for liquid oxygen not exceeding 1.5 L (0.396 gal) specifically designed for use as a medical device as defined by 21 USC Chapter 9, the United States Food, Drug and Cosmetic Act, that is intended for portable therapeutic use and to be filled from its companion base unit, which is a liquid oxygen base reservoir container. (MED)



3.3.30 Critical Branch. system of feeders and branch circuits supplying power for task illumination, fixed equipment, select receptacles, and select power circuits serving areas and functions related to patient care that are automatically connected to alternate power sources by one or more transfer switches during interruption of the normal power source. (ELS)

3.3.31 Critical Care Area. See 3.3.138, Patient Care Room.

3.3.32 Critical Equipment. That equipment essential to the safety of the occupants of the facility. (HYP)

3.3.33 Cylinder. A supply tank containing high-pressure gases or gas mixtures at pressures that can be in excess of 13.8 kPa gauge (2000 psi gauge). (MED)

3.3.34 Decompression Sickness. A syndrome due to evolved gas in the tissues resulting from a reduction in ambient pressure. (HYP)

3.3.35* Defend in Place. The operational response to an emergency in a building, in which the initial action does not involve evacuation of the building occupants. (FUN)

3.3.36 Demand Check. A paired set of fittings that permit gas flow when correctly mated but interrupt flow when separated. (PIP)

3.3.37 Detonation. An exothermic reaction wherein the reaction propagates through the unreacted material at a rate exceeding the velocity of sound, hence the explosive noise. (MED)

3.3.38* Direct Electrical Pathway to the Heart. An externalized conductive pathway, insulated except at its ends, one end of which is in direct contact with heart muscle while the other is outside the body and is accessible for inadvertent or intentional contact with grounded objects or energized, ground-referenced sources. (MED)

3.3.39* Disaster. Within the context of this code, any unusual occurrence or unforeseen situation that seriously overtaxes or threatens to seriously overtax the routine capabilities of a health care facility. (HES)

3.3.40 D.I.S.S. Connector. A system of noninterchangeable medical gas and vacuum connectors complying with CGA V-5, *Diameter-Index Safety System (Noninterchangeable Low Pressure Connections for Medical Gas Applications)*. (PIP)

3.3.41* Double-Insulated Appliances. Appliances where the primary means of protection against electrical shock is not grounding. The primary means is by the use of combinations of insulation and separation spacings in accordance with an approved standard. (MED)

3.3.42 Electrical Life Support Equipment. Electrically powered equipment whose continuous operation is necessary to maintain a patient's life. (ELS)

3.3.43 Electrode. An electrically conductive connection to a patient. (MED)

3.3.43.1 Active Electrode. An electrode intended to generate a surgical or physiological effect at its point of application to the patient. (MED)

3.3.43.2 Bipolar Electrode. An electrode consisting of adjacent contacts (e.g., the two legs of a forceps) such that the current passes between the pair of contacts generating the intended effect. (MED)

3.3.43.3* Dispersive Electrode. An electrode intended to complete the electrical path between patient and appliance and at which no surgical effect is intended. (MED)

3.3.44 Emergency Management. The act of developing procedures and plans to create effective preparedness, mitigation, response, and recovery during a disaster affecting a health care facility. (HES)

3.3.45 Emergency Oxygen Supply Connection. An assembly of equipment that permits a gas supplier to make a temporary connection to supply oxygen to a building that has had its normal source of oxygen disconnected. (PIP)

3.3.46 Equipment Branch. A system of feeders and branch circuits arranged for delayed, automatic, or manual connection to the alternate power source and that serves primarily 3-phase power equipment. (ELS)

3.3.47 Equipment Grounding Bus. A grounding terminal bus in the feeder circuit of the branch circuit distribution panel that serves a particular area. (MED)

3.3.48* Essential Electrical System. A system comprised of alternate sources of power and all connected distribution systems and ancillary equipment, designed to ensure continuity of electrical power to designated areas and functions of a health care facility during disruption of normal power sources, and also to minimize disruption within the internal wiring system. (ELS)

3.3.49 Evacuation — Waste Gas. See 3.3.183, Waste Anesthetic Gas Disposal.

3.3.50 Exposed Conductive Surfaces. Those surfaces that are capable of carrying electric current and that are unprotected, uninsulated, unenclosed, or unguarded, permitting personal contact. (ELE)

3.3.51* Failure. An incident that increases the hazard to personnel or patients or that affects the safe functioning of electric appliances or devices. (MED)

3.3.52 Fault Current. A current in an accidental connection between an energized and a grounded or other conductive element resulting from a failure of insulation, spacing, or containment of conductors. (ELS)

3.3.53 Feeder. All circuit conductors between the service equipment, the source of a separately derived system, or other power supply source and the final branch-circuit overcurrent device. (ELS)

3.3.54* Flammable. A combustible that is capable of easily being ignited and rapidly consumed by fire.

3.3.55 Flammable Gas. Any substance that exists in the gaseous state at normal atmospheric temperature and pressure and is capable of being ignited and burned when mixed with proper proportion of air, oxygen, or other oxidizers. (HYP)

3.3.56 Flammable Liquid. A liquid that has a closed-cup flash point that is below 37.8°C (100°F) and a maximum vapor pressure of 2068 mmHg (40 psi absolute) at 37.8°C (100°F).

3.3.57* Flash Point. The minimum temperature at which a liquid or a solid emits vapor sufficient to form an ignitable mixture with air near the surface of the liquid or the solid. (FUN)

3.3.58 Flow-Control Valve. A valve, usually a needle valve, that precisely controls flow of gas. (MED)

3.3.59 Flowmeter. A device for measuring volumetric flow rates of gases and liquids. (MED)

3.3.59.1 Pressure Compensated Flowmeter. A flowmeter indicating accurate flow of gas whether the gas is discharged into ambient pressure or into a system at nonambient pressure. (MED)

3.3.60* Frequency. The number of oscillations, per unit time, of a particular current or voltage waveform. The unit of frequency is the hertz. (MED)

3.3.61* Fume Hood. An enclosure designed to draw air inward by means of mechanical ventilation.

3.3.62 Gas-Powered System. A Level 3 gas distribution system comprised of component parts including but not limited to cylinders, manifolds, air compressor, motor, receivers, controls, filters, dryers, valves, and piping that delivers compressed air or nitrogen at pressures less than 1100 kPa (less than 160 psi) gauge to power devices (e.g., hand pieces, syringes, cleaning devices) as a power source. (PIP)

3.3.63* General Anesthesia and Levels of Sedation/Analgesia.

3.3.63.1 Deep Sedation/Analgesia. A drug-induced depression of consciousness during which patients cannot be easily aroused but respond purposefully following repeated or painful stimulation. The ability to independently maintain ventilatory function may be impaired. Patients may require assistance in maintaining a patent airway, and spontaneous ventilation may be inadequate. Cardiovascular function is usually maintained. (MED)

3.3.63.2 General Anesthesia. A drug-induced loss of consciousness during which patients are not arousable, even by painful stimulation. The ability to independently maintain ventilatory function is often impaired. Patients often require assistance in maintaining a patent airway, and positive pressure ventilation may be required because of depressed spontaneous ventilation or drug-induced depression of neuromuscular function. Cardiovascular function may be impaired. (MED)

3.3.63.3 Minimal Sedation (Anxiolysis). A drug-induced state during which patients respond normally to verbal commands. Although cognitive function and coordination may be impaired, ventilatory and cardiovascular functions are unaffected. (MED)

3.3.63.4 Moderate Sedation/Analgesia (Conscious Sedation). A drug-induced depression of consciousness during which patients respond purposefully to verbal commands, either alone or accompanied by light tactile stimulation. No interventions are required to maintain a patent airway, and spontaneous ventilation is adequate. Cardiovascular function is usually maintained. (MED)

3.3.64 General Care Area. See 3.3.138, Patient Care Room.

3.3.65 Governing Body. The person or persons who have the overall legal responsibility for the operation of a health care facility. (FUN)

3.3.66 Ground-Fault Circuit Interrupter (GFCI). A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit. (ELS)

3.3.67 Grounding. See 3.3.68, Grounding System.

3.3.68* Grounding System. A system of conductors that provides a low-impedance return path for leakage and fault currents. (ELS)

3.3.69 Hazard Current. For a given set of connections in an isolated power system, the total current that would flow through

a low impedance if it were connected between either isolated conductor and ground. (ELS)

3.3.69.1 Fault Hazard Current. The hazard current of a given isolated power system with all devices connected except the line isolation monitor. (ELS)

3.3.69.2 Monitor Hazard Current. The hazard current of the line isolation monitor alone. (ELS)

3.3.69.3 Total Hazard Current. The hazard current of a given isolated system with all devices, including the line isolation monitor, connected. (ELS)

3.3.70* Hazardous Chemical. A chemical with one or more of the following hazard ratings as defined in NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response* Health — 2, 3, or 4; Flammability — 2, 3, or 4; Reactivity — 2, 3, or 4.

3.3.71* Health Care Facilities. Buildings, portions of buildings, or mobile enclosures in which medical, dental, psychiatric, nursing, obstetrical, or surgical care is provided. (FUN)

3.3.72 Home Care. Medical services (equipment) provided in residential occupancies. (FUN)

3.3.73 Hospital. A building or portion thereof used on a 24-hour basis for the medical, psychiatric, obstetrical, or surgical care of four or more inpatients. [101, 2012] (FUN)

3.3.74 Hospital-Based. In the interpretation and application of this code, physically connected to a hospital. (MED)

3.3.75 Humidifier. A device used for adding water vapor to inspired gas. (MED)

3.3.76 Hyperbaric. Facility, building, or structure used to house chambers and all auxiliary service equipment for medical applications and procedures at pressures above normal atmospheric pressures. (HYP)

3.3.77 Hyperbaric Oxygenation. The application of pure oxygen or an oxygen-enriched gaseous mixture to a subject at elevated pressure. (HYP)

3.3.78 Hyperbaric Stand-Alone Oxygen System. The oxygen system is entirely separate from the hospital's Level 1 Oxygen System or is a freestanding hyperbaric facility. (HYP)

3.3.79 Hypobaric. Facility, building, or structure used to house chambers and all auxiliary service equipment for medical applications and procedures at pressures below atmospheric pressures. (HYP)

3.3.80 Hypoxia. A state of inadequate oxygenation of the blood and tissue sufficient to cause impairment of function. [99B, 2010] (HYP)

3.3.81 Immediate Restoration of Service. Automatic restoration of operation with an interruption of not more than 10 seconds. (ELS)

3.3.82* Impedance. Impedance is the ratio of the voltage drop across a circuit element to the current flowing through the same circuit element. The unit of impedance is the ohm. (MED)

3.3.83 Incident Command System (ICS). The combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure that has responsibility for the management of assigned resources to effectively accomplish stated objectives pertaining to an incident or training exercise. [1670, 2009] (HES)



3.3.84 Instrument Air. For the purposes of this code, instrument air is air intended for the powering of medical devices unrelated to human respiration (e.g., surgical tools, ceiling arms). Medical air and instrument air are distinct systems for mutually exclusive applications. Instrument air is a medical support gas that falls under the general requirements for medical gases. (PIP)

3.3.85 Intermittent Positive-Pressure Breathing (IPPB). Ventilation of the lungs by application of intermittent positive pressure to the airway. (MED)

3.3.86* Intrinsically Safe. As applied to equipment and wiring, equipment and wiring that are incapable of releasing sufficient electrical energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture. (HYP)

3.3.87 Invasive Procedure. Any procedure that penetrates the protective surfaces of a patient's body (i.e., skin, mucous membrane, cornea) and that is performed with an aseptic field (procedural site). [Not included in this category are placement of peripheral intravenous needles or catheters used to administer fluids and/or medications, gastrointestinal endoscopies (i.e., sigmoidoscopies), insertion of urethral catheters, and other similar procedures.] (ELS)

3.3.88 Isolated Patient Lead. A patient lead whose impedance to ground or to a power line is sufficiently high that connecting the lead to ground, or to either conductor of the power line, results in current flow below a hazardous limit in the lead. (MED)

3.3.89* Isolated Power System. A system comprising an isolation transformer or its equivalent, a line isolation monitor, and its ungrounded circuit conductors. (ELS)

3.3.90 Isolation Transformer. A transformer of the multiple-winding type, with the primary and secondary windings physically separated, that inductively couples its ungrounded secondary winding to the grounded feeder system that energizes its primary winding. (ELS)

3.3.91* Laboratory. A building, space, room, or group of rooms intended to serve activities involving procedures for investigation, diagnosis, or treatment in which flammable, combustible, or oxidizing materials are to be used.

3.3.92* Laboratory Work Area. A room or space for testing, analysis, research, instruction, or similar activities that involve the use of chemicals. This work area may or may not be enclosed.

3.3.93 Leak Detectant. For purposes of this standard, a reagent, a solution, or an electronic or mechanical device suitable for the detection or visualization of escaping gas. (PIP)

3.3.94 Life Safety Branch. A system of feeders and branch circuits supplying power for lighting, receptacles, and equipment essential for life safety that are automatically connected to alternate power sources by one or more transfer switches during interruption of the normal power source. (ELS)

3.3.95 Limited Care Facility. A building or portion of a building used on a 24-hour basis for the housing of four or more persons who are incapable of self-preservation because of age; physical limitations due to accident or illness; or limitations such as mental retardation/developmental disability, mental illness, or chemical dependency. [101, 2012] (FUN)

3.3.96* Limited-Combustible (Material). Refers to a building construction material not complying with the definition of *non-combustible material* that, in the form in which it is used, has a

potential heat value not exceeding 8141 kJ/kg (3500 Btu/lb), where tested in accordance with NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, and includes either of the following: (1) materials having a structural base of noncombustible material, with a surfacing not exceeding a thickness of 1/8 in. (3.2 mm) that has a flame spread index not greater than 50; or (2) materials, in the form and thickness used, having neither a flame spread index greater than 25 nor evidence of continued progressive combustion, and of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread index greater than 25 nor evidence of continued progressive combustion, when tested in accordance with ASTM E 84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*. [90A, 2012] (PIP)

3.3.97 Line Isolation Monitor. A test instrument designed to continually check the balanced and unbalanced impedance from each line of an isolated circuit to ground and equipped with a built-in test circuit to exercise the alarm without adding to the leakage current hazard. (ELS)

3.3.98* Liquid. Any material that (1) has a fluidity greater than that of 300 penetration asphalt when tested in accordance with ASTM D 5, *Standard Test Method for Penetration of Bituminous Materials*, or (2) is a viscous substance for which a specific melting point cannot be determined but that is determined to be a liquid in accordance with ASTM D 4359, *Standard Test for Determining Whether a Material is a Liquid or a Solid*. [30, 2012] (LAB)

3.3.99* Local Signal. A visible indication of the operating status of equipment. (PIP)

3.3.100 mA. Milliampere.

3.3.101 Manifold. A device for connecting the outlets of one or more gas cylinders to the central piping system for that specific gas. (PIP)

3.3.102* Manufactured Assembly. A factory-assembled product designed for aesthetics or convenience that contains medical gas or vacuum outlets, piping, or other devices related to medical gases. (PIP)

3.3.103 Mask. A device that fits over the mouth and nose (oro-nasal) or nose (nasal) used to administer gases to a patient. (MED)

3.3.104* Medical Air. For purposes of this code, medical air is air supplied from cylinders, bulk containers, or medical air compressors or reconstituted from oxygen USP and oil-free, dry nitrogen NF. (PIP)

3.3.104.1 Proportioning System for Medical Air USP. A central supply that produces medical air (USP) reconstituted from oxygen USP and nitrogen NF by means of a mixer or blender. (PIP)

3.3.105 Medical Air Compressor. A compressor that is designed to exclude oil from the air stream and compression chamber and that does not under normal operating conditions or any single fault add any toxic or flammable contaminants to the compressed air. (PIP)

3.3.106* Medical/Dental Office. A building or part thereof in which the following occur: (1) examinations and minor treatments/procedures are performed under the continuous supervision of a medical/dental professional; (2) only sedation or

local anesthesia is involved and treatment or procedures do not render the patient incapable of self-preservation under emergency conditions; and (3) overnight stays for patients or 24-hour operation are not provided. (FUN)

3.3.107 Medical Gas. A patient medical gas or medical support gas. (See also 3.3.142, *Patient Medical Gas* and 3.3.109, *Medical Support Gas*.) (PIP)

3.3.108 Medical Gas System. An assembly of equipment and piping for the distribution of nonflammable medical gases such as oxygen, nitrous oxide, compressed air, carbon dioxide, and helium. (PIP)

3.3.109 Medical Support Gas. Nitrogen or instrument air used for any medical support purpose (e.g., to remove excess moisture from instruments before further processing, or to operate medical-surgical tools, air-driven booms, pendants, or similar applications) and, if appropriate to the procedures, used in laboratories and are not respired as part of any treatment. Medical support gas falls under the general requirements for medical gases. (PIP)

3.3.110 Medical-Surgical Vacuum. A method used to provide a source of drainage, aspiration, and suction in order to remove body fluids from patients. (PIP)

3.3.111 Medical-Surgical Vacuum System. An assembly of central vacuum-producing equipment and a network of piping for patient suction in medical, medical-surgical, and waste anesthetic gas disposal (WAGD) applications. (PIP)

3.3.112 Multiple Treatment Facility. A diagnostic or treatment complex under a single management comprising a number of single treatment facilities, which can be accessed one from the other without exiting the facility (i.e., does not involve widely separated locations or separate distinct practices). (FUN)

3.3.113 mV. Millivolt.

3.3.114 Nasal Cannula. Device consisting of two short tubes to be inserted into the nostrils to administer oxygen or other therapeutic gases. (MED)

3.3.115 Nasal Catheter. A flexible tube for insertion through the nose into the nasopharynx to administer oxygen or other therapeutic gases. (MED)

3.3.116 Nebulizer. A device used for producing an aerosol of water and/or medication within inspired gas supply. (MED)

3.3.117 Negative Pressure. Pressure less than atmospheric. (MED)

3.3.118 Nitrogen. An element that, at atmospheric temperatures and pressures, exists as a clear, colorless, and tasteless gas; it comprises approximately four-fifths of the earth's atmosphere. (MED)

3.3.118.1 Nitrogen NF (Oil-Free, Dry). Nitrogen complying as a minimum with oil-free, dry nitrogen NF. (PIP)

3.3.119 Nitrogen Narcosis. A condition resembling alcoholic inebriation, which results from breathing nitrogen in the air under significant pressure. (HYP)

3.3.120 Nitrous Oxide. An inorganic compound, one of the oxides of nitrogen. It exists as a gas at atmospheric pressure and temperature, possesses a sweetish smell, and is used for inducing anesthesia when inhaled. The oxygen in the compound will be released under conditions of combustion, creating an oxygen-enriched atmosphere. (MED)

3.3.121 Noncombustible (Hyperbaric). An adjective describing a substance that will not burn in 95 ±5 percent oxygen at pressures up to 3 ATA (44.1 psia). (HYP)

3.3.122 Noncombustible (Hypobaric). An adjective describing a substance that will not burn in 95 ±5 percent oxygen at pressures of 101.325 kPa (760 mmHg). (HYP)

3.3.123 Noncombustible (Material). A material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors, when subjected to fire or heat. Materials that are reported as passing ASTM E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, shall be considered noncombustible materials. (HYP)

3.3.124 Nonflammable. Not readily capable of burning with a flame and not liable to ignite and burn when exposed to flame.

3.3.125* Nonflammable Anesthetic Agent. Refers to those inhalation agents that, because of their vapor pressure at 37°C (98.6°F) and at atmospheric pressure, cannot attain flammable concentrations when mixed with air, oxygen, or mixtures of oxygen and nitrous oxide. (MED)

3.3.126* Nonflammable Medical Gas System. See 3.3.105, Medical Gas System, and Chapter 5.

3.3.127 Nursing Home. A building or portion of a building used on a 24-hour basis for the housing and nursing care of four or more persons who, because of mental or physical incapacity, might be unable to provide for their own needs and safety without the assistance of another person. [101, 2012] (FUN)

3.3.128* Oxidizing Gas. A gas that supports combustion. (HYP)

3.3.129* Oxygen. A chemical element that, at normal atmospheric temperatures and pressures, exists as a colorless, odorless, and tasteless gas and comprises about 21 percent by volume of the earth's atmosphere. (MED)

3.3.129.1 Gaseous Oxygen. A colorless, odorless, tasteless, and nontoxic gas, comprising about 21 percent of normal air by volume, that is about 10 percent heavier than air; also the physical state of the element at atmospheric temperature and pressure. (MED)

3.3.129.2* Liquid Oxygen. Exists at cryogenic temperature, approximately -184.4°C (-300°F) at atmospheric pressure. It retains all of the properties of gaseous oxygen, but, in addition, when allowed to warm to room temperature at atmospheric pressure, it will evaporate and expand to fill a volume 860 times its liquid volume. (MED)

3.3.130* Oxygen Delivery Equipment. Any device used to transport and deliver an oxygen-enriched atmosphere to a patient. (MED)

3.3.131 Oxygen-Enriched Atmosphere (OEA). For the purposes of this code, an atmosphere in which the concentration of oxygen exceeds 23.5 percent by volume. (HYP)

3.3.132* Oxygen Hood. A device encapsulating a patient's head and used for a purpose similar to that of a mask. (See also 3.3.103, *Mask*.) (HYP)

3.3.133 Oxygen Index. The minimum concentration of oxygen, expressed as percent by volume, in a mixture of oxygen and nitrogen that will just support combustion of a material under conditions of ASTM D 2863, *Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)*. (HYP)



3.3.134* Oxygen Toxicity (Hyperbaric). Physical impairment resulting from breathing gaseous mixtures containing oxygen-enriched atmospheres at elevated partial pressures for extended periods of time. (HYP)

3.3.135 Oxygen USP. Oxygen complying with Medical USP.

3.3.136 Patient Bed Location. The location of a patient sleeping bed, or the bed or procedure table of a critical care area. (ELS)

3.3.137 Patient-Care-Related Electrical Equipment. Electrical equipment appliance that is intended to be used for diagnostic, therapeutic, or monitoring purposes in a patient care vicinity. (MED)

3.3.138* Patient Care Room. Any room of a health care facility wherein patients are intended to be examined or treated. (MED)

3.3.138.1* Basic Care Room. Room in which the failure of equipment or a system is not likely to cause injury to the patients or caregivers but can cause patient discomfort (Category 3). (MED)

3.3.138.2* Critical Care Room. Room in which failure of equipment or a system is likely to cause major injury or death of patients or caregivers (Category 1). (MED)

3.3.138.3* General Care Room. Room in which failure of equipment or a system is likely to cause minor injury to patients or caregivers (Category 2). (MED)

3.3.138.4* Support Room. Room in which failure of equipment or a system is not likely to have a physical impact on patients or caregivers (Category 4). (MED)

3.3.139 Patient Care Vicinity. A space, within a location intended for the examination and treatment of patients, extending 1.8 m (6 ft) beyond the normal location of the bed, chair, table, treadmill, or other device that supports the patient during examination and treatment and extending vertically to 2.3 m (7 ft 6 in.) above the floor. (MED)

3.3.140 Patient Equipment Grounding Point. A jack or terminal that serves as the collection point for redundant grounding of electric appliances serving a patient care vicinity or for grounding other items in order to eliminate electromagnetic interference problems. (MED)

3.3.141* Patient Lead. Any deliberate electrical connection that can carry current between an appliance and a patient. (MED)

3.3.142 Patient Medical Gas. Piped gases such as oxygen, nitrous oxide, helium, carbon dioxide, and medical air that are used in the application of human respiration and the calibration of medical devices used for human respiration. (PIP)

3.3.143 Piped Distribution System. A pipeline network assembly of equipment that starts at and includes the source valve, warning systems (master, area, local alarms), bulk gas system signal actuating switch wiring, interconnecting piping, and all other components up to and including the station outlets/inlets. (PIP)

3.3.144 Piping. The tubing or conduit of the system. The three general classes of piping are main lines, risers, and branch (lateral) lines. (PIP)

3.3.144.1 Branch (Lateral) Lines. Those sections or portions of the piping system that serve a room or group of rooms on the same story of the facility. (PIP)

3.3.144.2 Main Lines. The piping that connects the source (pumps, receivers, etc.) to the risers or branches, or both. (PIP)

3.3.144.3 Risers. The vertical pipes connecting the system main line(s) with the branch lines on the various levels of the facility. (PIP)

3.3.145 Plug (Attachment Plug, Cap). A device that, by insertion in a receptacle, establishes connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle. (MED)

3.3.146 Positive-Negative Pressure Breathing. Ventilation of the lungs by the application of intermittent positive-negative pressure to the airway. (MED)

3.3.147 Pressure.

3.3.147.1 Absolute Pressure. The total pressure in a system with reference to zero pressure. (HYP)

3.3.147.2 Ambient Pressure. Refers to total pressure of the environment referenced. (HYP)

3.3.147.3 Gauge Pressure. Refers to total pressure above (or below) atmospheric. (HYP)

3.3.147.4 High Pressure. A pressure exceeding 1.38 kPa (200 psi) gauge (215 psia). (MED)

3.3.147.5* Partial Pressure. The pressure, in absolute units, exerted by a particular gas in a gas mixture. (HYP)

3.3.147.6 Positive Pressure. Pressure greater than ambient atmospheric. (MED)

3.3.147.7* Working Pressure. A pressure not exceeding 200 psi (11.6 kg/cm²) gauge. (MED)

3.3.148* Pressure-Reducing Regulator. A device that automatically reduces gas under high pressure to a usable lower working pressure. (MED)

3.3.149 Procedure Room. Where the proceduralist is using instrumentation that requires constant observation and control. (MED)

3.3.150 psia. Pounds per square inch absolute, a unit of pressure measurement with zero pressure as the base or reference pressure. (HYP)

3.3.151* psig. Pounds per square inch gauge, a unit of pressure measurement with atmospheric pressure as the base or reference pressure. (HYP)

3.3.152 Reactance. The component of impedance contributed by inductance or capacitance. The unit of reactance is the ohm. (MED)

3.3.153 Reactive Material. A material that, by itself, is readily capable of detonation, explosive decomposition, or explosive reaction at normal or elevated temperatures and pressures. [45, 2011]

3.3.154 Receptacle. A receptacle is a contact device installed at the outlet for the connection of an attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is two or more contact devices on the same yoke. [70, 2011] (ELS)

3.3.155 Reference Grounding Point. The ground bus of the panelboard or isolated power system panel supplying the patient care room. (MED)

3.3.156* Refrigerating Equipment. Any mechanically operated equipment used for storing below normal ambient temperature hazardous materials having flammability ratings of 3 or 4.

3.3.157* Remote. A Level 3 source of supply that is accessed by exiting the single or multiple treatment facility. (PIP)

3.3.158 Reserve Supply. Where existing, that portion of the supply equipment that automatically supplies the system in the event of failure of the operating supply. The reserve supply only functions in an emergency and not as a normal operating procedure. (PIP)

3.3.159 Safety Can. An approved container, of not more than 18.9 L (5 gal) capacity, having a spring-closing lid and spout cover and so designed that it will safely relieve internal pressure when subjected to fire exposure.

3.3.160 Scavenging. Evacuation of exhaled mixtures of oxygen and nitrous oxide. (PIP)

3.3.161 SCFM. Abbreviation of flow rate units of standard cubic feet per minute. (PIP)

3.3.162 Selected Receptacles. A minimal number of receptacles selected by the governing body of a facility as necessary to provide essential patient care and facility services during loss of normal power. (ELS)

3.3.163 Self-Extinguishing. A characteristic of a material such that, once the source of ignition is removed, the flame is quickly extinguished without the fuel or oxidizer being exhausted. (HYP)

3.3.164 Semipermanent Connection. A noninterchangeable connection, usually a D.I.S.S. connector, which is the termination of the pipeline and that is intended to be detached only for service. It is not the point at which the user makes connections or disconnections. (PIP)

3.3.165 Service Inlet. The pneumatic terminus of a Level 3 piped vacuum system. (PIP)

3.3.166 Service Outlet. The pneumatic terminus of a piped gas system for other than critical, continuous duty, nonflammable medical life support-type gases such as oxygen, nitrous oxide, or medical air. (PIP)

3.3.167* Single Treatment Facility. A diagnostic or treatment complex under a single management comprising a number of use points, but confined to a single contiguous group of use points (i.e., does not involve widely separated locations or separate distinct practices). (PIP)

3.3.168* Site of Intentional Expulsion. All points within 0.3 m (1 ft) of a point at which an oxygen-enriched atmosphere is intentionally vented to the atmosphere. (MED)

3.3.169 Station Inlet. An inlet point in a piped medical/surgical vacuum distribution system at which the user makes connections and disconnections. (PIP)

3.3.170 Station Outlet. An outlet point in a piped medical gas distribution system at which the user makes connections and disconnections. (PIP)

3.3.171 Supply Source.

3.3.171.1 Operating Supply. The portion of the supply system that normally supplies the piping systems. The operating supply consists of a primary supply or a primary and secondary supply. (PIP)

3.3.171.2 Primary Supply. That portion of the source equipment that actually supplies the system. (PIP)

3.3.171.3 Reserve Supply. Where provided, that portion of the source equipment that automatically supplies the system in the event of failure of the primary and secondary operating supply. (PIP)

3.3.171.4 Secondary Supply. Where provided, that portion of the source equipment that automatically supplies the system when the primary supply becomes exhausted. (PIP)

3.3.172* Surface-Mounted Medical Gas Rail Systems. A surface-mounted gas delivery system intended to provide ready access for two or more gases through a common delivery system to provide multiple gas station outlet locations within a single patient room or critical care area. (PIP)

3.3.173 Task Illumination. Provisions for the minimum lighting required to carry out necessary tasks in the areas described in Chapter 6, including safe access to supplies and equipment and access to exits. (ELS)

3.3.174 Terminal. The end of a flexible hose or tubing used in a manufactured assembly where the user is intended to make connection and disconnection. (PIP)

3.3.175 Touch Current. Leakage current flowing from the enclosure or from parts thereof, excluding patient connections, accessible to any operator or patient in normal use, through an external path other than the protective grounding (earth) conductor to earth or to another part of the enclosure. (MED)

3.3.176 Transfilling. The process of transferring a medical gas in gaseous or liquid state from one container or cylinder to another container or cylinder (MED).

3.3.177 Tube.

3.3.177.1* Endotracheal Tube. A tube for insertion through the mouth or nose into the upper portion of the trachea (windpipe). (MED)

3.3.177.2* Tracheotomy Tube. A curved tube for insertion into the trachea (windpipe) below the larynx (voice box) during the performance of an appropriate operative procedure (tracheotomy). (MED)

3.3.178* Unattended Laboratory Operation. A laboratory procedure or operation at which there is no person present who is knowledgeable regarding the operation and emergency shutdown procedures. [45, 2011]

3.3.179 Use Point. A location with any number of station outlets and inlets arranged for access by a practitioner during treatment of a patient. (PIP)

3.3.180* Utility Center (J Box). A type of terminal enclosure for utilities (e.g., gas power, vacuum, water, electrical power) used in office-based occupancies. (PIP)

3.3.181 Vaporizer. A heat exchange unit designed to convert cryogenic liquid into the gaseous state. (PIP)

3.3.182* WAGD Interface. A device provided on the anesthesia gas machine that connects the WAGD network to the patient breathing circuit. (PIP)

3.3.183 Waste Anesthetic Gas Disposal (WAGD). The process of capturing and carrying away gases vented from the patient breathing circuit during the normal operation of gas anesthesia or analgesia equipment. (PIP)



3.3.184* Wet Procedure Locations. The area in a patient care room where a procedure is performed that is normally subject to wet conditions while patients are present, including standing fluids on the floor or drenching of the work area, either of which condition is intimate to the patient or staff. (FUN)

3.4 BICSI Definitions. These terms are defined in *The BICSI Information Transport Systems (ITS) Dictionary*. (HES)

3.4.1 Telecommunications Entrance Facility (EF). An entrance to a building for both public and private network service cables that includes the building entrance point and the entrance room or space at the point of demarcation between campus or utility service and building interior distribution of communications systems. (ELS)

3.4.2 Telecommunications Equipment Room (TER). An environmentally controlled centralized space for telecommunications equipment, typically including main or intermediate cross-connect equipment and cabling. (ELS)

3.4.3 Telecommunications Room (TR). An enclosed architectural space for housing telecommunications equipment, cable terminations, and cross-connect cabling, serving a floor or an area of a floor. (ELS)

Chapter 4 Fundamentals

4.1* Building System Categories. Building systems in health care facilities shall be designed to meet system Category 1 through Category 4 requirements as detailed in this code.

4.1.1* Category 1. Facility systems in which failure of such equipment or system is likely to cause major injury or death of patients or caregivers shall be designed to meet system Category 1 requirements as defined in this code.

4.1.2* Category 2. Facility systems in which failure of such equipment is likely to cause minor injury to patients or caregivers shall be designed to meet system Category 2 requirements as defined in this code.

4.1.3 Category 3. Facility systems in which failure of such equipment is not likely to cause injury to patients or caregivers, but can cause patient discomfort, shall be designed to meet system Category 3 requirements as defined in this code.

4.1.4 Category 4. Facility systems in which failure of such equipment would have no impact on patient care shall be designed to meet system Category 4 requirements as defined in this code.

4.2* Risk Assessment. Categories shall be determined by following and documenting a defined risk assessment procedure.

4.3 Application. The Category definitions in Chapter 4 shall apply to Chapters 5 through 11.

Chapter 5 Gas and Vacuum Systems

5.1 Category 1 Piped Gas and Vacuum Systems.

5.1.1* Applicability.

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

5.1.1.2* Where the terms *medical gas* or *medical support gas* occur, the provisions shall apply to all piped systems for oxygen, nitrous oxide, medical air, carbon dioxide, helium, nitrogen, instrument

air, and mixtures thereof. Wherever the name of a specific gas service occurs, the provision shall apply only to that gas.

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

5.1.1.4 An existing system that is not in strict compliance with the provisions of this code shall be permitted to be continued in use as long as the authority having jurisdiction has determined that such use does not constitute a distinct hazard to life.

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

5.1.1.6 Paragraph 5.1.14.4.3 through 5.1.14.4.9 and 5.1.13 through 5.1.15 shall apply to existing health care facilities.

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

5.1.2 Nature of Hazards of Gas and Vacuum Systems. Potential fire and explosion hazards associated with positive pressure gas central piping systems and medical-surgical vacuum systems shall be considered in the design, installation, testing, operation, and maintenance of these systems.

5.1.3* Category 1 Sources.

5.1.3.1 Central Supply System Identification and Labeling.

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

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

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

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

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

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

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

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

**Positive Pressure Gases
NO Smoking or Open Flame
Room May Have Insufficient Oxygen
Open Door and Allow Room to
Ventilate Before Entering**

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

**Medical Gases
NO Smoking or Open Flame**

5.1.3.2 Central Supply System Operations.

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

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

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

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

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

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

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

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

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

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

5.1.3.2.11 Containers shall not be stored in a tightly closed space.

5.1.3.3* Central Supply System Locations.

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

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

- (1) Manifolds for gas cylinders without reserve supply (*see 5.1.3.5.10*)
- (2) Manifolds for gas cylinders with reserve supply
- (3) Manifolds for cryogenic liquid containers (*see 5.1.3.5.12*)
- (4) Bulk cryogenic liquid systems (*see 5.1.3.5.13*)

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

- (1) Manifolds for gas cylinders without reserve supply (*see 5.1.3.5.10*)
- (2) Manifolds for gas cylinders with reserve supply
- (3) Manifolds for cryogenic liquid containers (*see 5.1.3.5.12*)
- (4) In-building emergency reserves (*see 5.1.3.5.14*)
- (5) Instrument air standby headers (*see 5.1.3.9.5*)

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

- (1) Medical air compressor supply sources (*see 5.1.3.6.3*)
- (2) Medical-surgical vacuum sources (*see 5.1.3.7*)
- (3) Waste anesthetic gas disposal (WAGD) sources (*see 5.1.3.8*)
- (4) Instrument air compressor sources (*see 5.1.3.9*)
- (5) Any other compressor, vacuum pump, or electrically powered machinery

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

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

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

- (1) Areas involved in critical patient care
- (2) Anesthetizing locations where moderate sedation, deep sedation, or general anesthesia is administered
- (3) Locations storing flammables
- (4) Rooms containing open electrical contacts or transformers
- (5) Storage tanks for flammable or combustible liquids
- (6) Engines
- (7) Kitchens
- (8) Areas with open flames

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

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

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

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

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

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



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

5.1.3.3.2* Design and Construction. Locations for central supply systems and the storage of positive-pressure gases shall meet the following requirements:

- (1) They shall be constructed with access to move cylinders, equipment, and so forth, in and out of the location on hand trucks complying with 11.4.3.1.1.
- (2) They shall be secured with lockable doors or gates or otherwise secured.
- (3) If outdoors, they shall be provided with an enclosure (wall or fencing) constructed of noncombustible materials with a minimum of two entry/exits.
- (4) If indoors, they shall be constructed and use interior finishes of noncombustible or limited-combustible materials such that all walls, floors, ceilings, and doors are of a minimum 1-hour fire resistance rating.
- (5)*They shall be compliant with *NFPA 70, National Electrical Code*, for ordinary locations.
- (6) They shall be heated by indirect means (e.g., steam, hot water) if heat is required.
- (7) They shall be provided with racks, chains, or other fastenings to secure all cylinders from falling, whether connected, unconnected, full, or empty.
- (8)*They shall be supplied with electrical power compliant with the requirements for essential electrical systems as described in Chapter 6.
- (9) They shall have racks, shelves, and supports, where provided, constructed of noncombustible materials or limited-combustible materials.
- (10) They shall protect electrical devices from physical damage.

5.1.3.3.3 Ventilation.

5.1.3.3.3.1 Venting of Relief Valves. Indoor supply systems shall have all relief valves vented per 5.1.3.5.6.1 (4) through (9).

5.1.3.3.3.2 Ventilation for Motor-Driven Equipment. The following source locations shall be adequately ventilated to prevent accumulation of heat:

- (1) Medical air sources (*see 5.1.3.6*)
- (2) Medical-surgical vacuum sources (*see 5.1.3.7*)
- (3) Waste anesthetic gas disposal (WAGD) sources (*see 5.1.3.8.1*)
- (4) Instrument air sources (*see 5.1.3.9*)

5.1.3.3.3.3 Ventilation for Outdoor Locations.

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

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

5.1.3.3.4 Storage.

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

5.1.3.3.4.2 Cylinders, whether full or empty, shall not be stored in enclosures containing motor-driven machinery, with the exception of cylinders intended for instrument air reserve headers complying with 5.1.3.9.5, which shall be permitted to be placed

in the same location containing an instrument air compressor when it is the only motor-driven machinery located within the room. Only cylinders intended for instrument air reserve headers complying with 5.1.3.9.5 shall be permitted to be stored in enclosures containing instrument air compressors.

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

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

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

5.1.3.5* Central Supply Systems. Central supply systems shall be permitted to consist of the following:

- (1) Cylinder manifolds for gas cylinders per 5.1.3.5.10
- (2) Manifolds for cryogenic liquid containers per 5.1.3.5.12
- (3) Bulk cryogenic liquid systems per 5.1.3.5.13
- (4) Medical air compressor systems per 5.1.3.6
- (5) Medical-surgical vacuum producers per 5.1.3.7
- (6) WAGD producers per 5.1.3.8
- (7) Instrument air compressor systems per 5.1.3.9
- (8) Proportioning systems for medical air USP per 5.1.3.6.3.4

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

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

- (1) Direct respiration by patients
- (2) Clinical application of the gas to a patient, such as the use of an insufflator to inject carbon dioxide into patient body cavities during laparoscopic surgery and carbon dioxide used to purge heart-lung machine blood flow ways
- (3) Medical device applications directly related to respiration
- (4) Power for medical devices used directly on patients
- (5) Calibration of medical devices intended for (1) through (4)

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

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

- (1) In those portions of systems intended to handle oxygen at gauge pressures greater than 2413 kPa (350 psi), interconnecting hose shall contain no polymeric materials.
- (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 in the containment and use of oxygen, nitrous oxide, mixtures of these gases, or mixtures containing more than 23.5 percent oxygen.
- (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.

5.1.3.5.5 Final Line Pressure Regulators.

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

- (1) They shall be provided with isolation valves on the source side of each regulator.
- (2) They shall be provided with isolation or check valves on the patient side of each regulator.
- (3) A pressure indicator(s) shall be located downstream (patient or use side) of each regulator or immediately downstream of the isolating valves for the regulators.
- (4) They shall be piped to allow either regulator to be serviced without interrupting supply.
- (5) Each regulator shall be sized for 100 percent of the peak calculated demand.
- (6) They shall be constructed of materials deemed suitable by the manufacturer.

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

5.1.3.5.6 Relief Valves.

5.1.3.5.6.1 All pressure relief valves shall meet the following requirements:

- (1) They shall be of brass, bronze, or stainless steel construction.
- (2) They shall be designed for the specific gas service.
- (3) They shall have a relief pressure setting not higher than the maximum allowable working pressure (MAWP) of the component with the lowest working pressure rating in the portion of the system being protected.
- (4) They shall be vented to the outside of the building, except that relief valves for compressed air systems having less than 84,950 L (3000 ft³) at STP shall be permitted to be diffused locally by means that will not restrict the flow.
- (5) They shall have a vent discharge line that is not smaller than the size of the relief valve outlet.
- (6) Where two or more relief valves discharge into a common vent line, its internal cross-sectional area shall be not less than the aggregate cross-sectional area of all relief valve vent discharge lines served.
- (7) They shall not discharge into locations creating potential hazards.
- (8) They shall have the discharge terminal turned down and screened to prevent the entry of rain, snow, or vermin.
- (9) They shall be designed in accordance with ASME B31.3, *Pressure Process Piping*.

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

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

- (1) They shall be located between each final line regulator and the source valve.
- (2) They shall have a relief setting that is 50 percent above the normal system operating pressure, as indicated in Table 5.1.11.

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

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

- (1) Medical air compressor systems: 5.1.3.5.9 (pressure regulators) and 5.1.9.2.4(7) (master alarm)
- (2) All central supply systems: 5.1.3.5.5 (pressure regulators), 5.1.3.5.6 (relief valves), 5.1.4.4 (source valve), and 5.1.9.2.4(7) (master alarm)

5.1.3.5.8 Local Signals.

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

- (1) Manifolds for gas cylinders without reserve supply (see 5.1.3.5.10)
- (2) Manifolds for gas cylinders with reserve supply
- (3) Manifolds for cryogenic liquid containers (see 5.1.3.5.12)
- (4) Bulk cryogenic liquid systems (see 5.1.3.5.13)
- (5) In-building emergency reserves (see 5.1.3.5.14)
- (6) Instrument air headers (see 5.1.3.5.9)

5.1.3.5.8.2 The local signals shall meet the following requirements:

- (1) Provision of visual indication only
- (2) Labeling for the service and condition being monitored
- (3) If intended for outdoor installation, be installed per manufacturer's requirements

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

- (1)*Cylinder connections in the number required for the header's application
- (2) Cylinder lead for each cylinder constructed of materials complying with 5.1.3.5.4 and provided with end fittings permanently attached to the cylinder lead complying with CGA V-1, *Compressed Gas Association Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections* (ANSI B57.1)
- (3) Filter of a material complying with 5.1.3.5.4 to prevent the intrusion of debris into the manifold controls
- (4) Header shutoff valve downstream of the nearest cylinder connection, but upstream of the point at which the header connects to the central supply system
- (5) Pressure indicator indicating the pressure of header contents
- (6) Check valve to prevent backflow into the header and to allow service to the header
- (7) If intended for gas cylinder service, a check valve at each connection for the cylinder lead in 5.1.3.5.9(2) to prevent loss of gas in the event of damage to the cylinder lead or operation of an individual cylinder relief valve
- (8) If intended for gas cylinder service, a pressure regulator to reduce the cylinder pressure to an intermediate pressure to allow the proper operation of the primary and secondary headers
- (9) If intended for service with cryogenic liquid containers, a pressure relief valve
- (10) Vent valves, if fitted on a header, vented outside of the building per 5.1.3.5.6.1(5) through 5.1.3.5.6.1(9) and 5.1.3.5.6.2

5.1.3.5.10* Manifolds for Gas Cylinders Without Reserve Supply.



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

- (1) If located outdoors, they shall be installed in an enclosure used only for this purpose and sited to comply with minimum distance requirements in NFPA 55.
- (2) If located indoors, they shall be installed within a room used only for enclosure of such manifolds.

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

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

5.1.3.5.10.4 The manifolds in this category shall consist of the following:

- (1) Two equal headers in accordance with 5.1.3.5.9, each with a sufficient number of gas cylinder connections for an average day's supply, but not fewer than two connections, and with the headers connected to the final line pressure regulator assembly in such a manner that either header can supply the system
- (2) Vent valves, if fitted on a header, vented outside of the building per 5.1.3.5.6.1(5) through (9) and 5.1.3.5.6.2
- (3) Intermediate relief valve(s), piped to the outside in accordance with 5.1.3.5.6.1(5) through (9), that protects the piping between the header pressure regulator and the line pressure regulator assembly, and protects the line pressure regulators from overpressure in the event of a header regulator failure

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

- (1) One header is the primary and the other is the secondary, with either being capable of either role.
- (2) When the primary header is supplying the system, the secondary header is prevented from supplying the system.
- (3) When the primary header is depleted, the secondary header automatically begins to supply the system.

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

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

5.1.3.5.11* Manifolds for Cryogenic Liquid Containers.

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

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

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

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

5.1.3.5.11.4 The manifolds in this category shall consist of the following:

- (1) Two equal headers per 5.1.3.5.9, each having sufficient number of liquid container connections for an average day's supply, and with the headers connected to the final line pressure regulator assembly in such a manner that either header can supply the system
- (2) Reserve header per 5.1.3.5.9 having sufficient number of gas cylinder connections for an average day's supply, but not fewer than three connections, and connected downstream of the primary/secondary headers and upstream of the final line pressure regulators
- (3) Pressure relief installed downstream of the connection of the reserve header and upstream of the final line pressure regulating assembly and set at 50 percent above the nominal inlet pressure

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

- (1) If provided with two liquid container headers, one cryogenic liquid header is the primary and the other is the secondary, with either being capable of either role.
- (2) If provided with one liquid container header and one gas cylinder header (a hybrid arrangement), the liquid container header is the primary and the gas cylinder header is the secondary.
- (3) When the primary header is supplying the system, the secondary header is prevented from supplying the system.
- (4) When the primary header is depleted, the secondary header automatically begins to supply the system.

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

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

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

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

- (1) When or at a predetermined set point before the secondary header begins to supply the system, indicating changeover
- (2) Where a hybrid arrangement is employed, when or at a predetermined set point before the secondary (cylinder) header contents fall to one day's average supply, indicating secondary low
- (3) When or at a predetermined set point before the reserve header begins to supply the system, indicating reserve is in use
- (4) When or at a predetermined set point before the reserve header contents fall to one day's average supply, indicating reserve low

5.1.3.5.12* Bulk Cryogenic Liquid Systems.

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

5.1.3.5.12.2 Bulk cryogenic liquid systems shall have the following protections:

- (1) Be installed in accordance with NFPA 55, *Compressed Gases and Cryogenic Fluids Code*
- (2) Meet the requirements of 5.1.3.3.2(1)
- (3) Meet the requirements of 5.1.3.3.2(8)
- (4) Meet the requirements of 5.1.3.3.2(10)
- (5) Be installed meeting the requirements in 5.1.10.1 through 5.1.10.4.7
- (6) Have a minimum work space clearance of 3 ft (1 m) around the storage container, vaporizer(s), and the cabinet opening or front side of the pressure regulating manifold for system maintenance and operation

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

- (1) When the main supply is supplying the system, the reserve supply shall be prevented from supplying the system until the main supply is reduced to a level at or below the reserve activation pressure.
- (2) When the main supply cannot supply the system, the reserve supply shall automatically begin to supply the system.
- (3) Where there is more than one main supply vessel, the system shall operate as described in 5.1.3.5.11 for primary, secondary, and reserve operation.
- (4) Where there are two or more cryogenic vessels, they shall be permitted to alternate (e.g., on a timed basis) in the roles of primary, secondary, and reserve, provided that an operating cascade (primary–secondary–reserve) as required in 5.1.3.5.11.4 is maintained at all times.
- (5) Where a cryogenic vessel is used as the reserve, the reserve vessel shall include a means to conserve the gas produced by evaporation of the cryogenic liquid in the reserve vessel and to discharge the gas into the line upstream of the final line regulator assembly as required by 5.1.3.5.11.6.

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

- (1) When or at a predetermined set point before the main supply reaches an average day's supply, indicating low contents
- (2) When or at a predetermined set point before the reserve supply begins to supply the system, indicating reserve is in use
- (3) When or at a predetermined set point before the reserve supply contents fall to one day's average supply, indicating reserve low
- (4) If the reserve is a cryogenic vessel, when or at a predetermined set point before the reserve internal pressure falls too low for the reserve to operate properly, indicating reserve failure
- (5) Where there is more than one main supply vessel, when or at a predetermined set point before the secondary vessel begins to supply the system, indicating changeover

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

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

- (2) There is no connected oxygen reserve sufficient for an average day's supply within the building. (*see 5.1.3.5.14 for requirements for such reserves*).
- (3) Multiple freestanding buildings are served from a single oxygen source such that damage to the interconnecting oxygen line could result in one or more buildings losing oxygen supply, in which case each building is required to be provided with a separate emergency connection.

5.1.3.5.13.1 EOSCs shall be located as follows:

- (1) Located on the exterior of the building being served in a location accessible by emergency supply vehicles at all times in all weather conditions
- (2) Connected to the main supply line immediately downstream of the main shutoff valve

5.1.3.5.13.2 EOSCs shall consist of the following:

- (1) Physical protection to prevent unauthorized tampering
- (2) Female DN (NPS) inlet for connection of the emergency oxygen source that is sized for 100 percent of the system demand at the emergency source gas pressure
- (3) Manual shutoff valve to isolate the EOSC when not in use
- (4) Two check valves, one downstream of the EOSC and one downstream of the main line shutoff valve, with both upstream from the tee connection for the two pipelines
- (5) Relief valve sized to protect the downstream piping system and related equipment from exposure to pressures in excess of 50 percent higher than normal line pressure
- (6) Any valves necessary to allow connection of an emergency supply of oxygen and isolation of the piping to the normal source of supply
- (7) Minimum of 1 m (3 ft) of clearance around the EOSC for connection of temporary auxiliary source

5.1.3.5.14 In-Building Emergency Reserves.

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

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

- (1) In a room or enclosure constructed per 5.1.3.3.2
- (2) In a room or enclosure ventilated per 5.1.3.3.3

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

- (1) Gas cylinder header per 5.1.3.5.9 with sufficient cylinder connections to provide for at least an average day's supply with the appropriate number of connections being determined after consideration of the delivery schedule, the proximity of the facility to alternate supplies, and the facility's emergency plan
- (2) Manifold for gas cylinders complying with 5.1.3.5.10

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

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



5.1.3.6* Category 1 Medical Air Supply Systems.

5.1.3.6.1* Quality of Medical Air. Medical air shall be required to have the following characteristics:

- (1) It shall be supplied from cylinders, bulk containers, or medical air compressor sources, or it shall be reconstituted from oxygen USP and oil-free, dry nitrogen NF.
- (2) It shall meet the requirements of medical air USP.
- (3) It shall have no detectable liquid hydrocarbons.
- (4) It shall have less than 25 ppm gaseous hydrocarbons.
- (5) It shall have equal to or less than 1 mg/m³ (6.85×10^{-7} lb/yd³) of permanent particulates sized 1 micron or larger in the air at normal atmospheric pressure.

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

5.1.3.6.3* Medical Air Compressor Sources.

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

- (1) Indoors in a dedicated mechanical equipment area, adequately ventilated and with any required utilities (e.g., electricity, drains, lighting)
- (2) In a room ventilated per 5.1.3.3.2
- (3) For air-cooled equipment, in a room designed to maintain the ambient temperature range as recommended by the manufacturer

5.1.3.6.3.2 Required Components. Medical air compressor systems shall consist of the following:

- (1) Components complying with 5.1.3.6.3.4 through 5.1.3.6.3.9, arranged per 5.1.3.6.3.10
- (2) Automatic means to prevent backflow from all on-cycle compressors through all off-cycle compressors
- (3) Manual shutoff valve to isolate each compressor from the centrally piped system and from other compressors for maintenance or repair without loss of pressure in the system
- (4) Intake filter-muffler(s) of the dry type
- (5) Pressure relief valve(s) set at 50 percent above line pressure
- (6) Piping and components between the compressor and the source shutoff valve that do not contribute to contaminant levels
- (7) Except as defined in 5.1.3.6.3.2(1) through (6), materials and devices used between the medical air intake and the medical air source valve that are of any design or construction appropriate for the service as determined by the manufacturer

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

5.1.3.6.3.4 Compressors for Medical Air.

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

- (1) Elimination of oil anywhere in the compressor (e.g., liquid ring and permanently sealed bearing compressors)
- (2) Reciprocating compressors provided with a separation of the oil-containing section from the compression chamber by at least two seals creating an area open to atmosphere that allows the following:

- (a) Direct and unobstructed visual inspection of the interconnecting shaft through vent and inspection openings no smaller than 1.5 shaft diameters in size
 - (b) Confirmation by the facility operators of proper seal operation by direct visual inspection through the above-shaft opening, without disassembly of the compressor (e.g., extended head compressors with an atmospheric vent between the compression chamber and the crankcase)
- (3) Rotating element compressors provided with a compression chamber free of oil that provide the following:
- (a) Separation of each oil-containing section from the compression chamber by at least one seal having atmospheric vents on each side with the vent closest to the oil-containing section supplied with a gravity drain to atmosphere
 - (b) Unobstructed visualization of the atmospheric vent(s), closest to each oil-containing section, that is accessible for inspection without disassembling the compressor
 - (c) Entry of the rotating shaft into each compression chamber at a point that is above atmospheric pressure
 - (d) Confirmation by the facility operators of proper seal operation by direct visual inspection of the atmospheric vents

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

(C) Liquid ring compressors shall comply with the following:

- (1) Service water and seal water of a quality recommended by the compressor manufacturer shall be used.
- (2) Reserve medical air standby headers or a backup compressor shall be installed.
- (3) When installed, the header shall comply with 5.1.3.5.9.
- (4) When installed, the number of attached cylinders shall be sufficient for 1 hour normal operation.

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

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

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

5.1.3.6.3.5 Aftercoolers.

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

(B) The receiver shall not be used as an aftercooler or aftercooler trap.

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

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

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

- (1) They shall be made of corrosion-resistant materials or otherwise be made corrosion resistant.
- (2) They shall comply with Section VIII, "Unfired Pressure Vessels," of the ASME *Boiler and Pressure Vessel Code*.

- (3) They shall be equipped with a pressure relief valve, automatic drain, manual drain, sight glass, and pressure indicator.
- (4) They shall be of a capacity sufficient to prevent the compressors from short-cycling.

5.1.3.6.3.7 Medical Air Dryers. Medical air dryers shall meet the following requirements:

- (1) They shall be designed to provide air at a maximum dew point that is below the frost point [0°C (32°F)] at 345 kPa to 380 kPa (50 psi to 55 psi) at any level of demand.
- (2) They shall be sized for 100 percent of the system peak calculated demand at design conditions.
- (3) They shall be constructed of materials deemed suitable by the manufacturer.
- (4) They shall be provided with antivibration mountings installed as required by equipment dynamics or location and in accordance with the manufacturer's recommendations.

5.1.3.6.3.8 Medical Air Filters. Medical air filters shall meet the following requirements:

- (1) They shall be appropriate for the intake air conditions.
- (2) They shall be located upstream (source side) of the final line regulators.
- (3) They shall be sized for 100 percent of the system peak calculated demand at design conditions and be rated for a minimum of 98 percent efficiency at 1 micron or greater.
- (4) They shall be equipped with a continuous visual indicator showing the status of the filter element life.
- (5) They shall be constructed of materials deemed suitable by the manufacturer.

5.1.3.6.3.9* Medical Air Local Alarm. A local alarm complying with 5.1.9.5 shall be provided for the medical air compressor source.

5.1.3.6.3.10 Piping Arrangement and Redundancies.

- (A) Component arrangement shall be as follows:
 - (1) Components shall be arranged to allow service and a continuous supply of medical air in the event of a single fault failure.
 - (2) Component arrangement shall be permitted to vary as required by the technology(ies) employed, provided that an equal level of operating redundancy and medical air quality is maintained.
- (B) Medical air compressors shall be sufficient to serve the peak calculated demand with the largest single compressor out of service. In no case shall there be fewer than two compressors.
- (C) When aftercoolers are provided, they shall be arranged to meet either one of the following:
 - (1) Arranged as a duplex or multiplex set, sized to serve the peak calculated demand with the largest single aftercooler out of service, and provided with valves adequate, to isolate any single aftercooler from the system without shutting down supply of medical air
 - (2) Arranged one per compressor, sized to handle the output of that compressor, and valved as appropriate to allow repair or replacement with that compressor out of service but without shutting down supply of medical air

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

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

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

- (1) They shall be installed for each component, upstream and downstream of each component, allowing each to be individually isolated.
- (2) They shall be installed upstream (source side) and downstream of components in series so as to create redundant parallel branches of components.

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

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

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

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

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

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

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

5.1.3.6.3.11 Electrical Power and Control.

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

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

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

- (1) Dedicated disconnect switch installed in the electrical circuit ahead of each motor starter
- (2) Motor starting device
- (3) Overload protection

- (4) Where compressor systems having two or more compressors employ a control transformer or other voltage control power device, installation of at least two such devices.
- (5) Control circuits arranged in such a manner that the shut-down of one compressor does not interrupt the operation of another compressor
- (6) Automatic restart function, such that the compressor(s) will restart after power interruption without manual intervention

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

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

5.1.3.6.3.12 Compressor Intake.

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

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

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

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

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

- (1) This alternate source of supply air shall be available on a continuous 24-hour-per-day, 7-day-per-week basis.
- (2) Ventilating systems having fans with motors or drive belts located in the airstream shall not be used as a source of medical air intake.

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

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

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

(H) The end of the intake shall be turned down and screened or otherwise be protected against the entry of vermin, debris, or precipitation by screening fabricated or composed of a noncorroding material.

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

(A) Where liquid ring air compressors, compressors having water-cooled heads, or water-cooled aftercoolers are used, air

receivers shall be equipped with a high water level sensor that shuts down the compressor system and activates a local alarm indicator. [See 5.1.9.5.4(7).]

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

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

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

- (1) The air temperature at the immediate outlet of each compressor chamber shall be monitored by a high-temperature sensor that shuts down that compressor and activates a local alarm indicator [see 5.1.9.5.4], the temperature setting shall be as recommended by the compressor manufacturer.
- (2) Coalescing filters with element change indicator shall be provided.
- (3) Charcoal absorber shall be provided.
- (4) Gaseous hydrocarbons shall be monitored on a quarterly basis.

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

5.1.3.6.3.14 Medical Air Quality Monitoring. Medical air quality shall be monitored downstream of the medical air regulators and upstream of the piping system as follows:

- (1) Dew point shall be monitored and shall activate a local alarm and all master alarms when the dew point at system delivery pressure exceeds +2°C (+35°F).
- (2) Carbon monoxide shall be monitored and shall activate a local alarm when the CO level exceeds 10 ppm. [See 5.1.9.5.4(2).]
- (3) Dew point and carbon monoxide monitors shall activate their individual monitor's signal at the alarm panels where their signals are required when their power is lost.

5.1.3.6.3.15 Category 1 Medical Air Proportioning System.

(A) General.

- (1) Medical air reconstituted from oxygen USP and nitrogen NF, produced using proportioning system(s), shall be required to meet the following:
 - (a) The quality of medical air shall be in accordance with 5.1.3.6.1.
 - (b) The system shall be capable of supplying this quality of medical air, per 5.1.3.5.1, over the entire range of flow.
 - (c) The system shall produce medical air with an oxygen content of 19.5 percent to 23.5 percent.
 - (d) The medical air shall be cleared for marketing by the FDA or approved by the FDA.
- (2) The medical air proportioning system shall operate automatically.
- (3) The mixture shall be analyzed continuously, and a recording capability shall be provided (e.g., via data port).

- (4) The analyzing system specified in 5.1.3.6.3.15(A)(3) shall be a dedicated and an independent analyzer used to control the medical air proportioning system.
- (5) If the mixture goes out of specification, an alarm shall be activated automatically, the primary medical air proportioning system shall be disconnected, and the reserve supply shall be activated.
- (6) The system shall be arranged such that manual intervention is necessary to correct the composition of the mixture before reconnecting the medical air proportioning system to the health care facility pipeline system.
- (7) If dedicated sources of oxygen USP and nitrogen NF supply the medical air proportioning system, reserve sources for the oxygen and nitrogen shall not be required.
- (8) If dedicated sources of oxygen USP and nitrogen NF supply the medical air proportioning system, they shall not be used as the reserves for oxygen and nitrogen systems supplying the pipelines of the health care facility.
- (9)*If the sources of oxygen USP and nitrogen NF that supply the medical air proportioning system are the same sources that supply the health care facility, engineering controls shall be provided to prevent cross contamination of oxygen and nitrogen supply lines, as provided in 5.1.3.5.7.
- (10) A risk analysis and approval from the authority having jurisdiction shall be required.

(B) Location. The medical air proportioning system shall be located per 5.1.3.3 as follows:

- (1) The medical air proportioning system's supply of oxygen USP and nitrogen NF shall be located per 5.1.3.3 and NFPA 55, as applicable.
- (2) The mixing device and controls, analyzers, and receivers shall be located indoors within a room or area per 5.1.3.3.1.
- (3) The indoor location shall include atmospheric monitoring for oxygen concentration.
- (4) The indoor location shall be constructed with all required utilities (e.g., electricity, drains, lighting) per *NFPA 5000*.
- (5) The indoor location shall be ventilated and heated per Chapter 9 and the manufacturer's recommendations.

(C) Required Components. The medical air proportioning system shall consist of the following:

- (1) Supply of oxygen USP and supply of nitrogen NF as follows:
 - (a) The supply lines shall be filtered to remove particulate entering the proportioning system.
 - (b) The minimum safe supply gas temperature and recommended local signal shall be specified by the medical air proportioning system manufacturer.
- (2) Mixing device with analyzers and engineering controls per manufacturer's recommendations to include, as a minimum, the following:
 - (a) At least two oxygen analyzers capable of independently monitoring oxygen concentration
 - (b) Mechanism where each analyzer based upon nonconforming oxygen concentration is capable, directly or via other medical air proportioning system controls, of automatically shutting off the supply from the medical air proportioning system to the medical air piped distribution system and activating the reserve supply
 - (c) Mechanism where each analyzer, based upon nonconforming oxygen concentration, is capable, directly or via other proportioning system controls, of automatically shutting off the supply of oxygen and

nitrogen to the proportioning system and activating the reserve supply

- (d) Provision for manual resetting of the proportioning system after detection of nonconforming oxygen concentration and subsequent shutdown once conforming oxygen concentration is established, in order to re-establish flow to the medical air piping system
- (e) Means of verifying the performance of the analyzers by reference to an air standard, with known traceable oxygen content
- (3) Minimum of one recorder for recording the medical air proportioning system performance and air quality for a period of not less than 24 hours
- (4) Continuous analysis of the mixture and a recording capability provided (e.g., via a data port)
- (5) Mechanism for isolating the primary medical air proportioning system from the reserve supply and the medical air piping distribution system by employing sequential valves for redundancy
- (6) Capability of the reserve supply to automatically activate if the primary supply is isolated
- (7) Reserve supply of medical air USP sized, at minimum, for an average day's supply and consisting of one of the following:
 - (a) Additional medical air proportioning unit with a dedicated supply of oxygen USP and nitrogen NF
 - (b) Medical air compressor system per 5.1.3.5.10, with the exception of the allowance of a simplex medical air compressor system
 - (c) Medical air cylinder manifold per 5.1.3.5.10
- (8) Receiver fitted with a pressure relief valve and pressure gauge as follows:
 - (a) The receiver shall be constructed of corrosion-resistant materials.
 - (b) The receiver, relief valves, and pressure gauges shall comply with ASME *Boiler and Vessel Code* and manufacturer's recommendations.
- (9)*Warning systems per 5.1.9, including a local signal and master alarm that indicates nonconforming oxygen concentration per manufacturer's recommendations
- (10) Final line pressure regulators complying with 5.1.3.5.5
- (11) Pressure relief complying with 5.1.3.5.6
- (12) Local signals complying with 5.1.3.5.8.2

5.1.3.7* Medical-Surgical Vacuum Supply Systems.

5.1.3.7.1 Medical-Surgical Vacuum Sources.

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

- (1) Indoors in a dedicated mechanical equipment area, adequately ventilated and with any required utilities
- (2) In a room ventilated per 5.1.3.3.3.2
- (3) For air-cooled equipment, in a room designed to maintain the ambient temperature range as recommended by the equipment manufacturer

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

- (1) Two or more vacuum pumps sufficient to serve the peak calculated demand with the largest single vacuum pump out of service
- (2) Automatic means to prevent backflow from any on-cycle vacuum pumps through any off-cycle vacuum pumps



- (3) Shutoff valve or other isolation means to isolate each vacuum pump from the centrally piped system and other vacuum pumps for maintenance or repair without loss of vacuum in the system
- (4) Vacuum receiver
- (5) Piping between the vacuum pump(s), discharge(s), receiver(s), and vacuum source shutoff valve in accordance with 5.1.10.2, except brass, galvanized, or black steel pipe, which is permitted to be used as recommended by the manufacturer
- (6) Except as defined in 5.1.3.7.1.2(1) through (5), materials and devices used between the medical vacuum exhaust and the medical vacuum source that are permitted to be of any design or construction appropriate for the service as determined by the manufacturer

5.1.3.7.2 Vacuum Pumps.

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

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

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

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

5.1.3.7.3 Vacuum Receivers. Receivers for vacuum shall meet the following requirements:

- (1) They shall be made of materials deemed suitable by the manufacturer.
- (2) They shall comply with Section VIII, "Unfired Pressure Vessels," of the ASME *Boiler and Pressure Vessel Code*.
- (3) They shall be capable of withstanding a gauge pressure of 415 kPa (60 psi) and 760 mm (30 in.) gauge HgV.
- (4) They shall be equipped with a manual drain.
- (5) They shall be of a capacity based on the technology of the pumps.

5.1.3.7.4 Vacuum Local Alarm. A local alarm complying with 5.1.9.5 shall be provided for the vacuum source.

5.1.3.7.5 Piping Arrangement and Redundancies.

5.1.3.7.5.1 Piping arrangement shall be as follows:

- (1) Piping shall be arranged to allow service and a continuous supply of medical-surgical vacuum in the event of a single fault failure.
- (2) Piping arrangement shall be permitted to vary based on the technology(ies) employed, provided that an equal level of operating redundancy is maintained.
- (3) Where only one set of vacuum pumps is available for a combined medical-surgical vacuum system and an analysis, a research, or a teaching laboratory vacuum system, such laboratories shall be connected separately from the medical-surgical system directly to the receiver tank through its own isolation valve and fluid trap located at the receiver, and between the isolation valve and fluid trap, a scrubber shall be permitted to be installed.

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

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

5.1.3.7.6 Electrical Power and Control.

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

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

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

- (1) Dedicated disconnect switch installed in the electrical circuit ahead of each motor starter
- (2) Motor starting device
- (3) Overload protection
- (4) Where pump systems having two or more pumps employ a control transformer or other voltage control power device, at least two such devices
- (5) Control circuits arranged in such a manner that the shutdown of one pump does not interrupt the operation of another pump
- (6) Automatic restart function such that the pump(s) will restart after power interruption without manual intervention

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

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

5.1.3.7.7 Medical-Surgical Vacuum Source Exhaust.

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

5.1.3.7.7.2 The exhaust shall be located as follows:

- (1) Outdoors
- (2) At least 3.05 m (10 ft) from any door, window, air intake, or other openings in buildings or places of public assembly
- (3) At a level different from air intakes
- (4) Where prevailing winds, adjacent buildings, topography, or other influences will not divert the exhaust into occupied areas or prevent dispersion of the exhaust

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

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

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

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

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

5.1.3.8* Waste Anesthetic Gas Disposal (WAGD).

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

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

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

- (1) The medical–surgical vacuum source shall comply with 5.1.3.7.
- (2) The total concentration of oxidizers (oxygen and nitrous oxide) shall be maintained below 23.6 percent, or the vacuum pump shall comply with 5.1.3.8.2.1.
- (3) The medical–surgical vacuum source shall be sized to accommodate the additional volume.

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

- (1) The WAGD source shall be located in accordance with 5.1.3.3.
- (2) The WAGD source shall be located indoors in a dedicated mechanical equipment area with any required utilities.
- (3) The WAGD source shall be ventilated per 5.1.3.3.3.2.
- (4) For air-cooled equipment, the WAGD source shall be located to maintain the ambient temperature range as recommended by the manufacturer.
- (5) The WAGD producers shall comply with 5.1.3.8.2.

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

- (1) The WAGD source shall be permitted to be located near the inlet(s) served.
- (2) For air-cooled equipment, the WAGD source shall be located to maintain the ambient temperature range as recommended by the manufacturer.

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

5.1.3.8.1.6 The WAGD source shall consist of the following:

- (1) Two or more WAGD producers sufficient to serve the peak calculated demand with the largest single WAGD producer out of service
- (2) Automatic means to prevent backflow from any on-cycle WAGD producers through any off-cycle WAGD producers
- (3) Shutoff valve to isolate each WAGD producer from the centrally piped system and other WAGD producers for maintenance or repair without loss of medical–surgical vacuum in the system
- (4) Piping between the WAGD producers and the source shutoff valve compliant with 5.1.10.2, as recommended by the manufacturer
- (5) Antivibration mountings installed for WAGD producers as required by equipment dynamics or location and in accordance with the manufacturer's recommendations

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

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

- (1) The venturi shall not be user-adjustable (i.e., require the use of special tools).
- (2) The venturi shall be driven using water, inert gas, instrument air, or other dedicated air source.
- (3) Medical air shall not be used to power the venturi.

5.1.3.8.2 WAGD Producers.

5.1.3.8.2.1 Vacuum pumps dedicated for WAGD service shall be as follows:

- (1) Compliant with 5.1.3.7.2
- (2) Designed of materials and using lubricants and sealants that are inert in the presence of oxygen, nitrous oxide, and halogenated anesthetics

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

- (1) Permitted to be made of any materials determined by the manufacturer as suitable for the service
- (2) Provided with antivibration mountings as required by equipment dynamics or location and in accordance with the manufacturer's recommendation
- (3) Connected with their intake and outlet piping through flexible connections
- (4) Used only for WAGD service and not employed for other services
- (5) Interconnected via piping, ductwork, and so forth, made of materials determined by the manufacturer as suitable to the service

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

5.1.3.8.4 WAGD Alarms.

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

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

5.1.3.8.5 Electrical Power and Control.

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

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

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

- (1) Dedicated disconnect switch installed in the electrical circuit ahead of each motor starter
- (2) Motor starting device
- (3) Overload protection



- (4) Where WAGD systems having two or more producers employ a control transformer or other voltage control power device, at least two such devices
- (5) Control circuits arranged in such a manner that the shut-down of one producer does not interrupt the operation of another producer
- (6) Automatic restart function such that the pump(s) will restart after power interruption without manual intervention

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

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

5.1.3.8.6 WAGD Exhaust. The WAGD pumps shall exhaust in compliance with 5.1.3.7.7.

5.1.3.9* Instrument Air Supply Systems.

5.1.3.9.1 Quality of Instrument Air. The quality of instrument air shall be as follows:

- (1) Compliant with instrument air section in ANSI/ISA S-7.0.01, *Quality Standard for Instrument Air*
- (2) Filtered to 0.01 micron
- (3) Free of liquids (e.g., water, hydrocarbons, solvents)
- (4) Free of hydrocarbon vapors
- (5) Dry to a dew point of -40°C (-40°F)

5.1.3.9.2 General.

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

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

- (1) Indoors, in a dedicated mechanical equipment area that is adequately ventilated and with any required utilities
- (2) In a room ventilated per 5.1.3.3.3.2
- (3) For air-cooled equipment, in a room designed to maintain the ambient temperature range as recommended by the equipment manufacturer

5.1.3.9.2.3 Instrument air systems shall be prohibited from the following:

- (1) Interconnection with medical air systems
- (2) Usage for any purpose where the air will be intentionally respired by patients or staff

5.1.3.9.3 Instrument Air Source.

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

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

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

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

5.1.3.9.4 Instrument Air Compressors. Instrument air compressors shall be permitted to be of any type capable of not less

than a gauge pressure of 1380 kPa (200 psi) output pressure and of providing air meeting the definition of *instrument air* in Chapter 3.

5.1.3.9.5 Instrument Air Standby Headers. Where instrument air systems are provided with a standby header, the header shall meet the following requirements:

- (1) It shall comply with 5.1.3.5.9, except that the number of attached cylinders shall be sufficient for 1 hour normal operation.
- (2) It shall use connectors as for medical air in CGA V-1, *Compressed Gas Association Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections* (ANSI B57.1).
- (3) It shall enter the system upstream (source side) of the final line filters. (See Figure A.5.1.3.9.)
- (4) It shall automatically serve the system in the event of a failure of the compressor.

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

5.1.3.9.7 Instrument Air Filters.

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

- (1) They shall be located upstream (source side) of the final line filters.
- (2) They shall be sized for 100 percent of the system peak calculated demand at design conditions.
- (3) They shall be constructed of materials deemed suitable by the manufacturer.

5.1.3.9.7.2 Final line filters shall meet the following requirements:

- (1) They shall be located upstream (source side) of the final line regulators and downstream of the carbon filters
- (2) They shall be sized for 100 percent of the system peak calculated demand at design conditions.
- (3) They shall be rated for a minimum of 98 percent efficiency at 0.01 micron.
- (4) They shall be equipped with a continuous visual indicator showing the status of the filter element life.
- (5) They shall be constructed of materials deemed suitable by the manufacturer.

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

5.1.3.9.8 Instrument Air Accessories. Accessories used for instrument air sources shall comply with the following subparagraphs:

- (1) 5.1.3.6.3.5 for aftercoolers
- (2) 5.1.3.6.3.6 for air receivers
- (3) 5.1.3.6.3.7 for air dryers
- (4) 5.1.3.5.9 for air regulators

5.1.3.9.9 Instrument Air Piping Arrangement and Redundancies. Instrument air sources shall comply with 5.1.3.6.3.10, except for the following:

- (1) Systems employing a standby header shall be permitted to have simplex aftercoolers and dryers.
- (2) Systems employing a standby header shall not require a three-valve receiver bypass.
- (3) Standby headers, where provided, shall be isolated from the compressor by a check valve to prevent backflow through the compressor.

5.1.3.9.10 Instrument Air Monitoring and Alarms.

5.1.3.9.10.1 Instrument air sources shall include the following alarms:

- (1) Local alarm that activates when or just before the backup compressor (if provided) activates, indicating that the lag compressor is in operation and that must be manually reset
- (2) Local alarm and alarms at all master alarm panels that activate when the dew point at system pressure exceeds -30°C (-22°F), indicating high dew point

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

- (1) Alarm that activates when or just before the reserve begins to supply the system, indicating reserve in use
- (2) Alarm that activates when or just before the reserve falls below an average hour's supply, indicating reserve low

5.1.3.9.11 Electrical Power and Control.

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

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

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

- (1) Dedicated disconnect switch installed in the electrical circuit ahead of each motor starter
- (2) Motor starting device
- (3) Overload protection
- (4) Where compressor systems having two or more compressors employ a control transformer or other voltage control power device, installation of at least two such devices
- (5) Control circuits arranged in such a manner that the shutdown of one compressor does not interrupt the operation of another compressor
- (6) Automatic restart function such that the compressor(s) will restart after power interruption without manual intervention

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

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

5.1.4* Valves.

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

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

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

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

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

5.1.4.3 Valve Types. New or replacement shutoff valves shall be as follows:

- (1) They shall be of the quarter turn, full ported, ball type.
- (2) They shall be of brass or bronze construction.
- (3) They shall have extensions for brazing.
- (4) They shall have a handle indicating open or closed.
- (5) They shall consist of three pieces permitting in-line serviceability.

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

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

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

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

5.1.4.4.2 The source valve shall be labeled in accordance with 5.1.11.2.

5.1.4.5* Main Line Valve. A shutoff valve shall be provided in the main supply line inside of the building, except where one or more of the following conditions exist:

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

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

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

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

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

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

5.1.4.6.2 The riser valve shall be labeled in accordance with 5.1.11.2.



5.1.4.7 Service Valves. Service valves shall be installed to allow servicing or modification of lateral branch piping from a main or riser without shutting down the entire main, riser, or facility.

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

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

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

- (1) Behind a locked access door
- (2) Locked open above a ceiling
- (3) Locked open in a secure area

5.1.4.7.4 Service valves shall be labeled in accordance with 5.1.11.2.

5.1.4.8 Zone Valves. All station outlets/inlets shall be supplied through a zone valve as follows:

- (1) The zone valve shall be placed such that a wall intervenes between the valve and outlets/inlets that it controls.
- (2) The zone valve shall serve only outlets/inlets located on that same story.
- (3) The zone valve shall not be located in a room with station outlets/inlets that it controls.

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

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

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

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

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

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

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

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

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

5.1.4.8.8 Zone valves shall be labeled in accordance with 5.1.11.2.

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

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

- (1) They shall be located in a restricted area.
- (2) They shall be locked or latched open.
- (3) They shall be identified in accordance with 5.1.11.2.

5.1.4.10 Valves for Future Connections. Shutoff valves provided for the connection of future piping shall meet the following requirements:

- (1) They shall be located in a restricted area.
- (2) They shall be locked or latched closed.
- (3) They shall be identified in accordance with 5.1.11.2.

5.1.4.10.1 Future connection valves shall be labeled as to gas content.

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

5.1.4.11 In-Line Check Valves. New or replacement check valves shall be as follows:

- (1) They shall be of brass or bronze construction.
- (2) They shall have brazed extensions.
- (3) They shall have in-line serviceability.
- (4) They shall not have threaded connections.
- (5) They shall have threaded purge points of 1/8 in. NPT.

5.1.5* Station Outlets/Inlets.

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

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

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

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

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

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

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

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

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

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

5.1.5.11 Factory-installed copper inlet tubes on station outlets extending no further than 205 mm (8 in.) from the body of the terminal shall be not less than DN8 (NPS ¼) (⅜ in. O.D.) size, with 8 mm (0.3 in.) minimum inside diameter.

5.1.5.12 Factory-installed copper inlet tubes on station inlets extending no further than 205 mm (8 in.) from the body of the terminal shall be not less than DN10 (NPS ⅜) (½ in. O.D.) size, with 10 mm (0.4 in.) minimum inside diameter.

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

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

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

- (1) They shall be gas-specific.
- (2) They shall be pressure-specific where a single gas is piped at more than one operating pressure [e.g., a station outlet for oxygen at 550 kPa (80 psi) shall not accept an adapter for oxygen at 345 kPa (50 psi)].
- (3) If operated at a pressure in excess of 550 kPa (80 psi), they shall be either D.I.S.S. connectors or comply with 5.1.5.15(4).
- (4) If operated at a gauge pressure between 1380 kPa and 2070 kPa (200 psi and 300 psi), the station outlet shall be designed so as to prevent the removal of the adapter until the pressure has been relieved to prevent the adapter injuring the user or others when removed from the outlet.

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

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

- (1) They shall not be interchangeable with any other systems, including medical-surgical vacuum.
- (2) Components necessary for the maintenance of WAGD specificity shall be legibly marked to identify them as components of a WAGD inlet.
- (3) They shall be of a type appropriate for the flow and vacuum level required by the facility's gas anesthetic machines.
- (4) They shall be located to avoid physical damage to the inlet.

5.1.6* Manufactured Assemblies.

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

- (1) Initial blowdown test per 5.1.12.2.2
- (2) Initial pressure test per 5.1.12.2.3
- (3) Piping purge test per 5.1.12.2.5
- (4) Standing pressure test per 5.1.12.2.6 or 5.1.12.2.7, except as permitted under 5.1.6.2

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

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

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

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

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

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

- (1) They shall be gas-specific connections with positive locking mechanisms that ensure the connector is firmly seated and cannot detach without intentional actuation of the release (e.g., D.I.S.S. connectors).
- (2) In pressure gases, they shall be permitted to omit the secondary valve (or assembly) required in 5.1.5.2.
- (3) In vacuum and WAGD, they shall be permitted to omit both primary and secondary valves (or assemblies) for minimum restriction to flow.
- (4) They shall be provided with a second terminal at which the user connects and disconnects that complies with 5.1.5.

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

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

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

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

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

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

5.1.7.4 MGR assemblies shall be cleaned per 5.1.10.1.1.

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

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

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

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



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

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

5.1.8 Pressure and Vacuum Indicators.

5.1.8.1 General.

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

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

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

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

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

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

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

5.1.8.2 Locations.

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

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

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

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

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

5.1.8.2.4 Demand check fittings shall be provided for all monitors.

5.1.9* Category 1 Warning Systems.

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

- (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 visually indicate a lamp or LED 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) Reinitiation of the audible signal if another alarm condition occurs while the audible alarm is silenced
- (9) Power for master, area alarms, sensors, and switches from the life safety branch of the emergency 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, National Electrical Code*, 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
- (12) Communication devices that do not use electrical wiring for signal transmission will be supervised such that failure of communication shall initiate an alarm.
- (13) 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
- (14) 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
- (15) Alarm switches/sensors installed so as to be removable

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

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

- (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 5.1.9.4.

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

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

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

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

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

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

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

- (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 5.1.9.2.3.2 and 5.1.9.2.3.3 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 through 5.1.9.2.3.5 in all respects.

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

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

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

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

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

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

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

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

5.1.9.3* Area Alarms. Area alarm panels shall be provided to monitor all medical gas, medical-surgical vacuum, and piped WAGD systems supplying the following:

- (1) Anesthetizing locations where moderate sedation, deep sedation, or general anesthesia is administered
- (2)*Critical care areas

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

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

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

5.1.9.3.4 Alarm sensors for area alarms shall be located as follows:

- (1)*Critical care areas 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.

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

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



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

- (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 5.1.9.4.1(1), the power supply for the signaling switches/sensors shall be powered from the life safety branch of the emergency electrical system as described in Chapter 6.
- (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(12).

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

- (1) Medical gas alarms 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), 5.1.9.1(2), 5.1.9.1(3), 5.1.9.1(5), 5.1.9.1(6), and 5.1.9.1(8).

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

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

- (1) On or in the control panel(s) for the machinery 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 medical air compressor system, instrument air compressor system, WAGD system, medical-surgical vacuum pump system, or proportioning system at different locations in the facility, or if the compressors and vacuum

sources are in different locations in the facility, then it shall be necessary for each location to have separate alarms at the master panels.

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

- (1) Backup or lag compressor in operation, to indicate when the primary or lead air compressor is incapable of satisfying the demand of the requirements of the system, except when the medical air system consists of three or more compressors, in which case the backup or lag signal is permitted to energize when the last compressor has been signaled to start
- (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) Backup or lag vacuum pump in operation, to indicate when the primary or lead vacuum pump is incapable of satisfying the demand of the requirements of the system, except when the vacuum pump system consists of three or more pumps, in which case the backup or lag signal is permitted to energize when the last pump has been signaled to start
- (5) When a central dedicated WAGD producer is provided per 5.1.3.8.1.3, WAGD lag in use with the signal to be manually reset
- (6) Instrument air dew point high, to indicate when the line pressure dew point is greater than -30°C (-22°F)
- (7) 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
- (8) For compressor systems using liquid ring compressors, high water in the separators
- (9) For compressor systems using other than liquid ring compressors, high discharge air temperature
- (10) Proportioning systems high/low indicator when the oxygen concentration is outside 19.5 percent to 23.5 percent oxygen
- (11) Proportion systems reserve system in operation

5.1.10 Category 1 Distribution.

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

5.1.10.1.1 Tubes, valves, fittings, station outlets, and other piping components in medical gas systems shall have been cleaned for oxygen service by the manufacturer prior to installation in accordance with CGA G-4.1, *Cleaning Equipment for Oxygen Service*, except that fittings shall be permitted to be cleaned by a supplier or agency other than the manufacturer.

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

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

5.1.10.1.4* Tubes shall be hard-drawn seamless copper in accordance with ASTM B 819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems*, medical gas tube, Type L, except Type K shall be used where operating pressures are above a gauge pressure of 1275 kPa (185 psi) and the pipe sizes are larger than DN80 [NPS 3 (3½ in. O.D.)].

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

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

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

5.1.10.2.1 Tubes for Vacuum. Piping for vacuum systems shall be constructed of any of the following:

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

5.1.10.2.2 Vacuum Tube Marking Where Required.

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

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

5.1.10.2.3 WAGD System Piping. WAGD systems shall be piped as follows:

- (1) Using materials compliant with 5.1.10.2.1 or 5.1.10.2.2
- (2) In systems operated under 130 mm (5 in.) HgV maximum vacuum only, using any noncorroding tube or ductwork

5.1.10.3 Joints.

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

- (1) Brazing, as described in 5.1.10.4
- (2) Welding, as described in 5.1.10.5
- (3) Memory metal fittings, as described in 5.1.10.6
- (4) Axially swaged, elastic preload fittings, as described in 5.1.10.7
- (5) Threaded, as described under 5.1.10.8

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

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

5.1.10.4 Brazed Joints.

5.1.10.4.1 General Requirements.

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

5.1.10.4.1.2 Cast copper alloy fittings shall not be permitted.

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

5.1.10.4.1.4 Brazed tube joints shall be the socket type.

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

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

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

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

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

5.1.10.4.1.10 Braze joints shall be continuously purged with nitrogen NF.

5.1.10.4.2 Cutting Tube Ends.

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

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

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

5.1.10.4.3 Cleaning Joints for Brazing.

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

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

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

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



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

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

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

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

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

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

5.1.10.4.3.11 Other aqueous cleaning solutions shall be permitted to be used for on-site recleaning permitted in 5.1.10.4.3.10, provided that they are as recommended in CGA G-4.1, *Cleaning Equipment for Oxygen Service*, and are listed in CGA O2-DIR, *Directory of Cleaning Agents for Oxygen Service*.

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

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

5.1.10.4.4 Brazing Dissimilar Metals.

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

5.1.10.4.4.2 Surfaces shall be cleaned for brazing in accordance with 5.1.10.4.3.

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

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

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

5.1.10.4.4.6 On joints DN20 (NPS ¾) (⅞ in. O.D.) size and smaller, flux-coated brazing rods shall be permitted to be used in lieu of applying flux to the surfaces being joined.

5.1.10.4.5* Nitrogen Purge.

5.1.10.4.5.1 When brazing, joints shall be continuously purged with oil-free, dry nitrogen NF to prevent the formation of copper oxide on the inside surfaces of the joint.

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

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

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

5.1.10.4.5.5 In order to ensure that all ambient air has been removed from the pipeline prior to brazing, an oxygen analyzer shall be used to verify the effectiveness of the purge. The oxygen analyzer shall read below 1 percent oxygen concentration before brazing begins.

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

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

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

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

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

5.1.10.4.5.11 After a final brazed connection in a positive pressure medical gas pipeline is made without a nitrogen purge, an outlet in the immediate downstream zone of the affected portion(s) of both the new and existing piping shall be tested in accordance with the final tie-in test in 5.1.12.3.9.

5.1.10.4.5.12* When using the autogenous orbital welding process, joints shall be continuously purged inside and outside with inert gas(es) in accordance with the qualified welding procedure.

5.1.10.4.6 Assembling and Heating Brazed Joints.

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

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

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

5.1.10.4.6.4 Techniques for heating the joint, applying the brazing filler metal, and making horizontal, vertical, and large-diameter joints shall be as stated in sections on applying heat and brazing and horizontal and vertical joints in Chapter VII, "Brazed Joints," in the CDA *Copper Tube Handbook*.

5.1.10.4.7 Inspection of Brazed Joints.

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

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

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

5.1.10.4.7.4 Joints exhibiting the following conditions shall not be permitted:

- (1) Flux or flux residue (when flux or flux-coated BAg series rods are used with dissimilar metals)
- (2) Base metal melting or erosion
- (3) Unmelted filler metal
- (4) Failure of the filler metal to be clearly visible all the way around the joint at the interface between the socket and the tube
- (5) Cracks in the tube or component
- (6) Cracks in the braze filler metal
- (7) Failure of the joint to hold the test pressure under the installer-performed initial pressure test (*see 5.1.12.2.3*) and standing pressure test (*see 5.1.12.2.6 or 5.1.12.2.7*)

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

5.1.10.4.7.6 Brazed joints that are identified as defective under the conditions of 5.1.10.4.7.4(1), (3), (4), (6), or (7) shall be permitted to be repaired, except that no joint shall be reheated more than once before being replaced.

5.1.10.5 Welded Joints.

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

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

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

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

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

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

5.1.10.5.1.6 The shield gas shall be as required in 5.1.10.5.1.5.

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

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

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

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

5.1.10.5.2 Welding for Stainless Tube.

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

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

5.1.10.6 Memory Metal Fittings.

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

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

5.1.10.7 Axially Swaged Fittings.

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

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

5.1.10.8 Threaded Fittings. Threaded fittings shall meet the following criteria:

- (1) They shall be limited to connections for pressure and vacuum indicators, alarm devices, check valves, and source equipment on the source side of the source valve.
- (2) They shall be tapered pipe threads complying with ASME B1.20.1, *Pipe Threads, General Purpose, Inch*.
- (3)*They shall be made up with polytetrafluoroethylene tape or other thread sealant recommended for oxygen service, with sealant applied to the male threads only and care taken to ensure sealant does not enter the pipe.

5.1.10.9 Special Fittings.

5.1.10.9.1 Listed or approved metallic gas tube fittings that, when made up, provide a permanent joint having the mechanical, thermal, and sealing integrity of a brazed joint shall be permitted to be used.

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

- (1) They shall be of brass or copper construction with an appropriate dielectric.
- (2) They shall be permitted to be a union.
- (3) They shall be clean for oxygen where used for medical gases and medical support gases.

5.1.10.10 Prohibited Joints. The following joints shall be prohibited throughout medical gas and vacuum distribution pipeline systems:

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



- (3) Pipe-crimping tools used to permanently stop the flow of medical gas and vacuum piping
- (4) Removable and nonremovable push-fit fittings that employ a quick assembly push fit connector

5.1.10.11 Installation of Piping and Equipment.

5.1.10.11.1 Pipe Sizing.

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

5.1.10.11.1.2 Mains and branches in medical gas piping systems shall be not less than DN15 (NPS ½) (⅝ in. O.D.) size.

5.1.10.11.1.3 Mains and branches in medical-surgical vacuum systems shall be not less than DN20 (NPS ¾) (⅞ in. O.D.) size.

5.1.10.11.1.4 Drops to individual station outlets and inlets shall be not less than DN15 (NPS ½) (⅝ in. O.D.) size.

5.1.10.11.1.5 Runouts to alarm panels and connecting tubing for gauges and alarm devices shall be permitted to be DN8 (NPS ¼) (⅜ in. O.D.) size.

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

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

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

5.1.10.11.3 Location of Piping.

5.1.10.11.3.1 Piping risers shall be permitted to be installed in pipe shafts if protected from physical damage, effects of excessive heat, corrosion, or contact with oil.

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

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

5.1.10.11.3.3 Medical gas piping shall be permitted to be installed in the same service trench or tunnel with fuel gas lines, fuel oil lines, electrical lines, steam lines, and similar utilities, provided that the space is ventilated (naturally or mechanically) and the ambient temperature around the medical gas piping is limited to 54°C (130°F) maximum.

5.1.10.11.3.4 Medical gas piping shall not be located where subject to contact with oil, including a possible flooding area in the case of a major oil leak.

5.1.10.11.4 Pipe Support.

5.1.10.11.4.1 Piping shall be supported from the building structure.

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

5.1.10.11.4.3 Supports for copper tube shall be sized for copper tube.

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

5.1.10.11.4.5 Maximum support spacing shall be in accordance with Table 5.1.10.11.4.5.

Table 5.1.10.11.4.5 Maximum Pipe Support Spacing

Pipe Size	Hanger Spacing	
	mm	ft
DN8 (NPS ¼) (⅜ in. O.D.)	1520	5
DN10 (NPS ⅜) (½ in. O.D.)	1830	6
DN15 (NPS ½) (⅝ in. O.D.)	1830	6
DN20 (NPS ¾) (⅞ in. O.D.)	2130	7
DN25 (NPS 1) (1⅛ in. O.D.)	2440	8
DN32 (NPS 1¼) (1⅜ in. O.D.)	2740	9
DN40 (NPS 1½) (1⅝ in. O.D.)	3050	10
and larger		
Vertical risers, all sizes, every floor, but not to exceed	4570	15

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

5.1.10.11.5 Underground Piping Outside of Buildings.

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

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

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

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

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

5.1.10.11.5.5 The minimum backfilled cover above the top of the pipe or its enclosure for buried piping outside of buildings shall be 900 mm (36 in.), except that the minimum cover shall be permitted to be reduced to 450 mm (18 in.) where there is no potential for damage from surface loads or surface conditions.

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

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