

NFPA 99

Standard for Health Care Facilities

2005 Edition



NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
An International Codes and Standards Organization

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NFPA 99

Standard for

Health Care Facilities

2005 Edition

This edition of NFPA 99, *Standard for Health Care Facilities*, was prepared by the Technical Committees on Administration, Electrical Equipment, Electrical Systems, Gas Delivery Equipment, Health Care Emergency Management, Hyperbaric and Hypobaric Facilities, Laboratories, and Piping Systems, released by the Technical Correlating Committee on Health Care Facilities, and acted on by NFPA at its November Association Technical Meeting held November 13–17, 2004, in Miami Beach, FL. It was issued by the Standards Council on January 14, 2005, with an effective date of February 7, 2005, and supersedes all previous editions.

A tentative interim amendment (TIA) to subsection 5.1.5.16 was issued on January 14, 2005. For further information on tentative interim amendments see Section 5 of the NFPA Regulations Governing Committee Projects available at <http://www.nfpa.org/Codes/NFPADirectory.asp#Regs&Procedures>.

This edition of NFPA 99 was approved as an American National Standard on February 7, 2005.

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 are mainly for clarity, and are editorial in nature. In Chapter 3, the definitions for medical gas, patient medical gas, and medical support gas have been modified to differentiate between the different types of gases.

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

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

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

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

Chapter 12 has been 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 have been made.

Chapter 20 has been revised to heating and ventilation changes in the chamber. Additional restrictions to the types of materials that are allowed in the chamber have been added.

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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, as follows:

- (1) 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
- (2) From fire and explosion hazards associated with laboratory practices
- (3) In connection with the use of hyperbaric and hypobaric facilities (NFPA 99B) for medical purposes
- (4) Through performance, maintenance, and testing criteria for electrical systems, both normal and essential
- (5) Through performance, maintenance and testing, and installation criteria, as follows:
 - (a) For vacuum systems for medical or surgical purposes
 - (b) For medical gas systems

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(Chapters 1, 2, 3, and 7, and related paragraphs in Chapters 4–14 and 17–21)

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Safety, ME [E]
Mark A. Trudzinski, U.S. Army Medical Command, TX [U]

Alternate

William M. Dorfler, The RJA Group, Inc., IL [SE]
(Alt. to M. A. Crowley)

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Committee Scope: This Committee shall have primary responsibility for documents or portions of documents on the scope, application, and intended use of documents under the Health Care Facilities Project, as well as definitions not assigned to other committees in the Health Care Facilities Project.

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(Chapters 8, 10, and related paragraphs in Chapters 13, 14, 17, 18, 19, 21, and Annex D)

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[RT]
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Rep. American Society of Anesthesiologists
Joseph P. Murnane, Underwriters Laboratories Inc.,
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Lawrence S. Sandler, U.S. Department of Veterans Affairs,
CA [U]
George F. Stevens, U.S. Department of Health and
Human Services, AZ [E]
Michael Velvikis, High Voltage Maintenance
Corporation, WI [IM]
Rep. InterNational Electrical Testing Association Inc.
Robert F. Willey, III, Siemens Medical Systems, Inc., NJ [M]
Rep. Health Industry Manufacturers Association

Alternates

Ralph E. Patterson, SETA-AC Testing, NC [IM]
(Alt. to M. Velvikis)

Dale Woodin, American Society for Healthcare
Engineering, IL [U]
(Alt. to ASHE Rep.)

Richard P. Bielen, NFPA Staff Liaison

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

Technical Committee on Electrical Systems (HEA-ELS)
(Chapter 4 and related paragraphs in Chapters 13, 14, 17, 18, and 21)

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Dan Chisholm, Healthcare Engineering Network, FL [IM]
James H. Costley, Jr., Newcomb & Boyd, GA [SE]
 Rep. NFPA Health Care Section
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Herbert Daugherty, Electric Generating Systems Association, NJ [U]
 Rep. Electrical Generating Systems Association
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Larry Lau, U.S. Department of Veterans Affairs, DC [U]
 Rep. U.S. Department of Veterans Affairs

Edward A. Lobnitz, TLC Engineering for Architecture, FL [SE]
James E. Meade, U.S. Army Corps of Engineers, MD [U]
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Alternates

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 (Alt. to R. M. Smidt)
Donald R. Morelli, TLC Engineering for Architecture, FL [SE]
 (Alt. to E. A. Lobnitz)

Jeffrey L. Steplowski, U.S. Department of Veterans Affairs, DC [E]
 (Alt. to L. Lau)
Howard Stickley, U.S. Army Corps of Engineers, DC [U]
 (Alt. to J. E. Meade)
Herbert V. Whittall, Electrical Generating Systems Association, FL [U]
 (Alt. to H. Daugherty)

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Committee Scope: This Committee shall have primary responsibility for documents or portions of documents covering performance, maintenance, and testing of electrical systems for the purpose of safeguarding patients, staff, and visitors within health care facilities.

Technical Committee on Gas Delivery Equipment (HEA-GAS)
(Chapter 9 and related paragraphs in Chapters 6, 13, 14, 17, 18, 19, 21, and Annex E)

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 Texas Childrens Hospital, TX [U]

Jay Crowley, U.S. Department of Health and Human Services, MD [E]
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Alan Lipschultz, Christiana Care-Health Services, DE [SE]
 Rep. Association for the Advancement of Medical Instrumentation
George Mills, MM EC, Ltd., IL [U]
 Rep. American Society for Healthcare Engineering

Dwight R. (DAK) Quarles, Institute of Exercise and Environmental Medicine, TX [U]
Jay R. Sommers, Kimberly-Clark Corporation, GA [M]
Robert M. Sutter, BOC Gases, NJ [M]
 Rep. Compressed Gas Association
Gerald L. Wolf, SUNY/HSCB, Brooklyn, NY [C]
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Committee Scope: This Committee shall have primary responsibility for documents or portions of documents on the performance and maintenance criteria for safeguarding patients and health care personnel from fire, explosion, electrical, and related hazards in anesthetizing locations involving the administration of both flammable and nonflammable anesthetics, including equipment and facilities ancillary thereto; and the performance, maintenance, and testing of patient-related gas equipment for the purpose of safeguarding patients and staff within health care facilities.

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Committee Scope: This Committee shall have primary responsibility for documents or portions of documents covering the performance of health care facilities under disaster conditions.

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Rep. Undersea & Hyperbaric Medical Society

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Harold D. Beeson, U.S. National Aeronautics and Space Administration, NM [RT]
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Paul J. Sheffield, International ATMO, Inc., TX [U]
Harry G. Vincent, Total Wound Treatment Center, TX [C]
Rep. Baromedical Nurses Association

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(Alt. to R. E. Peterson)

Glenn J. Butler, Life Support Technologies, Inc., NY [M]

(Alt. to R. W. Hamilton)

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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.

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Committee Scope: This Committee shall have primary responsibility for documents or portions of documents covering the maintenance of equipment and environment for the purpose of safeguarding patients, visitors, and staff within laboratories in health care facilities.

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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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NFPA 99**Standard for****Health Care Facilities****2005 Edition**

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

Changes other than editorial are indicated by a vertical rule beside the paragraph, table, or figure in which the change occurred. These rules are included as an aid to the user in identifying changes from the previous edition. Where one or more complete paragraphs have been deleted, the deletion is indicated by a bullet (•) between the paragraphs that remain.

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 mandatory extracts are given in Chapter 2 and those for nonmandatory extracts are given in Annex G. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. 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 G.

Further explanatory information on Chapters 1 through 20 can be found in Annex C.

Chapter 1 Administration**1.1 Scope.**

1.1.1 The scope of this document is to establish criteria to minimize the hazards of fire, explosion, and electricity in health care facilities providing services to human beings.

1.1.2 Annex D covers principles of design and use of electrical and electronic appliances generating high-frequency currents for medical treatment in hospitals, clinics, ambulatory care facilities, and dental offices, whether fixed or mobile.

1.1.2.1 Areas Not Addressed. The following areas are not addressed:

- (1) Communication equipment, resuscitation equipment (e.g., defibrillators), or physiological stimulators (e.g., used for anesthesia, acupuncture)
- (2) Experimental or research apparatus built to order, or under development, provided such apparatus is used under qualified supervision and provided the builder demonstrates to the authority having jurisdiction that the apparatus has a degree of safety equivalent to that described in Annex D

1.1.3 Annex E retains the established requirements that would be necessary for the safe use of flammable inhalation anesthetics should the use of this type of anesthetic be reinstituted.

1.1.4 Chapter 4, Electrical Systems, covers the performance, maintenance, and testing of electrical systems (both normal and essential) used within health care facilities.

1.1.4.1 Areas Not Addressed in Chapter 4. The following areas are not addressed in NFPA 99, but are addressed in other NFPA documents:

- (1) Specific requirements for wiring and installation on 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 fire protection signaling systems.
- (4) Requirements for fire pumps are covered in NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, except that the alternate source of power shall be permitted to be the essential electrical system.
- (5) Requirements for the 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 Chapter 5, Gas and Vacuum Systems, 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 used within 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)

1.1.5.1 Areas Not Addressed in Chapter 5. Requirements for portable compressed gas systems are covered in Chapter 9, Gas Equipment.

1.1.6 Chapter 6, Environmental Systems, covers the performance, maintenance, and testing of the environmental systems used within health care facilities.

1.1.7 Chapter 7, Materials, covers the hazards associated with the use of flammable and combustible materials used within health care facilities.

1.1.8 Chapter 8, Electrical Equipment, covers the performance, maintenance, and testing of electrical equipment used within health care facilities.

1.1.9 Chapter 9, Gas Equipment, covers the performance, maintenance, and testing of gas equipment used within health care facilities.

1.1.10 Chapter 10, Manufacturer Requirements, covers the performance, maintenance, and testing, with regard to safety, required of manufacturers of equipment used within health care facilities.

1.1.11 Chapter 11, Laboratories, establishes criteria to minimize the hazards of fire and explosions in laboratories, as defined in Chapter 3.

1.1.11.1 Areas Not Addressed in Chapter 11. Subsection 1.1.11 is not intended to cover hazards resulting from any of the following:

- (1) Chemicals
- (2) Radioactive materials
- (3)*Biological materials that will not result in fires or explosions

1.1.12* Chapter 12, Health Care Emergency Management, establishes minimum criteria for health care facility emergency management in the development of a program for effective disaster preparedness, response, mitigation, and recovery.

1.1.13 Chapter 13, Hospital Requirements, addresses safety requirements of hospitals.

1.1.14 Chapter 14, Other Health Care Facilities, addresses safety requirements for facilities, or portions thereof, that provide diagnostic and treatment services to patients in health care facilities. Requirements for specific health care facilities are addressed in the following chapters:

- (1) Hospitals — Chapter 13
- (2) Nursing homes — Chapter 17
- (3) Limited care facilities — Chapter 18

1.1.15 Reserved.

1.1.16 Reserved.

1.1.17 Chapter 17, Nursing Home Requirements, addresses safety requirements of nursing homes.

1.1.18 Chapter 18, Limited Care Facility Requirements, covers safety requirements of limited care facilities.

1.1.19 Chapter 19, Electrical and Gas Equipment for Home Care, addresses the requirements for the safe use of electrical and gas equipment used for home care medical treatment.

1.1.20* Chapter 20, Hyperbaric Facilities, 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 to 690 kPa (0 to 100 psi). Chapter 20 applies to both single- and multiple-occupancy hyperbaric chambers; to animal chambers, the size of which precludes human occupancy; and to those in which the chamber atmosphere contains an oxygen partial pressure greater than an absolute pressure of 21.3 kPa (3.09 psi) (0.21 atmospheres).

1.1.21 Chapter 21, Freestanding Birthing Centers, addresses the requirements for the safe use of electrical and gas equipment, and for electrical, gas, and vacuum systems used for the delivery and care of infants in freestanding birthing centers.

1.2 Purpose.

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

1.3 Application.

1.3.1 This document shall apply to all 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. Only the altered, renovated, or modernized portion of an existing system or individual component shall be required to meet the installation and equipment requirements stated in this standard. If the alteration, renovation, or modernization adversely impacts existing performance requirements of a system or component, additional upgrading shall be required.

1.3.3 Chapters 13 through 19 specify the conditions under which the requirements of Chapters 4 through 12 shall apply in Chapters 13 through 19.

1.3.4 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 areas of health care facilities. Nonflammable piped medical gases covered by this document include, but are not limited to, oxygen, nitrogen, nitrous oxide, medical air, carbon dioxide, and helium.

1.4 Equivalency.

1.4.1 The authority having jurisdiction for the enforcement of this document shall be permitted to grant exceptions to its requirements.

1.4.2 Nothing in this standard 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 standard. 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.

1.5 Units and Formulas.

1.5.1* Primary units will be trade units, secondary will be the conversion. Although it is common practice for medical appliances to have metric units on their dials, gauges, and controls, many components of systems within the scope of this document, which are manufactured and used in the United States, employ nonmetric dimensions. Since these dimensions (such as nominal pipe sizes) are not established by the National Fire Protection Association, the Technical Correlating Committee on Health Care Facilities cannot independently change them. Accordingly, this document uses dimensions that are presently in common use by the building trades in the United States.

1.6 Standard 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 standard shall be administered and enforced by the authority having jurisdiction designated by the governing authority. (See Annex F 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 standard 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*, 2002 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2002 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2003 edition.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 2002 edition.

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 2004 edition.

NFPA 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*, 2002 edition.

NFPA 54, *National Fuel Gas Code*, 2002 edition.

NFPA 55, *Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks*, 2005 edition.

NFPA 58, *Liquefied Petroleum Gas Code*, 2004 edition.

NFPA 70, *National Electrical Code*[®], 2005 edition.

NFPA 72[®], *National Fire Alarm Code*[®], 2002 edition.

NFPA 99B, *Standard for Hypobaric Facilities*, 2005 edition.

NFPA 101[®], *Life Safety Code*[®], 2003 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems*, 2005 edition.

NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems*, 2005 edition.

NFPA 220, *Standard on Types of Building Construction*, 1999 edition.

NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*, 2000 edition.

NFPA 326, *Standard for the Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair*, 2005 edition.

NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films*, 2004 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, 2001 edition.

NFPA 1600, *Standard on Disaster/Emergency Management and Business Continuity Programs*, 2004 edition.

2.3 Other Publications.

2.3.1 ANSI Publication. 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 Z66.1, *Specifications for Paints and Coatings Accessible to Children to Minimize Dry Film Toxicity*, 1964.

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

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

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

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

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

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

2.3.3 ASSE Publications. American Society of Sanitary Engineering, 28901 Clemens Road, Suite 100, Westlake, OH 44145.

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

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

2.3.4 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM A 53, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*, 1994.

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 2855, *Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings*, 1996 (2002).

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

2.3.5 AWS Publications. American Welding Society, 550 N.W. 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.

2.3.6 CDA Publication. Copper Development Association Inc., 260 Madison Avenue, New York, NY 10016.

Copper Tube Handbook.

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

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

CGA G-4, *Oxygen*, 1996.

CGA G-4.1, *Cleaning Equipment for Oxygen Service*, 2004.

CGA G-6.1, *Standard for Insulated Carbon Dioxide Systems at Consumer Sites*, 2002.

CGA G-6.5, *Standard for Small, Stationary Insulated Carbon Dioxide Supply Systems*, 2001.

CGA G-8.1, *Standard for Nitrous Oxide Systems at Consumer Sites*, 1990.

CGAM-1, *Guide for Medical Gas Installations at Consumer Sites*, 2003.

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*, 2000.

CGA P-2.6, *Transfilling of Liquid Oxygen to be Used for Respiration*, 1995.

CGA P-2.7, *Guide for the Safe Storage, Handling, and Use of Portable Liquid Oxygen Systems in Healthcare Facilities*, 2000.

CGAV-1, *Compressed Gas Association Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections* (ANSI B57.1), 2003.

CGAV-5, *Diameter-Index Safety System (Noninterchangeable Low Pressure Connections for Medical Gas Applications)*, 2000.

CGAV-6, *Standard Cryogenic Liquid Transfer Connection*, 2000.

2.3.8 IEC Publication. 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.

2.3.9 ISA Publications. The 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.

2.3.10 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, and Manufacture*, 2002.

SP-69, *Pipe Hangers and Supports — Selection and Application*, 2002.

2.3.11 UL Publication. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 94, *Test for Flammability of Plastic Materials for Parts in Devices and Appliances*, 2001.

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

MIL-Standard 104C, *Limit for Electrical Insulation Color*.

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

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. 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. (GAS)

3.3.4 Alarm Systems.

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

3.3.4.2 Level 3 Alarm System. A warning system within an area of use that provides continuous visible and audible surveillance of Level 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. (ADM)

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 standard, applies to any inhalation agent used to produce relative analgesia or general anesthesia. (GAS)

3.3.9* Anesthetizing Location. Any area of a facility that has been designated to be used for the administration of nonflammable inhalation anesthetic agents in the course of examination or treatment, including the use of such agents for relative analgesia. (See also 3.3.158, *Relative Analgesia*.) (GAS)

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. (ELE)

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

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. (GAS)

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

3.3.17 Branch Circuit. The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s). [70, 2005] (ELS)

3.3.18 Branch Line. See 3.3.145, Piping.

3.3.19 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)

3.3.19.1 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 3200 lb (1452 kg) [approximately 28,000 ft³ (793 m³) (at normal temperature and pressure)] of nitrous oxide. (PIP)

3.3.19.2* 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)

3.3.20 Cold Room. A refrigerated area large enough for personnel to enter. (LAB)

3.3.21 Combustible. Capable of undergoing combustion. (GAS)

3.3.22* Combustible Liquid. A liquid having a flash point at or above 37.8°C (100°F). Combustible liquids shall be subdivided as follows: (a) Class II liquids shall include those having flash points at or above 37.8°C (100°F) and below 60°C (140°F); (b) Class IIIA liquids shall include those having flash points at or above 60°C (140°F) and below 93°C (200°F); (c) Class IIIB liquids shall include those having flash points at or above 93°C (200°F). (LAB)

3.3.23* Combustion. A chemical process (such as oxidation) accompanied by the rapid evolution of heat and light. (GAS)

3.3.24 Combustion Products. The gases, volatilized liquids and solids, particulate matter, and ash generated by combustion. (GAS)

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

3.3.26 Critical Branch. A subsystem of the emergency system consisting of feeders and branch circuits supplying energy to task illumination, special power circuits, and selected receptacles serving areas and functions related to patient care and that are connected to alternate power sources by one or more transfer switches during interruption of normal power source. (ELS)

3.3.27 Critical Care Area. See 3.3.138, Patient Care Area.

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

3.3.29 Critical System. A system of feeders and branch circuits in nursing homes and custodial care facilities arranged for connection to the alternate power source to restore service to certain critical receptacles, task illumination, and equipment. (ELS)

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

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

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

3.3.33* 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. (ELE)

3.3.34* Disaster. Within the context of this document, a disaster is defined as any unusual occurrence or unforeseen situation that seriously overtakes or threatens to seriously overtax the routine capabilities of a health care facility. (HCE)

3.3.35 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)

3.3.36* 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. (ELE)

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

3.3.38 Electrode. An electrically conductive connection to a patient. (ELE)

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

3.3.38.2 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. (ELE)

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

3.3.39 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. (HCE)

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

3.3.41 Emergency System. A system of circuits and equipment intended to supply alternate power to a limited number of prescribed functions vital to the protection of life and safety. (ELS)

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

3.3.43 Equipment System. A system of feeders and branch circuits arranged for delayed, automatic, or manual connection

the alternate power source and that serves primarily 3-phase power equipment. (ELS)

3.3.44 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)

3.3.45 Evacuation — Waste Gas. See 3.3.184, Waste Anesthetic Gas Disposal.

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

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

3.3.48 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)

3.3.49 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)

3.3.50* Flame Resistant. The property of a material that passes the small-scale test in NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films*. (HYP)

3.3.51* Flammable. A combustible that is capable of easily being ignited and rapidly consumed by fire. (LAB)

3.3.52 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)

3.3.53 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 mm Hg (40 psi absolute) at 37.8°C (100°F). (LAB)

3.3.54* Flash Point. The minimum temperature at which a liquid gives off vapor in sufficient concentration to form an ignitable mixture with air near the surface of the liquid within the vessel, as specified by appropriate test procedures and apparatus. (LAB)

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

3.3.56 Flowmeter. A device for measuring volumetric flow rates of gases and liquids. (GAS)

3.3.56.1 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. (GAS)

3.3.57 Freestanding Birthing Center. A facility in which low-risk births are expected following normal, uncomplicated pregnancies, and in which professional midwifery care is provided to women during pregnancy, birth, and postpartum. (ADM)

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

3.3.59* Fume Hood. An enclosure designed to draw air inward by means of mechanical ventilation. (LAB)

3.3.60 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)

3.3.61 General Care Area. See 3.3.138, Patient Care Area.

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

3.3.63 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)

3.3.64 Grounding. See 3.3.65, Grounding System.

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

3.3.66 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)

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

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

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

3.3.67* 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. (LAB)

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

3.3.69 Home Care. Medical services (equipment) provided in residential occupancies. (ADM)

3.3.70 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, 2003] (ADM)

3.3.71 Hospital-Based. In the interpretation and application of this document, physically connected to a hospital. (GAS)

3.3.72 Humidifier. A device used for adding water vapor to inspired gas. (GAS)

3.3.73 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)

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

3.3.75 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)

3.3.76 Hypoxia. A state of inadequate oxygenation of the blood and tissue sufficient to cause impairment of function. [99B, 2005] (HYP)

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

3.3.78* 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. (ELE)

3.3.79 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, 2004] (HCE)

3.3.80 Instrument Air. For the purposes of this standard, 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)

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

3.3.82* 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)

3.3.83 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)

3.3.84 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. (ELE)

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

3.3.86 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)

3.3.87* 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. (LAB)

3.3.88* 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. (LAB)

3.3.89 Leakage Current. Any current, including capacitively coupled current, not intended to be applied to a patient, that is conveyed from exposed conductive parts of an appliance to ground or to other accessible parts of an appliance. (ELE)

3.3.90 Level 1 Medical Piped Gas and Vacuum Systems. Systems serving occupancies where interruption of the piped medical gas and vacuum system would place patients in imminent danger of morbidity or mortality. (PIP)

3.3.91 Level 1 Vacuum System. A system consisting of central-vacuum-producing equipment with pressure and operating controls, shutoff valves, alarm warning systems, gauges, and a network of piping extending to and terminating with suitable station inlets at locations where patient suction could be required. (PIP)

3.3.92 Level 2 Medical Piped Gas and Vacuum Systems. Systems serving occupancies where interruption of the piped medical gas and vacuum system would place patients at manageable risk of morbidity or mortality. (PIP)

3.3.93* Level 3 Compressed Air System. A system of component parts, including, but not limited to, air compressor, motor, receiver, controls, filters, dryers, valves, and piping, that delivers compressed air <1100 kPa (<160 psi gauge) to power devices (hand pieces, syringe, cleaning devices, etc.) as a power source. (PIP)

3.3.94 Level 3 Piped Gas Systems. Systems serving occupancies where interruption of the piped medical gas would terminate procedures but would not place patients at risk of morbidity or mortality. (PIP)

3.3.95* Level 3 Piped Vacuum System. A Level 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)

3.3.96 Life Safety Branch. A subsystem of the emergency system consisting of feeders and branch circuits, meeting the requirements of Article 700 of NFPA 70, *National Electrical Code*, and intended to provide adequate power needs to ensure safety to patients and personnel, and that is automatically connected to alternate power sources during interruption of the normal power source. (ELS)

3.3.97 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. (ADM)

3.3.98* Limited-Combustible Material. A material (as defined in NFPA 220, *Standard on Types of Building Construction*) not complying with the definition of noncombustible material that, in the form in which it is used, has a potential heat value not exceeding 8141 kJ/kg (3500 Btu/lb) and complies with one of the following: (a) materials having a structural base of

noncombustible material, with a surfacing not exceeding a thickness of 3.2 mm (1/8 in.) and having a flame-spread rating not greater than 50 or (b) materials, in the form and thickness used, other than as described in (a), having neither a flame-spread rating 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 rating greater than 25 nor evidence of continued progressive combustion. (PIP)

3.3.99 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)

3.3.100* Liquid. Any material that 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*. [30, 2003] (LAB)

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

3.3.102 mA. Milliampere.

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

3.3.104* 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)

3.3.105 Mask. A device that fits over the mouth and nose (oronasal) or nose (nasal), used to administer gases to a patient. (GAS)

3.3.106* Medical Air. For purposes of this standard, medical air is air supplied from cylinders, bulk containers, medical air compressors, or has been reconstituted from oxygen USP and oil-free, dry nitrogen NF.

3.3.107 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)

3.3.108* 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; (3) Overnight stays for patients or 24-hour operation are not provided. (ADM)

3.3.109 Medical Gas. A patient medical gas or medical support gas. (See also 3.3.143, *Patient Medical Gas* and 3.3.111, *Medical Support Gas*.) (PIP)

3.3.110 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)

3.3.111 Medical Support Gas. Piped gases such as nitrogen and instrument air that are used to support medical procedures by operating medical-surgical tools, equipment booms, pendants, and similar medical support applications.

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

3.3.113 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)

3.3.114 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). (ADM)

3.3.115 mV. Millivolt.

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

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

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

3.3.119 Negative Pressure. Pressure less than atmospheric. (GAS)

3.3.120 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. (GAS)

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

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

3.3.122 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. (GAS)

3.3.123 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)

3.3.124 Noncombustible (Hypobaric). An adjective describing a substance that will not burn in 95 percent, plus or minus 5 percent oxygen at pressures of 101.325 kPa (760 mm Hg). (HYP)

3.3.125* Noncombustible Material. A material (as defined in NFPA 220, *Standard on Types of Building Construction*) 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. (PIP)

3.3.126 Nonflammable. An adjective describing a substance that will not burn under the conditions set forth in the definition of flame resistant. (HYP)

3.3.127* 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. (GAS)

3.3.128* Nonflammable Medical Gas System. See 3.3.110, Medical Gas System.

3.3.129 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. (ADM)

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

3.3.131* Oxygen. An element that, at atmospheric temperatures and pressures, exists as a colorless, odorless, tasteless gas. (GAS)

3.3.131.1 Gaseous Oxygen. A colorless, odorless, and tasteless gas; also, the physical state of the element at atmospheric temperature and pressure. (GAS)

3.3.131.2* 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. (GAS)

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

3.3.133 Oxygen-Enriched Atmosphere. For the purpose of this standard, and only for the purpose of this standard, an atmosphere in which the concentration of oxygen exceeds 23.5 percent by volume. (HYP)

3.3.134 Oxygen Hood. A device encapsulating a patient's head and used for a purpose similar to that of a mask. (See also 3.3.105, Mask.) (HYP)

3.3.135 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)

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

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

3.3.138* Patient Care Area. Any portion of a health care facility wherein patients are intended to be examined or treated. (ELE)

3.3.138.1* Critical Care Areas. Those special care units, intensive care units, coronary care units, angiography laboratories, cardiac catheterization laboratories, delivery rooms, operating rooms, postanesthesia recovery rooms, emergency departments, and similar areas in which patients are intended to be subjected to invasive procedures and connected to line-operated, patient-care-related electrical appliances.

3.3.138.2* General Care Areas. Patient bedrooms, examining rooms, treatment rooms, clinics, and similar areas in which it is intended that the patient will come in contact with ordinary appliances such as a nurse-call system, electric beds, examining lamps, telephones, and entertainment devices. (ELE)

3.3.139 Patient-Care-Related Electrical Appliance. An electrical appliance that is intended to be used for diagnostic, therapeutic, or monitoring purposes in a patient care vicinity. (ELE)

3.3.140 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. (ELE)

3.3.141 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. (ELE)

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

3.3.143 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)

3.3.144 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)

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

3.3.145.1 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)

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

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

3.3.146 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. (ELE)

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

3.3.148 Pressure.

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

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

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

3.3.148.4 High Pressure. A pressure exceeding 200 psig (1.38 kPa gauge) (215 psia). (GAS)

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

3.3.148.6 Positive Pressure. Pressure greater than ambient atmospheric. (GAS)

3.3.148.7* Working Pressure. A pressure not exceeding 11.6 kg/cm² (200 psig). (GAS)

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

3.3.150 Procedure Room. Where the proceduralist is using instrumentation that requires constant observation and control.

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

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

3.3.153 Quiet Ground. A system of grounding conductors, insulated from portions of the conventional grounding of the power system, that interconnects the grounds of electric appliances for the purpose of improving immunity to electromagnetic noise. (ELS)

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

3.3.155* 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, 2004] (LAB)

3.3.156 Reference Grounding Point. The ground bus of the panelboard or isolated power system panel supplying the patient care area. (ELE)

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

3.3.158 Relative Analgesia. A state of sedation and partial block of pain perception produced in a patient by the inhalation of concentrations of nitrous oxide insufficient to produce loss of consciousness (conscious sedation). (GAS)

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

3.3.160 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)

3.3.161 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. (LAB)

3.3.162 Scavenging. An alternate term for WAGD often applied in Level 3. (PIP)

3.3.163 SCFM. Standard cubic feet per minute. (PIP)

3.3.164 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)

3.3.165 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)

3.3.166 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)

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

3.3.168 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)

3.3.169* 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)

3.3.170* 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. (GAS)

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

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

3.3.173 Supply Source.

3.3.173.1 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)

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

3.3.173.3 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)

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

3.3.174 Support Gas. Nitrogen or instrument air that is used to support medical procedures by operating medical-surgical tools, equipment booms, pendants, and similar devices, and are not respired as part of any treatment. (PIP)

3.3.175* 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)

3.3.176 Task Illumination. Provisions for the minimum lighting required to carry out necessary tasks in the areas described in Chapter 4, including safe access to supplies and equipment and access to exits. (ELS)

3.3.177 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)

3.3.178 Tube.

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

3.3.178.2* 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). (GAS)

3.3.179* Unattended Laboratory Operation. A laboratory procedure or operation at which there is no person present who is knowledgeable regarding the operation and emergency shut-down procedures. [45, 2004] (LAB)

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

3.3.181* 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)

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

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

3.3.184 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)

3.3.185* Wet Locations. The area in a patient care area 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. (ADM)

Chapter 4 Electrical Systems

4.1* Applicability. This chapter applies to health care facilities as referenced in other chapters.

4.2 Nature of Hazards. See Section B.1.

4.2.1* Fire and Explosions.

4.2.2 Shock.

4.2.2.1 General.

4.2.2.2 Control. See B.1.2.2.2.

4.2.3 Thermal. (Reserved)

4.2.4 Interruption of Power. See B.1.4.1.

4.3 Electrical System Requirements.

4.3.1 Sources. Each appliance of a hospital requiring electrical line power for operation shall be supported by power sources and distribution systems that provide power adequate for each service.

4.3.1.1 Power/Utility Company. (Reserved)

4.3.1.2 On-Site Generator Set. (Reserved)

4.3.2 Distribution.

4.3.2.1 Electrical Installation. Installation shall be in accordance with NFPA 70, *National Electrical Code*.

4.3.2.2* All Patient Care Areas.

4.3.2.2.1* Regular voltage wiring shall comply with the requirements in 4.3.2.2.1.1 through 4.3.2.2.1.3.

4.3.2.2.1.1* Circuits. Branch circuits serving a given patient bed location shall be fed from not more than one normal branch circuit distribution panel. When required, branch circuits serving a given patient bed location shall be permitted to be fed from more than one emergency branch circuit distribution panel.

4.3.2.2.1.2 Critical Care Areas. These areas shall be served by circuits from critical branch panel(s) served from a single automatic transfer switch and a minimum of one circuit served by the normal power distribution system or by a system originating from a second critical branch transfer switch.

4.3.2.2.1.3 Special Purpose Outlets. Branch circuits serving only special-purpose outlets or receptacles (e.g., portable X-ray receptacles) shall not be required to conform to the requirements of 4.3.2.2.1.2.

4.3.2.2.2 Grounding requirements shall comply with the requirements in 4.3.2.2.2.1 through 4.3.2.2.2.4.

4.3.2.2.2.1 Grounding Circuitry Integrity. Grounding circuits and conductors in patient care areas shall be installed in such a way that the continuity of other parts of those circuits cannot be interrupted nor the resistance raised above an acceptable level by the installation, removal, and replacement of any installed equipment, including power receptacles.

4.3.2.2.2.2* Reliability of Grounding. Where used, the reliability of installed grounding circuits to a power receptacle in all patient care areas shall be at least equivalent to that provided by an electrically continuous copper conductor of appropriate ampacity run from the receptacle to a grounding bus in the distribution panel. The grounding conductor shall conform to NFPA 70, *National Electrical Code*.

4.3.2.2.2.3 Separate Grounding Conductor. When existing construction does not use a separate grounding conductor, the continued use of the system shall be permitted to be used, provided it meets the performance requirements in 4.3.3.1, Grounding System in Patient Care Areas.

4.3.2.2.2.4 Metal Receptacle Boxes. Where metal receptacle boxes are used, the performance of the connection between the receptacle grounding terminal and the metal box shall be equivalent to the performance provided by copper wire no smaller than 12 AWG.

4.3.2.2.3* Grounding Interconnects. In patient care areas supplied by the normal distribution system and any branch of the essential electrical system, the grounding system of the normal distribution system and that of the essential electrical system shall be interconnected.

4.3.2.2.4 Circuit Protection.

4.3.2.2.4.1* The main and downstream ground-fault protective devices (where required) shall be coordinated as required in 4.3.2.5.

4.3.2.2.4.2* If used, ground-fault circuit interrupters (GFCIs) shall be listed and approved for the purpose.

4.3.2.2.5 Low-voltage wiring shall comply with either of the following:

- (1) Fixed systems of 30 V (dc or ac rms) or less shall be ungrounded, provided the insulation between each ungrounded conductor and the primary circuit, which is supplied from a conventionally grounded distribution system, is the same protection as required for the primary voltage.
- (2) A grounded low-voltage system shall be permitted provided that load currents are not carried in the grounding conductors.

4.3.2.2.5.1 Wiring for low-voltage control systems and non-emergency communications and signaling systems shall not be required to be installed in metal raceways in anesthetizing locations.

4.3.2.2.6* Receptacles.

4.3.2.2.6.1* Types of Receptacles. Each power receptacle shall provide at least one separate, highly dependable grounding pole capable of maintaining low-contact resistance with its mating plug despite electrical and mechanical abuse. Special receptacles such as the following shall be permitted:

- (1) Four-pole units providing an extra pole for redundant grounding or ground continuity monitoring
- (2) Locking-type receptacles
- (3) Where required for reduction of electrical noise on the grounding circuit, receptacles in which the grounding terminals are purposely insulated from the receptacle yoke

4.3.2.2.6.2 Minimum Number of Receptacles. The number of receptacles shall be determined by the intended use of the patient care areas in accordance with 4.3.2.2.6.2(A) through 4.3.2.2.6.2(D).

(A) Receptacles for Patient Bed Locations in General Care Areas. Each patient bed location shall be provided with a minimum of four receptacles (or two duplex receptacles).

(B) Receptacles for Patient Bed Locations in Critical Care Areas. Each patient bed location shall be provided with a minimum of six receptacles (or three duplex receptacles).

(C) Receptacles for Bathrooms or Toilets. Receptacles shall not be required in bathrooms or toilet rooms.

(D) Receptacles for Special Areas. Receptacles shall not be required in areas where medical requirements mandate otherwise (e.g., certain psychiatric, pediatric, or hydrotherapy areas).

4.3.2.2.6.3 Polarity of Receptacles. Each receptacle shall be wired in accordance with NFPA 70, *National Electrical Code*, to ensure correct polarity.

4.3.2.2.6.4 Receptacles and Amperage. Receptacles for use with 250 V, 50 A, and 60 A ac service shall be designed for use in anesthetizing locations and shall be so designed that the 60 A receptacle will accept either the 50 A or the 60 A plug. Fifty-ampere receptacles shall be designed so as not to accept the 60 A attachment plug. These receptacles shall be of the two-pole, three-wire design with the third contact connecting to the grounding wire (green or green with yellow stripe) of the electrical system.

4.3.2.2.6.5 Other Services Receptacles. Receptacles provided for other services having different voltages, frequencies, or types on the same premises shall be of such design that attachment plugs and caps used in such receptacles cannot be connected to circuits of a different voltage, frequency, or type, but shall be interchangeable within each classification and rating required for two-wire, 125 V, single-phase ac service.

4.3.2.2.7 Special Grounding.

4.3.2.2.7.1* Use of Quiet Grounds. A quiet ground, if used, shall not defeat the purposes of the safety features of the grounding systems detailed herein.

4.3.2.2.7.2 Patient Equipment Grounding Point. A patient equipment grounding point comprising one or more grounding terminals or jacks shall be permitted in an accessible location in the patient care vicinity.

4.3.2.2.7.3* Special Grounding in Patient Care Areas. In addition to the grounding required to meet the performance requirements of 4.3.3.1, additional grounding shall be permitted where special circumstances so dictate.

4.3.2.2.8 Wet Locations.

4.3.2.2.8.1* Wet location patient care areas shall be provided with special protection against electric shock. This special protection shall be provided as follows:

- (1) A power distribution system that inherently limits the possible ground-fault current due to a first fault to a low value, without interrupting the power supply
- (2) A power distribution system in which the power supply is interrupted if the ground-fault current does, in fact, exceed a value of 6 mA

4.3.2.2.8.2 Patient beds, toilets, bidets, and wash basins shall not be required to be considered wet locations.

4.3.2.2.8.3 In existing construction, the requirements of 4.3.2.2.8.1 are not required when written inspection procedure, acceptable to the authority having jurisdiction, is continuously enforced by a designated individual at the hospital, to indicate that equipment-grounding conductors for 120 V, single-phase, 15 A and 20 A receptacles, equipment connected by cord and plug, and fixed electrical equipment are installed and maintained in accordance with NFPA 70, *National Electrical Code*, and applicable performance requirements of this chapter.

(A) The procedure shall include electrical continuity tests of all required equipment, grounding conductors, and their connections.

(B) Fixed receptacles, equipment connected by cord and plug, and fixed electrical equipment shall be tested as follows:

- (1) When first installed
- (2) Where there is evidence of damage
- (3) After any repairs
- (4) At intervals not exceeding 6 months

4.3.2.2.8.4 The use of an isolated power system (IPS) shall be permitted as a protective means capable of limiting ground fault current without power interruption. When installed, such a power system shall conform to the requirements of 4.3.2.6.

4.3.2.2.8.5 Where power interruption under first fault condition (line-to-ground fault) is tolerable, the use of a ground-fault circuit interrupter (GFCI) shall be permitted as the protective means that monitors the actual ground-fault current and interrupts the power when that current exceeds 6 mA.

4.3.2.2.9 Isolated Power. An isolated power system shall not be required to be installed in any patient care area except as specified in 4.3.2.2.8. The system shall be permitted to be installed where it conforms to the performance requirements specified in 4.3.2.6.

4.3.2.3 Laboratories. Outlets with two to four receptacles, or an equivalent power strip, shall be installed every 0.5 m to 1.0 m (1.6 ft to 3.3 ft) in instrument usage areas, and either installation is to be at least 8 cm (3.15 in.) above the countertop.

4.3.2.4 Other Nonpatient Areas. (Reserved)

4.3.2.5 Ground-Fault Protection.

4.3.2.5.1 Applicability. The requirements of 4.3.2.5.2 shall apply to hospitals and other buildings housing critical care areas or utilizing life support equipment, and buildings that provide essential utilities or services for the operation of critical care areas or electrical life support equipment.

4.3.2.5.2 When ground-fault protection is provided for operation of the service or feeder disconnecting means, an additional step of ground-fault protection shall be provided in the next level of feeder downstream toward the load. Ground-fault protection for operation of the service and feeder disconnecting means shall be fully selective such that the downstream device and not the upstream device shall open for downstream ground faults.

4.3.2.6* Isolated Power Systems.

4.3.2.6.1 Isolation Transformer.

4.3.2.6.1.1 The isolation transformer shall be listed and approved for the purpose.

4.3.2.6.1.2 The primary winding shall be connected to a power source so that it is not energized with more than 600 V (nominal). The neutral of the primary winding shall be grounded in an approved manner. If an electrostatic shield is present, it shall be connected to the reference grounding point.

4.3.2.6.1.3 Wiring of isolated power systems shall be in accordance with Section 517.62 of NFPA 70, *National Electrical Code*.

4.3.2.6.2 Impedance of Isolated Wiring.

4.3.2.6.2.1* The impedance (capacitive and resistive) to ground of either conductor of an isolated system shall exceed 200,000 ohms when installed. The installation at this point shall include receptacles but is not required to include lighting fixtures or components of fixtures. This value shall be determined by energizing the system and connecting a low-impedance ac milliammeter (0 mA to 1 mA scale) between the reference grounding point and either conductor in sequence. This test shall be permitted to be performed with the line isolation monitor (*see 4.3.2.6.3*) connected, provided the connection between the line isolation monitor and the reference grounding point is open at the time of the test. After the test is made, the milliammeter shall be removed and the grounding connection of the line isolation monitor shall be restored. When the installation is completed, including permanently connected fixtures, the reading of the meter on the line isolation monitor, which corresponds to the unloaded line condition, shall be made. This meter reading shall be recorded as a reference for subsequent line-impedance evaluation. This test shall be conducted with no phase conductors grounded.

4.3.2.6.2.2 An approved capacitance suppressor shall be permitted to be used to improve the impedance of the perma-

nently installed isolated system; however, the resistive impedance to ground of each isolated conductor of the system shall be at least 1 megohm prior to the connection of the suppression equipment. Capacitance suppressors shall be installed so as to prevent inadvertent disconnection during normal use.

4.3.2.6.3 Line Isolation Monitor.

4.3.2.6.3.1* In addition to the usual control and protective devices, each isolated power system shall be provided with an approved continually operating line isolation monitor that indicates possible leakage or fault currents from either isolated conductor to ground.

4.3.2.6.3.2 The monitor shall be designed such that a green signal lamp, conspicuously visible in the area where the line isolation monitor is utilized, remains lighted when the system is adequately isolated from ground; and an adjacent red signal lamp and an audible warning signal (remote if desired) shall be energized when the total hazard current (consisting of possible resistive and capacitive leakage currents) from either isolated conductor to ground reaches a threshold value of 5.0 mA under normal line voltage conditions. The line isolation monitor shall not alarm for a fault hazard current of less than 3.7 mA.

4.3.2.6.3.3* The line isolation monitor shall comply with either of the following:

- (1) It shall have sufficient internal impedance such that, when properly connected to the isolated system, the maximum internal current that will flow through the line isolation monitor, when any point of the isolated system is grounded, shall be 1 mA.
- (2) It shall be permitted to be of the low-impedance type such that the current through the line isolation monitor, when any point of the isolated system is grounded, will not exceed twice the alarm threshold value for a period not exceeding 5 msec.

4.3.2.6.3.4* An ammeter connected to indicate the total hazard current of the system (contribution of the fault hazard current plus monitor hazard current) shall be mounted in a plainly visible place on the line isolation monitor with the "alarm on" zone (total hazard current = 5.0 mA) at approximately the center of the scale. It is desirable to locate the ammeter such that it is conspicuously visible to persons in the anesthetizing location.

4.3.2.6.3.5 Means shall be provided for shutting off the audible alarm while leaving the red warning lamp activated. When the fault is corrected and the green signal lamp is reactivated, the audible alarm silencing circuit shall reset automatically, or an audible or distinctive visual signal shall indicate that the audible alarm is silenced.

4.3.2.6.3.6 A reliable test switch shall be mounted on the line isolation monitor to test its capability to operate (i.e., cause the alarms to operate and the meter to indicate in the "alarm on" zone). This switch shall transfer the grounding connection of the line isolation monitor from the reference grounding point to a test impedance arrangement connected across the isolated line; the test impedance(s) shall be of the appropriate magnitude to produce a meter reading corresponding to the rated total hazard current at the nominal line voltage, or to a lesser alarm hazard current if the line isolation monitor is so rated. The operation of this switch shall break the grounding connection of the line isolation monitor to the reference grounding point before transferring this grounding connector to the test impedance(s), so that making this test

will not add to the hazard of a system in actual use, nor will the test include the effect of the line to ground stray impedance of the system. The test switch shall be of a self-restoring type.

4.3.2.6.3.7 The line isolation monitor shall not generate energy of sufficient amplitude or frequency, as measured by a physiological monitor with a gain of at least 10^4 with a source impedance of 1000 ohms connected to the balanced differential input of the monitor, to create interference or artifact on human physiological signals. The output voltage from the amplifier shall not exceed 30 mV when the gain is 10^4 . The 1000 ohms impedance shall be connected to the ends of typical unshielded electrode leads that are a normal part of the cable assembly furnished with physiological monitors. A 60 Hz notch filter shall be used to reduce ambient interference as is typical in physiological monitor design.

4.3.2.6.4 Identification of Conductors for Isolated (Ungrounded) Systems. The isolated conductors shall be identified in accordance with Section 517.160(a)(5) of NFPA 70, *National Electrical Code*.

4.3.3 Performance Criteria and Testing.

4.3.3.1 Grounding System in Patient Care Areas.

4.3.3.1.1* Grounding System Testing. The effectiveness of the grounding system shall be determined by voltage measurements and impedance measurements.

4.3.3.1.1.1 For new construction, the effectiveness of the grounding system shall be evaluated before acceptance.

4.3.3.1.1.2 Small, wall-mounted conductive surfaces, not likely to become energized, such as surface-mounted towel and soap dispensers, mirrors, and so forth, shall not be required to be intentionally grounded or tested.

4.3.3.1.1.3 Large, metal conductive surfaces not likely to become energized, such as windows, door frames, and drains, shall not be required to be intentionally grounded or periodically tested.

4.3.3.1.1.4* Whenever the electrical system has been altered or replaced, that portion of the system shall be tested.

4.3.3.1.2 Reference Point. The voltage and impedance measurements shall be taken with respect to a reference point. The reference point shall be one of the following:

- (1) A reference grounding point (*see Chapter 3, Definitions*)
- (2) A grounding point, in or near the room under test, that is electrically remote from receptacles, for example, an all-metal cold-water pipe
- (3) The grounding contact of a receptacle that is powered from a different branch circuit from the receptacle under test

4.3.3.1.3* Voltage Measurements. The voltage measurements shall be made under no-fault conditions between a reference point and exposed fixed electrical equipment with conductive surfaces in a patient care vicinity. The voltage measurements shall be made with an accuracy of ± 20 percent. Voltage measurements for faceplates of wiring devices shall not be required.

4.3.3.1.4* Impedance Measurements. The impedance measurement shall be made with an accuracy of ± 20 percent. For new construction, the impedance measurement shall be made between the reference point and the grounding contact of 10 percent of all receptacles in each patient care vicinity. The impedance measurement shall be the ratio of voltage developed (either

60 Hz or dc) between the point under test and the reference point to the current applied between these two points.

4.3.3.1.5 Test Equipment. Electrical safety test instruments shall be tested periodically, but not less than annually, for acceptable performance.

4.3.3.1.5.1 Voltage measurements specified in 4.3.3.1.3 shall be made with an instrument having an input resistance of 1000 ohms $\pm$ 10 percent at frequencies of 1000 Hz or less.

4.3.3.1.5.2 The voltage across the terminals (or between any terminal and ground) of resistance-measuring instruments used in occupied patient care areas shall not exceed 500 mV rms or 1.4 dc or peak to peak.

4.3.3.1.6 Criteria for Acceptability for New Construction.

4.3.3.1.6.1 Voltage limit shall be 20 mV.

4.3.3.1.6.2 Impedance limit shall be 0.2 ohms for quiet ground systems, and 0.1 ohms for all others.

4.3.3.2 Receptacle Testing in Patient Care Areas.

4.3.3.2.1 The physical integrity of each receptacle shall be confirmed by visual inspection.

4.3.3.2.2 The continuity of the grounding circuit in each electrical receptacle shall be verified.

4.3.3.2.3 Correct polarity of the hot and neutral connections in each electrical receptacle shall be confirmed.

4.3.3.2.4 The retention force of the grounding blade of each electrical receptacle (except locking-type receptacles) shall be not less than 115 g (4 oz).

4.3.3.3 Isolated Power Systems.

4.3.3.3.1 Patient Care Areas. If installed, the isolated power system shall be tested in accordance with 4.3.3.3.2.

4.3.3.3.2 Line Isolation Monitor Tests.

4.3.3.3.2.1 The Line Isolation Monitor (LIM) circuit shall be tested after installation, and prior to being placed in service, by successively grounding each line of the energized distribution system through a resistor of $200 \times V$ ohms, where V equals measured line voltage. The visual and audible alarms (*see* 4.3.2.6.3.2) shall be activated.

4.3.3.4 Ground-Fault Protection Testing. When equipment ground-fault protection is first installed, each level shall be performance-tested to ensure compliance with 4.3.2.5.

4.3.4* Administration of Electrical System.

4.3.4.1 Maintenance and Testing of Electrical System.

4.3.4.1.1 Testing for hospital grade receptacles required at patient bed locations and in anesthetizing locations shall be performed after initial installation, replacement, or servicing of the device.

4.3.4.1.2 Additional testing of receptacles in patient care areas shall be performed at intervals defined by documented performance data.

4.3.4.1.3 Receptacles at patient bed locations and in anesthetizing locations not listed as hospital-grade shall be tested at intervals not exceeding 12 months.

4.3.4.1.4 The LIM circuit shall be tested at intervals of not more than 1 month by actuating the LIM test switch (*see* 4.3.2.6.3.6). For a LIM circuit with automated self-test and self-

calibration capabilities, this test shall be performed at intervals of not more than 12 months. Actuation of the test switch shall activate both visual and audible alarm indicators.

4.3.4.1.5 After any repair or renovation to an electrical distribution system, the LIM circuit shall be tested in accordance with 4.3.3.3.2.1.

4.3.4.2 Recordkeeping.

4.3.4.2.1* General. A record shall be maintained of the tests required by this chapter and associated repairs or modification. At a minimum, this record shall contain the date, the rooms or areas tested, and an indication of which items have met or have failed to meet the performance requirements of this chapter.

4.3.4.2.2 Isolated Power System (Where Installed). A permanent record shall be kept of the results of each of the tests.

4.4 Essential Electrical System Requirements — Type 1.

4.4.1 Sources (Type 1 EES).

4.4.1.1 On-Site Generator Set.

4.4.1.1.1* Design Considerations. Dual sources of normal power shall be considered but shall not constitute an alternate source of power as described in this chapter.

4.4.1.1.1.1 Distribution system arrangements shall be designed to minimize interruptions to the electrical systems due to internal failures by the use of adequately rated equipment.

4.4.1.1.1.2 The following factors shall be considered in the design of the distribution system:

- (1) Abnormal voltages such as single phasing of three-phase utilization equipment, switching and/or lightning surges, voltage reductions, and so forth
- (2) Capability of achieving the fastest possible restoration of any given circuit(s) after clearing a fault
- (3) Effects of future changes, such as increased loading and/or supply capacity
- (4) Stability and power capability of the prime mover during and after abnormal conditions
- (5)*Sequence reconnection of loads to avoid large current inrushes that trip overcurrent devices or overload the generator(s)
- (6) Bypass arrangements to permit testing and maintenance of system components that could not otherwise be maintained without disruption of important hospital functions
- (7) Effects of any harmonic currents on neutral conductors and equipment

4.4.1.1.2 Current-sensing devices, phase and ground, shall be selected to minimize the extent of interruption to the electrical system due to abnormal current caused by overload and/or short circuits.

4.4.1.1.3 Generator load-shed circuits designed for the purpose of load reduction or for load priority systems shall not shed life safety branch loads, critical branch loads serving critical care areas, medical air compressors, medical-surgical vacuum pumps, pressure maintenance (jockey) pump(s) for water-based fire protection systems, generator fuel pumps, or other generator accessories.

4.4.1.1.4 Essential electrical systems shall have a minimum of two independent sources of power: a normal source generally supplying the entire electrical system and one or more alternate sources for use when the normal source is interrupted.

4.4.1.1.5 Where the normal source consists of generating units on the premises, the alternate source shall be either another generating set or an external utility service.

4.4.1.1.6 General. Generator sets installed as an alternate source of power for essential electrical systems shall be designed to meet the requirements of such service.

4.4.1.1.6.1 Type 1 and Type 2 essential electrical system power sources shall be classified as Type 10, Class X, Level 1 generator sets per NFPA 110, *Standard for Emergency and Standby Power Systems*.

4.4.1.1.6.2 Type 3 essential electrical system power sources shall be classified as Type 10, Class X, Level 2 generator sets per NFPA 110, *Standard for Emergency and Standby Power Systems*.

4.4.1.1.7 Uses for Essential Electrical System.

4.4.1.1.7.1 The generating equipment used shall be either reserved exclusively for such service or normally used for other purposes of peak demand control, internal voltage control, load relief for the external utility, or cogeneration. If normally used for the other purposes listed above, two or more sets shall be installed, such that the maximum actual demand likely to be produced by the connected load of the emergency system as well as medical air compressors, medical-surgical vacuum pumps, electrically operated fire pumps, jockey pumps, fuel pumps, and generator accessories shall be met with the largest single generator set out-of-service. The alternate source of emergency power for illumination and identification of means of egress shall be the essential electrical system. The alternate power source for fire protection signaling systems shall be the essential electrical systems.

4.4.1.1.7.2 A single generator set that operates the essential electrical system shall be permitted to be part of the system supplying the other purposes as listed in 4.4.1.1.7.1, provided any such use will not decrease the mean period between service overhauls to less than three years.

4.4.1.1.7.3* Optional loads shall be permitted to be served by the essential electrical system generating equipment. Optional loads shall be served by their own transfer means, such that these loads shall not be transferred onto the generating equipment if the transfer will overload the generating equipment and shall be shed upon a generating equipment overload. Use of the generating equipment to serve optional loads shall not constitute "other purposes" as described in 4.4.1.1.7.1 and therefore shall not require multiple generator sets.

4.4.1.1.7.4 Where optional loads include contiguous or same-site facilities not covered in Chapters 12 through 20, provisions shall be made to meet the requirements of NFPA 101, *Life Safety Code*, Article 700 of NFPA 70, *National Electrical Code*, and other applicable NFPA requirements for emergency egress under load-shed conditions.

4.4.1.1.8 Work Space or Room.

4.4.1.1.8.1 The EPS shall be installed in a separate room for Level 1 installations. EPSS equipment shall be permitted to be installed in this room. [110:7.2.1]

(A) The room shall have a minimum 2-hour fire rating or be located in an adequate enclosure located outside the building capable of resisting the entrance of snow or rain at a maximum wind velocity required by local building codes. [110:7.2.1.1]

4.4.1.1.8.2 The rooms, shelters, or separate buildings housing Level 1 or Level 2 EPSS equipment shall be designed and

located to minimize the damage from flooding, including that caused by the following:

- (1) Flooding resulting from fire fighting
- (2) Sewer water backup
- (3) Similar disasters or occurrences [110:7.2.3]

4.4.1.1.8.3 The EPS equipment shall be installed in a location that permits ready accessibility and a minimum of 76 cm (30 in.) from the skid rails' outermost point in the direction of access for inspection, repair, maintenance, cleaning, or replacement. This requirement shall not apply to units in outdoor housings. [110:7.2.5]

4.4.1.1.9* Capacity and Rating. The generator set(s) shall have sufficient capacity and proper rating to meet the maximum actual demand likely to be produced by the connected load of the essential electrical system(s) at any one time.

4.4.1.1.10 Load Pickup. The energy converters shall have the required capacity and response to pick up and carry the load within the time specified in Table 4.1(b) of NFPA 110, *Standard for Emergency and Standby Power Systems*, after loss of primary power.

4.4.1.1.11 Maintenance of Temperature. The EPS shall be heated as necessary to maintain the water jacket temperature determined by the EPS manufacturer for cold start and load acceptance for the type of EPSS. [110:5.3.1]

4.4.1.1.12 Heating, Cooling, and Ventilating.

4.4.1.1.12.1* With the EPS running at rated load, ventilation airflow shall be provided to limit the maximum air temperature in the EPS room to the maximum ambient air temperature required by the EPS manufacturer. [110:7.7.1]

(A) Consideration shall be given to all the heat rejected to the EPS equipment room by the energy converter, uninsulated or insulated exhaust pipes, and other heat-producing equipment. [110:7.7.1.1]

4.4.1.1.12.2 Air shall be supplied to the EPS equipment for combustion. [110:7.7.2]

(A) For EPS supplying Level 1 EPSS, ventilation air shall be supplied directly from a source outside of the building by an exterior wall opening or from a source outside the building by a 2-hour fire-rated air transfer system. [110:7.7.2.1]

(B) For EPS supplying Level 1 EPSS, discharge air shall be directed outside of the building by an exterior wall opening or to an exterior opening by a 2-hour fire-rated air transfer system. [110:7.7.2.2]

(C) Fire dampers, shutters, or other self-closing devices shall not be permitted in ventilation openings or ductwork for supply or return/discharge air to EPS equipment for Level 1 EPSS. [110:7.7.2.3]

4.4.1.1.12.3 Ventilation air supply shall be from outdoors or from a source outside of the building by an exterior wall opening or from a source outside the building by a 2-hour fire-rated air transfer system. [110:7.7.3]

4.4.1.1.12.4 Ventilation air shall be provided to supply and discharge cooling air for radiator cooling of the EPS when running at rated load. [110:7.7.4]

(A) Ventilation air supply and discharge for radiator cooled EPS shall have a maximum static restriction of 125 Pa (0.5 in.) of water column in the discharge duct at the radiator outlet. [110:7.7.4.1]

(B) Radiator air discharge shall be ducted outdoors or to an exterior opening by a 2-hour fire-rated air transfer switch. [110:7.7.4.2]

4.4.1.1.12.5 Motor operated dampers, when used, shall be spring-operated to open and motor-closed. Fire dampers, shutters, or other self-closing devices shall not be permitted in ventilation openings or ductwork for supply or return/discharge air to EPS equipment for Level 1 EPSS. [110:7.7.5]

4.4.1.1.12.6 The ambient air temperature in the EPS equipment room or outdoor housing containing Level 1 rotating equipment shall be not less than 4.5°C (40°F). [110:7.7.6]

4.4.1.1.12.7 Units housed outdoors shall be heated as specified in 5.3.3 of NFPA 110, *Standard for Emergency and Standby Power Systems*. [110:7.7.7]

4.4.1.1.12.8 Design of the heating, cooling, and ventilation system for the EPS equipment room shall include provision for factors including, but not limited to, the following:

- (1) Heat
- (2) Cold
- (3) Dust
- (4) Humidity
- (5) Snow and ice accumulations around housings
- (6) Louvers
- (7) Remote radiator fans
- (8) Prevailing winds blowing against radiator fan discharge air [110:7.7.8]

4.4.1.1.13 Cranking Batteries. Internal combustion engine cranking batteries shall be in accordance with the battery requirements of NFPA 110, *Standard for Emergency and Standby Power Systems*.

4.4.1.1.14 Compressed Air Starting Devices. Other types of stored energy starting systems (except pyrotechnic) shall be permitted to be used where recommended by the manufacturer of the prime mover and subject to approval of the authority having jurisdiction, under the following conditions:

- (1) Where two complete periods of cranking cycles are completed without replacement of the stored energy
- (2) Where a means for automatic restoration from the emergency source of the stored energy is provided
- (3) Where the stored energy system has the cranking capacity specified in 5.6.4.2.1 of NFPA 110, *Standard for Emergency and Standby Power Systems*
- (4) Where the stored energy system has a "black start" capability in addition to normal discharge capability [110:5.6.4.1.2]

4.4.1.1.15 Fuel Supply. The fuel supply for the generator set shall comply with Sections 5.5 and 7.9 of NFPA 110, *Standard for Emergency and Standby Power Systems*.

4.4.1.1.16 Requirements for Safety Devices.

4.4.1.1.16.1 Internal Combustion Engines. Internal combustion engines serving generator sets shall be equipped with the following:

- (1) A sensor device plus visual warning device to indicate a water-jacket temperature below those required in 4.4.1.1.11
- (2) Sensor devices plus visual prealarm warning device to indicate the following:
 - (a) High engine temperature (above manufacturer's recommended safe operating temperature range)

- (b) Low lubricating oil pressure (below manufacturer's recommended safe operating range)
- (c) Low water coolant level

(3) An automatic engine shutdown device plus visual device to indicate that a shutdown took place due to the following:

- (a) Overcrank (failed to start)
- (b) Overspeed
- (c) Low lubricating oil pressure
- (d) Excessive engine temperature

(4) A common audible alarm device to warn that any one or more of the prealarm or alarm conditions exist

4.4.1.1.16.2 Safety indications and shutdowns shall be in accordance with Table 4.4.1.1.16.2.

4.4.1.1.17 Alarm Annunciator. A remote annunciator, storage battery-powered, shall be provided to operate outside of the generating room in a location readily observed by operating personnel at a regular work station (*see Section 700.12 of NFPA 70, National Electrical Code*). The annunciator shall be hard-wired to indicate alarm conditions of the emergency or auxiliary power source as follows:

- (1) Individual visual signals shall indicate the following:
 - (a) When the emergency or auxiliary power source is operating to supply power to load
 - (b) When the battery charger is malfunctioning
- (2) Individual visual signals plus a common audible signal to warn of an engine-generator alarm condition shall indicate the following:
 - (a) Low lubricating oil pressure
 - (b) Low water temperature (below those required in 4.4.1.1.11)
 - (c) Excessive water temperature
 - (d) Low fuel — when the main fuel storage tank contains less than a 4-hour operating supply
 - (e) Overcrank (failed to start)
 - (f) Overspeed

4.4.1.1.17.1* A remote, common audible alarm shall be provided as specified in 4.4.1.1.17.4 that is powered by the storage battery and located outside of the EPS service room at a work site observable by personnel. [110:5.6.6]

4.4.1.1.17.2 An alarm-silencing means shall be provided, and the panel shall include repetitive alarm circuitry so that, after the audible alarm has been silenced, it reactivates after the fault condition has been cleared and has to be restored to its normal position to be silenced again. [110:5.6.6.1]

4.4.1.1.17.3 In lieu of the requirement of 5.6.6.1 of NFPA 110, a manual alarm-silencing means shall be permitted that silences the audible alarm after the occurrence of the alarm condition, provided such means do not inhibit any subsequent alarms from sounding the audible alarm again without further manual action. [110:5.6.6.2]

4.4.1.1.17.4 Individual alarm indication to annunciate any of the conditions listed in Table 4.4.1.1.16.2 shall have the following characteristics:

- (1) Battery-powered
- (2) Visually indicated
- (3) Have additional contacts or circuits for a common audible alarm that signals locally and remotely when any of the itemized conditions occurs
- (4) Have a lamp test switch(es) to test the operation of all alarm lamps

Table 4.4.1.1.16.2 Safety Indications and Shutdowns

Indicator Function (at Battery Voltage)	Level 1		
	C.V.	S.	R.A.
(a) Overcrank	X	X	X
(b) Low water temperature	X		X
(c) High engine temperature prealarm	X		X
(d) High engine temperature	X	X	X
(e) Low lube oil pressure prealarm	X		X
(f) Low lube oil pressure	X	X	X
(g) Overspeed	X	X	X
(h) Low fuel main tank	X		X
(i) Low coolant level	X	O	X
(j) EPS supplying load	X		
(k) Control switch not in automatic position	X		X
(l) High battery voltage	X		
(m) Low cranking voltage	X		X
(n) Low voltage in battery	X		
(o) Battery charger ac failure	X		
(p) Lamp test	X		
(q) Contacts for local and remote common alarm	X		X
(r) Audible alarm silencing switch			X
(s) Low starting air pressure	X		
(t) Low starting hydraulic pressure	X		
(u) Air shutdown damper when used	X	X	X
(v) Remote emergency stop		X	

C.V.: Control panel-mounted visual. S.: Shutdown of EPS indication. R.A.: Remote audible. X: Required. O: Optional.

Notes:

- Item (p) shall be provided, but a separate remote audible signal shall not be required when the regular work site in 5.6.6 of NFPA 110 is staffed 24 hours a day.
- Item (b) is not required for combustion turbines.
- Item (r) or (s) shall apply only where used as a starting method.
- Item (j): EPS ac ammeter shall be permitted for this function.
- All required C.V. functions shall be visually annunciated by a remote, common visual indicator.
- All required functions indicated in the R.A. column shall be annunciated by a remote, common audible alarm as required in 5.6.5.2(4) of NFPA 110.
- Item (i) on gaseous systems shall require a low gas pressure alarm.
- Item (b) shall be set at 11°C (20°F) below the regulated temperature determined by the EPS manufacturer as required in 5.3.1 of NFPA 110.

4.4.1.2 Battery. Battery systems shall meet all requirements of Article 700 of NFPA 70, *National Electrical Code*.

4.4.2* Distribution (Type 1 EES).

4.4.2.1 General Requirements.

4.4.2.1.1 Electrical characteristics of the transfer switches shall be suitable for the operation of all functions and equipment they are intended to supply.

4.4.2.1.2 Switch Rating. The rating of the transfer switches shall be adequate for switching all classes of loads to be served and for withstanding the effects of available fault currents without contact welding.

4.4.2.1.3 Automatic Transfer Switch. Transfer of all loads shall be accomplished using automatic transfer switch(es). Each automatic transfer switch 600 volts or below shall be listed for the purpose and approved for emergency electrical service (see NFPA 70, *National Electrical Code, Article 700.3*) as a complete assembly.

4.4.2.1.4 Automatic Transfer Switch Features.

4.4.2.1.4.1 Source Monitoring.

(A)* Undervoltage-sensing devices shall be provided to monitor all ungrounded lines of the primary source of power as follows:

- (1) When the voltage on any phase falls below the minimum operating voltage of any load to be served, the transfer switch shall automatically initiate engine start and the process of transfer to the emergency power supply (EPS).
- (2)*When the voltage on all phases of the primary source returns to within specified limits for a designated period of time, the process of transfer back to primary power shall be initiated. [110:6.2.2.1]

(B) Both voltage-sensing and frequency-sensing equipment shall be provided to monitor one ungrounded line of the EPS power. [110:6.2.2.2]

(C) Transfer to the EPS shall be inhibited until the voltage and frequency are within a specified range to handle loads to be served. [110:6.2.2.3]

(D) Sensing equipment shall not be required in the transfer switch, provided it is included with the engine control panel. [110:6.2.2.3(A)]

(E) Frequency-sensing equipment shall not be required for monitoring the public utility source where used as an EPS, as permitted by 5.1.4 of NFPA 110, *Standard for Emergency and Standby Power Systems*. [110:6.2.2.3(B)]

4.4.2.1.4.2 Interlocking. Mechanical interlocking or an approved alternate method shall prevent the inadvertent interconnection of the primary power supply and the EPS, or any two separate sources of power. [110:6.2.3]

4.4.2.1.4.3* Manual Operation.

(A) Instruction and equipment shall be provided for safe manual nonelectric transfer in the event the transfer switch malfunctions. [110:6.2.4.1]

(B) An automatic transfer switch shall visually annunciate when “not-in-automatic.” [110:6.2.4.2]

4.4.2.1.4.4* Time Delay on Starting of EPS. A time-delay device shall be provided to delay starting of the EPS. The timer shall prevent nuisance starting of the EPS and possible subsequent load transfer in the event of harmless momentary power dips and interruptions of the primary source. [110:6.2.5]

4.4.2.1.4.5 Time Delay at Engine Control Panel. Time delays shall be permitted to be located at the engine control panel in lieu of in the transfer switches. [110:6.2.6]

4.4.2.1.4.6 Time Delay on Transfer to EPS. An adjustable time-delay device shall be provided to delay transfer and sequence load transfer to the EPS to avoid excessive voltage drop when the transfer switch is installed for Level 1 use. [110:6.2.7]

(A) **Time Delay Commencement.** The time delay shall commence when proper EPS voltage and frequency are achieved. [110:6.2.7.1]

(B) **Time Delay at Engine Control Panel.** Time delays shall be permitted to be located at the engine control panel in lieu of in the transfer switches. [110:6.2.7.2]

4.4.2.1.4.7* Time Delay on Retransfer to Primary Source. An adjustable time-delay device with automatic bypass shall be provided to delay retransfer from the EPS to the primary source of power, and allow the primary source to stabilize before retransfer of the load. [110:6.2.8]

4.4.2.1.4.8 Time Delay Bypass If EPS Fails. The time delay shall be automatically bypassed if the EPS fails. [110:6.2.9]

(A) The transfer switch shall be permitted to be programmed for a manually initiated retransfer to the primary source to provide for a planned momentary interruption of the load. [110:6.2.9.1]

(B) If used, the arrangement in 6.2.9.1 of NFPA 110, *Standard for Emergency and Standby Power Systems*, shall be provided with a bypass feature to allow automatic retransfer in the event that the EPS fails and the primary source is available. [110:6.2.9.2]

4.4.2.1.4.9 Time Delay on Engine Shutdown. A minimum time delay of 5 minutes shall be provided for unloaded running of the EPS prior to shutdown to allow for engine cooldown. [110:6.2.10]

(A) The minimum 5-minute delay shall not be required on small (15 kW or less) air-cooled prime movers. [110:6.2.10.1]

(B) A time-delay device shall not be required, provided it is included with the engine control panel, or if a utility feeder is used as an EPS. [110:6.2.10.2]

4.4.2.1.4.10 Engine Generator Exercising Timer. A program timing device shall be provided to exercise the EPS as described in Chapter 8 of NFPA 110, *Standard for Emergency and Standby Power Systems*. [110:6.2.11]

(A) Transfer switches for Level 1 and Level 2 shall transfer the connected load to the EPS and immediately return to primary power automatically in case of the EPS failure. [110:6.2.11.1]

(B) Exercising timers shall be permitted to be located at the engine control panel in lieu of in the transfer switches. [110:6.2.11.2]

(C) A program timing device shall not be required in health care facilities that provide scheduled testing in accordance with NFPA 99, *Standard for Health Care Facilities*. [110:6.2.11.3]

4.4.2.1.4.11 Test Switch. A test means shall be provided on each automatic transfer switch (ATS) that simulates failure of the primary power source and then transfers the load to the EPS. [110:6.2.12]

4.4.2.1.4.12* Indication of Switch Position. Two pilot lights with identification nameplates or other approved position indicators shall be provided to indicate the transfer switch position. [110:6.2.13]

4.4.2.1.4.13 Motor Load Transfer. Provisions shall be included to reduce currents resulting from motor load transfer if such currents could damage EPSS equipment or cause nuisance tripping of EPSS overcurrent protective devices. [110:6.2.14]

4.4.2.1.4.14* Isolation of Neutral Conductors. Provisions shall be included for ensuring continuity, transfer, and isolation of the primary and the EPS neutral conductors wherever they are separately grounded to achieve ground-fault sensing. [110:6.2.15]

4.4.2.1.4.15* Nonautomatic Transfer Switch Features. Switching devices shall be mechanically held and shall be operated by direct manual or electrical remote manual control. [110:6.2.16]

(A) **Interlocking.** Reliable mechanical interlocking, or an approved alternate method, shall prevent the inadvertent interconnection of the primary power source and the EPS. [110:6.2.16.1]

(B) **Indication of Switch Position.** Two pilot lights with identification nameplates, or other approved position indicators, shall be provided to indicate the switch position. [110:6.2.16.2]

4.4.2.1.5 Nonautomatic Transfer Device Classification. Non-automatic transfer devices 600 volts or below shall be listed for the purpose and approved.

4.4.2.1.6 Nonautomatic Transfer Device Features.

4.4.2.1.6.1 General. Switching devices shall be mechanically held and shall be operated by direct manual or electrical remote manual control. [110:6.2.16]

4.4.2.1.6.2 Interlocking. Reliable mechanical interlocking, or an approved alternate method, shall prevent the inadvertent interconnection of the primary power source and the EPS. [110:6.2.16.1]

4.4.2.1.6.3 Indication of Switch Position. Two pilot lights with identification nameplates, or other approved position indicators, shall be provided to indicate the switch position. [110:6.2.16.2]

4.4.2.1.7 Bypass-Isolation Switches. Bypass-isolation switches shall be permitted for bypassing and isolating the transfer switch and installed in accordance with 4.4.2.1.7.1 through 4.4.2.1.7.4. [110:6.4.1]

4.4.2.1.7.1 Bypass-Isolation Switch Rating. The bypass-isolation switch shall have a continuous current rating and a current rating compatible with that of the associated transfer switch. [110:6.4.2]

4.4.2.1.7.2 Bypass-Isolation Switch Classification. Each bypass-isolation switch shall be listed for emergency electrical service as a completely factory-assembled and factory-tested apparatus. [110:6.4.3]

4.4.2.1.7.3* Operation. With the transfer switch isolated or disconnected, the bypass-isolation switch shall be designed so it can function as an independent nonautomatic transfer switch and allow the load to be connected to either power source. [110:6.4.4]

4.4.2.1.7.4 Reconnection of Transfer Switch. Reconnection of the transfer switch shall be possible without a load interruption greater than the maximum time, in seconds, specified by the type of system. [110:6.4.5]

4.4.2.2 Specific Requirements.

4.4.2.2.1* General.

4.4.2.2.1.1 The emergency system shall be limited to circuits essential to life safety and critical patient care and are designated the life safety branch and the critical branch.

4.4.2.2.1.2 The equipment system shall supply major electrical equipment necessary for patient care and basic Type 1 operation.

4.4.2.2.1.3 Both systems shall be arranged for connection, within time limits specified in this chapter, to an alternate source of power following a loss of the normal source.

4.4.2.2.1.4 The number of transfer switches to be used shall be based upon reliability, design, and load considerations. Each branch of the emergency system and each equipment system shall have one or more transfer switches. One transfer switch shall be permitted to serve one or more branches or systems in a facility with a continuous load on the switch of 150 kVA (120 kW) or less.

4.4.2.2.2 Emergency System.

4.4.2.2.2.1 General. Those functions of patient care depending on lighting or appliances that shall be permitted to be connected to the emergency system are divided into two mandatory branches, described in 4.4.2.2.2.2 and 4.4.2.2.2.3.

4.4.2.2.2.2 Life Safety Branch. The life safety branch of the emergency system shall supply power for the following lighting, receptacles, and equipment:

- (1) Illumination of means of egress as required in NFPA 101, *Life Safety Code*
- (2) Exit signs and exit direction signs required in NFPA 101, *Life Safety Code*
- (3) Alarm and alerting systems including the following:
 - (a) Fire alarms
 - (b) Alarms required for systems used for the piping of non-flammable medical gases as specified in Chapter 5, Gas and Vacuum Systems
- (4)*Hospital communication systems, where used for issuing instruction during emergency conditions

- (5) Generator set location: Task illumination, battery charger for emergency battery-powered lighting unit(s), and selected receptacles at the generator set location and essential electrical system transfer switch locations
- (6) Elevator cab lighting, control, communication, and signal systems
- (7) Automatically operated doors used for building egress
- (8) The auxiliary functions of fire alarm combination systems complying with NFPA 72, *National Fire Alarm Code*

No function other than those listed in items 4.4.2.2.2(1) through 4.4.2.2.2(8) shall be connected to the life safety branch.

4.4.2.2.2.3* Critical Branch. The critical branch shall be permitted to be subdivided into two or more branches. The critical branch of the emergency system shall supply power for task illumination, fixed equipment, selected receptacles, and selected power circuits serving the following areas and functions related to patient care:

- (1) Critical care areas that utilize anesthetizing gases, task illumination, selected receptacles, and fixed equipment
- (2) The isolated power systems in special environments
- (3) Task illumination and selected receptacles in the following:
 - (a) Patient care areas, including infant nurseries, selected acute nursing areas, psychiatric bed areas (omit receptacles), and ward treatment rooms
 - (b) Medication preparation areas
 - (c) Pharmacy dispensing areas
 - (d) Nurses' stations (unless adequately lighted by corridor luminaires)
- (4) Additional specialized patient care task illumination and receptacles, where needed
- (5) Nurse call systems
- (6) Blood, bone, and tissue banks
- (7)*Telephone equipment rooms and closets
- (8) Task illumination, selected receptacles, and selected power circuits for the following areas:
 - (a) General care beds with at least one duplex receptacle per patient bedroom, and task illumination as required by the governing body of the health care facility
 - (b) Angiographic labs
 - (c) Cardiac catheterization labs
 - (d) Coronary care units
 - (e) Hemodialysis rooms or areas
 - (f) Emergency room treatment areas (selected)
 - (g) Human physiology labs
 - (h) Intensive care units
 - (i) Postoperative recovery rooms (selected)
- (9) Additional task illumination, receptacles, and selected power circuits needed for effective facility operation. Single-phase fractional horsepower motors shall be permitted to be connected to the critical branch.

4.4.2.2.3 Equipment System.

4.4.2.2.3.1 General. The equipment system shall be connected to equipment described in 4.4.2.2.3.3 through 4.4.2.2.3.5.

4.4.2.2.3.2 Connection to Alternate Power Source. The equipment system shall be installed and connected to the alternate power source, such that equipment described in 4.4.2.2.3.4 is automatically restored to operation at appropriate time-lag intervals following the energizing of the emergency system. Its arrangement shall also provide for the subsequent connection of equipment described in 4.4.2.2.3.5.

4.4.2.2.3.3 AC Equipment for Nondelayed Automatic Connection. Generator accessories, including, but not limited to, the transfer fuel pump, electrically operated louvers, and other generator accessories essential for generator operation, shall be arranged for automatic connection to the alternate power source.

4.4.2.2.3.4* Equipment for Delayed-Automatic Connection. The following equipment shall be permitted to be arranged for delayed-automatic connection to the alternate power source:

- (1) Central suction systems serving medical and surgical functions, including controls. It shall be permitted to place such suction systems on the critical branch.
- (2) Sump pumps and other equipment required to operate for the safety of major apparatus, including associated control systems and alarms.
- (3) Compressed air systems serving medical and surgical functions, including controls. It shall be permitted to place such air systems on the critical branch.
- (4) Smoke control and stair pressurization systems.
- (5) Kitchen hood supply and/or exhaust systems, if required to operate during a fire in or under the hood.
- (6) Supply, return, and exhaust ventilating systems for airborne infectious/isolation rooms, protective environment rooms, exhaust fans for laboratory fume hoods, nuclear medicine areas where radioactive material is used, ethylene oxide evacuation, and anesthetic evacuation. Where delayed automatic connection is not appropriate, such ventilation systems shall be permitted to be placed on the critical branch.

4.4.2.2.3.5* Equipment for Delayed-Automatic or Manual Connection. The following equipment shall be permitted to be arranged for either delayed-automatic or manual connection to the alternate power source (*also see A.4.4.2.2.3.4*):

- (1) Heating equipment to provide heating for operating, delivery, labor, recovery, intensive care, coronary care, nurseries, infection/isolation rooms, emergency treatment spaces, and general patient rooms; and pressure maintenance (jockey or make-up) pump(s) for water-based fire protection systems.
- (2)*Heating of general patient rooms during disruption of the normal source shall not be required under any of the following conditions:
 - (a) The outside design temperature is higher than -6.7°C ($+20^{\circ}\text{F}$).
 - (b) The outside design temperature is lower than -6.7°C ($+20^{\circ}\text{F}$) and a selected room(s) is provided for the needs of all confined patients [then only such room(s) need be heated].
 - (c) The facility is served by a dual source of normal power as described in 4.3.2.1.
- (3) Elevator(s) selected to provide service to patient, surgical, obstetrical, and ground floors during interruption of normal power.
- (4) Supply, return, and exhaust ventilating systems for surgical and obstetrical delivery suites, intensive care, coronary care, nurseries, and emergency treatment spaces.
- (5) Hyperbaric facilities.
- (6) Hypobaric facilities.
- (7) Autoclaving equipment shall be permitted to be arranged for either automatic or manual connection to the alternate source.

(8) Controls for equipment listed in 4.4.2.2.3.

(9)*Other selected equipment shall be permitted to be served by the equipment system.

4.4.2.2.4 Wiring Requirements.

4.4.2.2.4.1* Separation from Other Circuits. The life safety branch and critical branch of the emergency system shall be kept entirely independent of all other wiring and equipment.

4.4.2.2.4.2 Receptacles. The requirements for receptacles shall comply with 4.4.2.2.4.2(A) and 4.4.2.2.4.2(B).

(A) The number of receptacles on a single branch circuit for areas described in 4.4.2.2.2.3(8) shall be minimized to limit the effects of a branch circuit outage. Branch circuit overcurrent devices shall be readily accessible to authorized personnel.

(B)* The electrical receptacles or the cover plates for the electrical receptacles supplied from the emergency system shall have a distinctive color or marking so as to be readily identifiable.

4.4.2.2.4.3 Switches. Switches installed in the lighting circuits connected to the essential electrical system shall comply with Article 700, Section V, of NFPA 70, *National Electrical Code*.

4.4.2.2.4.4 Mechanical Protection of the Emergency System. The wiring of the emergency system shall be mechanically protected by raceways, as defined in NFPA 70, *National Electrical Code*.

4.4.2.2.4.5 Flexible power cords of appliances or other utilization equipment connected to the emergency system shall not be required to be enclosed in raceways.

4.4.2.2.4.6 Secondary circuits of transformer-powered communication or signaling systems shall not be required to be enclosed in raceways unless otherwise specified by Chapters 7 or 8 of NFPA 70, *National Electrical Code*.

4.4.3 Performance Criteria and Testing (Type 1 EES).

4.4.3.1 Source. The branches of the emergency system shall be installed and connected to the alternate power source specified in 4.4.1.1.4 and 4.4.1.1.5 so that all functions specified herein for the emergency system shall be automatically restored to operation within 10 seconds after interruption of the normal source.

4.4.3.2 Transfer Switches.

4.4.3.2.1 All ac-powered support and accessory equipment necessary to the operation of the EPS shall be supplied from the load side of the automatic transfer switch(es), or the output terminals of the EPS, ahead of the main EPS overcurrent protection, as necessary, to ensure continuity of the EPSS operation and performance. [110:7.12.5]

4.4.3.2.2 The essential electrical system shall be served by the normal power source except when the normal power source is interrupted or drops below a predetermined voltage level. Settings of the sensors shall be determined by careful study of the voltage requirements of the load.

4.4.3.2.3 Failure of the normal source shall automatically start the alternate source generator after a short delay as described in 4.4.2.1.4.4. When the alternate power source has attained a voltage and frequency that satisfies minimum operating requirements of the essential electrical system, the load shall be connected automatically to the alternate power source.

4.4.3.2.4 Upon connection of the alternate power source, the loads comprising the emergency system shall be automatically re-energized. The load comprising the equipment system shall be connected either automatically after a time

delay as described in 4.4.2.1.4.6 or nonautomatically and in such a sequential manner as not to overload the generator.

4.4.3.2.5 When the normal power source is restored, and after a time delay as described in 4.4.2.1.4.7, the automatic transfer switches shall disconnect the alternate source of power and connect the loads to the normal power source. The alternate power source generator set shall continue to run unloaded for a preset time delay as described in 4.4.2.1.4.9.

4.4.3.2.6 If the emergency power source fails and the normal power source has been restored, retransfer to the normal source of power shall be immediate, bypassing the retransfer delay timer.

4.4.3.2.7 If the emergency power source fails during a test, provisions shall be made to immediately retransfer to the normal source.

4.4.3.2.8 Nonautomatic transfer switching devices shall be restored to the normal power source as soon as possible after the return of the normal source or at the discretion of the operator.

4.4.4 Administration (Type 1 EES).

4.4.4.1 Maintenance and Testing of Essential Electrical System.

4.4.4.1.1 Maintenance and Testing of Alternate Power Source and Transfer Switches.

4.4.4.1.1.1 Maintenance of Alternate Power Source. The generator set or other alternate power source and associated equipment, including all appurtenant parts, shall be so maintained as to be capable of supplying service within the shortest time practicable and within the 10-second interval specified in 4.4.1.1.10 and 4.4.3.1. Maintenance shall be performed in accordance with NFPA 110, *Standard for Emergency and Standby Power Systems*, Chapter 8.

4.4.4.1.1.2 Inspection and Testing. Criteria, conditions, and personnel requirements shall be in accordance with 4.4.4.1.1.2(A) through 4.4.4.1.1.2(C).

(A)* Test Criteria. Generator sets shall be tested 12 times a year with testing intervals between not less than 20 days or exceeding 40 days. Generator sets serving emergency and equipment systems shall be tested in accordance with NFPA 110, *Standard for Emergency and Standby Power Systems*, Chapter 8.

(B) Test Conditions. The scheduled test under load conditions shall include a complete simulated cold start and appropriate automatic and manual transfer of all essential electrical system loads.

(C) Test Personnel. The scheduled tests shall be conducted by competent personnel. The tests are needed to keep the machines ready to function and, in addition, serve to detect causes of malfunction and to train personnel in operating procedures.

4.4.4.1.2 Maintenance and Testing of Circuitry.

4.4.4.1.2.1* Circuit Breakers. Main and feeder circuit breakers shall be inspected annually and a program for periodically exercising the components shall be established according to manufacturer's recommendations.

4.4.4.1.2.2 Insulation Resistance. The resistance readings of main feeder insulation shall be taken prior to acceptance and whenever damage is suspected.

4.4.4.1.3 Maintenance of Batteries. Batteries for on-site generators shall be maintained in accordance with NFPA 110, *Standard for Emergency and Standby Power Systems*.

4.4.4.2 Recordkeeping. A written record of inspection, performance, exercising period, and repairs shall be regularly maintained and available for inspection by the authority having jurisdiction.

4.5 Essential Electrical System Requirements — Type 2.

4.5.1 Sources (Type 2 EES). The requirements for sources for Type 2 essential electrical systems shall conform to those listed in 4.4.1.

4.5.2 Distribution (Type 2 EES).

4.5.2.1 General. The distribution requirements for Type 2 essential electrical systems shall conform to those listed in 4.4.2.1.

4.5.2.2 Specific Requirements.

4.5.2.2.1* General. The number of transfer switches to be used shall be based upon reliability, design, and load considerations. Each branch of the emergency system and each critical system shall have one or more transfer switches. One transfer switch shall be permitted to serve one or more branches or systems in a facility with a continuous load on the switch of 150 kVA (120 kW) or less.

4.5.2.2.2 Emergency System. The emergency system shall supply power for lighting, receptacles, and equipment as follows:

- (1) Illumination of means of egress in accordance with NFPA 101, *Life Safety Code*
- (2) Exit signs and exit directional signs in accordance with NFPA 101, *Life Safety Code*
- (3) Alarm and alerting systems, including the following:
 - (a) Fire alarms
 - (b) Alarms required for systems used for the piping of non-flammable medical gases as specified in Chapter 5, Gas and Vacuum Systems
- (4)*Communication systems, where used for issuing instructions during emergency conditions
- (5) Sufficient lighting in dining and recreation areas to provide illumination to exit ways of a minimum of 5 ft-candles
- (6) Task illumination and selected receptacles at the generator set location
- (7) Elevator cab lighting, control, communication, and signal systems

No function other than those listed in 4.5.2.2.2(1) through 4.5.2.2.2(7) shall be connected to the emergency system.

4.5.2.2.3 Critical System.

4.5.2.2.3.1 General. The critical system shall be so installed and connected to the alternate power source that equipment listed in 4.5.2.2.3.2 shall be automatically restored to operation at appropriate time-lag intervals following the restoration of the emergency system to operation. Its arrangement shall also provide for the additional connection of equipment listed in 4.5.2.2.3.3.

4.5.2.2.3.2 AC Equipment for Nondelayed Automatic Connection. Generator accessories, including but not limited to, the transfer fuel pump, electrically operated louvers, and other generator accessories essential for generator operation, shall be arranged for automatic connection to the alternative power source.

4.5.2.2.3.3 Delayed-Automatic Connections to Critical System. The following equipment shall be permitted to be connected to the critical system and be arranged for delayed-automatic connection to the alternate power source:

- (1) Task illumination and selected receptacles in the following:
 - (a) Patient care areas
 - (b) Medication preparation areas
 - (c) Pharmacy dispensing areas
 - (d) Nurses' stations (unless adequately lighted by corridor luminaires)
- (2) Supply, return, and exhaust ventilating systems for airborne infectious isolation rooms
- (3) Sump pumps and other equipment required to operate for the safety of major apparatus and associated control systems and alarms
- (4) Smoke control and stair pressurization systems
- (5) Kitchen hood supply and/or exhaust systems, if required to operate during a fire in or under the hood

4.5.2.2.3.4* Delayed-Automatic or Manual Connections to Critical System. The equipment in 4.5.2.2.3.4(A) and 4.5.2.2.3.4(B) shall be permitted to be connected to the critical system and be arranged for either delayed-automatic or manual connection to the alternate power source.

(A) Heating Equipment to Provide Heating for General Patient Rooms. Heating of general patient rooms during disruption of the normal source shall not be required under any of the following conditions:

- (1)*The outside design temperature is higher than -6.7°C ($+20^{\circ}\text{F}$).
- (2) The outside design temperature is lower than -6.7°C ($+20^{\circ}\text{F}$) and, where a selected room(s) is provided for the needs of all confined patients, then only such room(s) need be heated.
- (3) The facility is served by a dual source of normal power as described in A.4.4.1.1.1.

(B)* Elevator Service. In instances where interruptions of power would result in elevators stopping between floors, throw-over facilities shall be provided to allow the temporary operation of any elevator for the release of passengers.

(C) Optional Connections to the Critical System. Additional illumination, receptacles, and equipment shall be permitted to be connected only to the critical system.

(D) Multiple Systems. Where one switch serves multiple systems as permitted under 4.5.2.2, transfer for all loads shall be nondelayed automatic.

4.5.2.2.4 Wiring Requirements.

4.5.2.2.4.1* Separation from Other Circuits. The emergency system shall be kept entirely independent of all other wiring and equipment.

4.5.2.2.4.2* Receptacles. The electrical receptacles or the cover plates for the electrical receptacles supplied from the emergency system shall have a distinctive color or marking so as to be readily identifiable.

4.5.3 Performance Criteria and Testing (Type 2 EES).

4.5.3.1 Source. The emergency system shall be installed and connected to the alternate source of power specified in 4.4.1.1.4 and 4.4.1.1.5 so that all functions specified herein for the emer-

gency system will be automatically restored to operation within 10 seconds after interruption of the normal source.

4.5.3.2 Transfer Switches.

4.5.3.2.1 The essential electrical system shall be served by the normal power source until the normal power source is interrupted or drops below a predetermined voltage level. Settings of the sensors shall be determined by careful study of the voltage requirements of the load.

4.5.3.2.2 Failure of the normal source shall automatically start the alternate source generator, after a short delay as described in 4.4.2.1.4.4. When the alternate power source has attained a voltage and frequency that satisfies minimum operating requirements of the essential electrical system, the load shall be connected automatically to the alternate power source.

4.5.3.2.2.1 All ac-powered support and accessory equipment necessary to the operation of the EPS shall be supplied from the load side of the automatic transfer switch(es), or the output terminals of the EPS, ahead of the main EPS overcurrent protection to ensure continuity of the EPSS operation and performance.

4.5.3.2.3 Upon connection of the alternate power source, the loads comprising the emergency system shall be automatically reenergized. The loads comprising the critical system shall be connected either automatically after a time delay as described in 4.4.2.1.4.6 or nonautomatically and in such a sequential manner as not to overload the generator.

4.5.3.2.4 When the normal power source is restored, and after a time delay as described in 4.4.2.1.4.7, the automatic transfer switches shall disconnect the alternate source of power and connect the loads to the normal power source. The alternate power source generator set shall continue to run unloaded for a preset time delay as described in 4.4.2.1.4.9.

4.5.3.2.5 If the emergency power source fails and the normal power source has been restored, retransfer to the normal source of power shall be immediate, bypassing the retransfer delay timer.

4.5.3.2.6 If the emergency power source fails during a test, provisions shall be made to immediately retransfer to the normal source.

4.5.3.2.7 Nonautomatic transfer switching devices shall be restored to the normal power source as soon as possible after the return of the normal source or at the discretion of the operator.

4.5.4 Administration (Type 2 EES).

4.5.4.1 Maintenance and Testing of Essential Electrical System.

4.5.4.1.1 Maintenance and Testing of Alternate Power Source and Transfer Switches.

4.5.4.1.1.1 Maintenance of Alternate Power Source. The generator set or other alternate power source and associated equipment, including all appurtenant parts, shall be so maintained as to be capable of supplying service within the shortest time practicable and within the 10-second interval specified in 4.4.1.1.7 and 4.4.3.1.

4.5.4.1.1.2 Inspection and Testing. Generator sets shall be inspected and tested in accordance with 4.4.4.1.1.2.

4.5.4.1.1.2 Maintenance and Testing of Circuitry. Circuitry shall be maintained and tested in accordance with 4.4.4.1.2.

4.5.4.1.1.3 Maintenance of Batteries. Batteries shall be maintained in accordance with 4.4.4.1.3.

4.5.4.2 Recordkeeping. A written record of inspection, performance, exercising period, and repairs shall be regularly maintained and available for inspection by the authority having jurisdiction.

4.6 Essential Electrical System Requirements — Type 3.

4.6.1 Sources (Type 3 EES). The alternate source of power for the system shall be specifically designed for this purpose and shall be either a generator, battery system, or self-contained battery integral with the equipment.

4.6.1.1 Generators shall conform to 4.4.1.1 and 4.4.1.1.6.2.

4.6.1.2 Battery systems shall conform to 4.4.1.2.

4.6.2 Distribution (Type 3 EES).

4.6.2.1 General. The distribution requirements for Type 3 essential electrical systems shall conform to those listed in 4.4.2.1.

4.6.2.2 Specific Requirements.

4.6.2.2.1* General.

4.6.2.2.2 Connection to the Essential Electrical System. The system shall supply power for task illumination that is related to the safety of life and that is necessary for the safe cessation of procedures in progress.

4.6.2.2.3 Wiring Requirements.

4.6.2.2.3.1 General. The design, arrangement, and installation of the system shall be in accordance with NFPA 70, *National Electrical Code*.

4.6.2.2.3.2* Receptacles. The cover plates for the electrical receptacles or the electrical receptacles themselves supplied from the emergency system shall have a distinctive color or marking so as to be readily identifiable.

4.6.3 Performance Criteria and Testing (Type 3 EES).

4.6.3.1 Source.

4.6.3.1.1 The emergency system shall have an alternate source of power separate and independent from the normal source that will be effective for a minimum of 1½ hours after loss of the normal source.

4.6.3.1.2 The emergency system shall be so arranged that, in the event of failure of normal power source, the alternate source of power shall be automatically connected to the load within 10 seconds.

4.6.3.2 Transfer Switches with Engine Generator Sets.

4.6.3.2.1 The operation of the equipment shall be arranged such that the load will be served by the normal source until the normal source is interrupted, or when the voltage drops below the setting of the voltage-sensing device. The settings of the voltage-sensing relays shall be determined by careful study of the voltage requirements of the load.

4.6.3.2.2 When the normal source is restored, and after a time delay as described in 4.4.2.1.4.7, the automatic transfer switch shall disconnect the alternate source of power and connect the loads to the normal power source.

4.6.3.2.3 If the alternate power source fails and the normal power source has been restored, retransfer to the normal source of power shall be immediate.

4.6.3.3 Transfer Switches with Battery System.

4.6.3.3.1 Failure of the normal source shall automatically transfer the load to the battery system.

4.6.3.3.2 Retransfer to the normal source shall be automatic upon restoration of the normal source.

4.6.4 Administration (Type 3 EES).

4.6.4.1 Maintenance and Testing.

4.6.4.1.1 Maintenance and Testing of Alternate Power Source and Transfer Switches.

4.6.4.1.1.1 Maintenance of Alternate Power Source. The generator set or other alternate power source and associated equipment, including all appurtenant parts, shall be so maintained as to be capable of supplying service within the shortest time practicable and within the 10-second interval specified in 4.4.1.1.10 and 4.6.3.1.2.

4.6.4.1.1.2 Inspection and Testing. Generator sets shall be inspected and tested in accordance with 4.4.4.1.1.2.

4.6.4.1.1.3 Stored Energy Power Source. Maintenance and testing of stored emergency power supply systems shall be in accordance with NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems*, Section 6.1 through 6.4.5.

4.6.4.1.2 Maintenance and Testing Circuitry. Circuitry shall be maintained and tested in accordance with 4.4.4.1.2.

4.6.4.1.3 Maintenance of Batteries. Batteries shall be maintained in accordance with 4.4.4.1.3.

4.6.4.2 Recordkeeping. A written record of inspection, performance, exercising period, and repairs shall be regularly maintained and available for inspection by the authority having jurisdiction.

Chapter 5 Gas and Vacuum Systems

5.1 Level 1 Piped Gas and Vacuum Systems.

5.1.1* Applicability.

5.1.1.1 These requirements shall apply to health care facilities that require Level 1 systems as referenced in Chapters 13 through 21.

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

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 standard 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.

5.1.2 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* Level 1 Sources.

5.1.3.1 Central Supply System Identification and Labeling.

5.1.3.1.1* Only cylinders and containers constructed, tested, and maintained in accordance with U.S. Department of Transportation specifications and regulations shall be permitted to be used.

5.1.3.1.2 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 Inlet and Outlet 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 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 substantially as follows:

CAUTION

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:

CAUTION

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 5.1.13.

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 Wooden racks for cylinder storage shall be permitted.

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

5.1.3.2.7 Cylinders not in use shall have their valve protection caps secured tightly in place.

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

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

5.1.3.2.10 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.

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

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

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

5.1.3.3* Central Supply System Locations.

5.1.3.3.1 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 5.1.3.4.10.*)
- (2) Manifolds for gas cylinders with reserve supply
- (3) Manifolds for cryogenic liquid containers (*See 5.1.3.4.12.*)
- (4) Bulk cryogenic liquid systems (*See 5.1.3.4.13.*)

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 5.1.3.4.10.*)
- (2) Manifolds for gas cylinders with reserve supply
- (3) Manifolds for cryogenic liquid containers (*See 5.1.3.4.12.*)
- (4) In-building emergency reserves (*See 5.1.3.4.15.*)
- (5) Instrument air standby headers (*See 5.1.3.8.5.*)

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 5.1.3.5.3.*)
- (2) Medical-surgical vacuum sources (*See 5.1.3.6.*)
- (3) Waste anesthetic gas disposal (WAGD) sources (*See 5.1.3.7.*)
- (4) Instrument air compressor sources (*See 5.1.3.8.*)
- (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 5.1.3.8.5 shall be allowed to be in the same room as an instrument air compressor.

5.1.3.3.1.5 Locations shall be chosen to permit access by delivery vehicles and management of cylinders (e.g., proximity to loading docks, access to elevators, 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
- (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 -7°C (20°F) or greater than 54°C (130°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 at standard temperature and pressure (STP) shall comply with NFPA 50, *Standard for Bulk Oxygen Systems at Consumer Sites*.

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*.

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

- (1) Be constructed with access to move cylinders, equipment, and so forth, in and out of the location on hand trucks complying with 9.5.3.1.1
- (2) Be secured with lockable doors or gates or otherwise secured
- (3) If outdoors, be provided with an enclosure (wall or fencing) constructed of noncombustible materials
- (4) If indoors, 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) Be compliant with NFPA 70, *National Electrical Code*, for ordinary locations, with electrical devices located at or above 1520 mm (5 ft) above finished floor to avoid physical damage
- (6) Be heated by indirect means (e.g., steam, hot water), if heat is required
- (7) Be provided with racks, chains, or other fastenings to secure all cylinders, whether connected, unconnected, full, or empty, from falling

(8) Be supplied with electrical power compliant with the requirements for essential electrical systems as described in Chapter 4 of this document

(9) Have racks, shelves, and supports, where provided, constructed of noncombustible materials or limited-combustible materials

5.1.3.3.3 Ventilation.

5.1.3.3.3.1 Ventilation of Locations for Manifolds. Locations containing central supply systems or used for storing medical gas containers shall be ventilated to prevent the accumulation of medical gases from leaks and operation of cylinder or manifold overpressure safety devices in accordance with 5.1.3.3.3.1(A) through 5.1.3.3.3.1(G).

(A) Indoor supply systems shall have all relief valves vented per 5.1.3.4.6.1(4) through 5.1.3.4.6.1(9).

(B) Where the total volume of medical gases connected and in storage is greater than 84,950 L (3000 ft³) at STP, indoor supply locations shall be provided with dedicated mechanical ventilation systems that draw air from within 300 mm (1 ft) of the floor and operate continuously. A means of makeup air shall be provided.

(C) The power supply for mechanical ventilation fans shall conform to the requirements of an essential electrical system as described in Chapter 4 of this document.

(D) Where the total volume of medical gases connected and in storage is less than 84,950 L (3000 ft³) at STP or the only compressed gas in the room is medical air, natural ventilation shall be permitted to be employed.

(E) Where natural ventilation is permitted, it shall consist of two louvered openings, each having a minimum free area of 46,500 mm² (72 in.²), with one located within 300 mm (1 ft) of the floor and one located within 300 mm (1 ft) of the ceiling.

(F) Louvered natural ventilation openings shall not be located in an exit access corridor.

(G) Mechanical ventilation shall be provided if the requirements of 5.1.3.3.3.1(F) cannot be met.

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 5.1.3.5.*)
- (2) Medical-surgical vacuum sources (*See 5.1.3.6.*)
- (3) Waste anesthetic gas disposal (WAGD) sources (*See 5.1.3.7.1.*)
- (4) Instrument air sources (*See 5.1.3.8.*)

5.1.3.3.3.3 Ventilation for Outdoor Locations. 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. 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 medical air compressor

sources, medical vacuum supply systems, or WAGD supply systems. Only cylinders intended for instrument air reserve headers complying with 5.1.3.8.5 shall be permitted to be stored in enclosures containing instrument air compressors.

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

- (1) Cylinder manifolds for gas cylinders per 5.1.3.4.10
- (2) Manifolds for cryogenic liquid containers per 5.1.3.4.12
- (3) Bulk cryogenic liquid systems per 5.1.3.4.13
- (4) Medical air compressor systems per 5.1.3.5
- (5) Medical-surgical vacuum producers per 5.1.3.6
- (6) WAGD producers per 5.1.3.7
- (7) Instrument air compressor systems per 5.1.3.8

5.1.3.4.1 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.

5.1.3.4.2* Central supply systems for oxygen, medical air, nitrous oxide, carbon dioxide, and all other patient medical gases shall not be piped to, or used for, any purpose except patient care application. Medical air shall be used only in the application of human respiration, and calibration of medical devices for respiratory application.

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

5.1.3.4.4* 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 2070 kPa (300 psi), interconnecting hose shall contain no polymeric materials.
- (2) In those portions of systems intended to handle oxygen or nitrous oxide at gauge pressures of less than 2070 kPa (300 psi), 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.

5.1.3.4.5 Final Line Pressure Regulators.

5.1.3.4.5.1 All positive pressure central supply systems shall be provided with duplex final line pressure regulators, installed in parallel with isolation valves before each regulator, and an isolation or check valve after each regulator permitting service to either regulator without interruption of supply.

5.1.3.4.5.2 The line pressure regulators required under 5.1.3.4.5.1 when used for bulk cryogenic liquid systems shall be of a balanced design.

5.1.3.4.5.3 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.

5.1.3.4.6 Relief Valves.

5.1.3.4.6.1 All pressure relief valves shall meet the following requirements:

- (1) Be of brass, bronze, or stainless steel construction
- (2) Be designed for the specific gas service
- (3) Have a relief pressure setting not higher than the maximum allowable working pressure (MAWP) of the component with lowest working pressure rating in the portion of the system being protected
- (4) 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) 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) Shall not discharge into locations creating potential hazards
- (8) Have the discharge terminal turned down and screened to prevent the entry of rain, snow, or vermin
- (9) Shall be designed in accordance with ASME B31.3, *Pressure Process Piping*

5.1.3.4.6.2 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*).

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

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

5.1.3.4.6.4 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.

5.1.3.4.7 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: 5.1.3.4.5 (pressure regulators), 5.1.3.4.6 (relief valves), 5.1.4.4 (source valve), 5.1.9.2.4(7) (master alarm)

5.1.3.4.8 Local Signals.

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

- (1) Manifolds for gas cylinders without reserve supply (*See 5.1.3.4.10.*)
- (2) Manifolds for gas cylinders with reserve supply
- (3) Manifolds for cryogenic liquid containers (*See 5.1.3.4.12.*)
- (4) Bulk cryogenic liquid systems (*See 5.1.3.4.13.*)
- (5) In-building emergency reserves (*See 5.1.3.4.15.*)
- (6) Instrument air headers (*See 5.1.3.4.9.*)

5.1.3.4.8.2 The local signals shall meet the following requirements:

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

5.1.3.4.9* 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) A cylinder lead for each cylinder constructed of materials complying with 5.1.3.4.4 and provided with end fittings permanently attached to the cylinder lead complying with CGA V-1, *Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections* (ANSI B57.1)
- (3) A filter of a material complying with 5.1.3.4.4 to prevent the intrusion of debris into the manifold controls
- (4) A 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) A pressure indicator indicating the pressure of header contents
- (6) A check valve to prevent backflow into the header and to permit service to the header
- (7) If intended for gas cylinder service, a check valve at each connection for the cylinder lead in 5.1.3.4.9(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 permit 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, shall be vented outside of the building per 5.1.3.4.6.1(5) through 5.1.3.4.6.1(9) and 5.1.3.4.6.2.

5.1.3.4.10* Manifolds for Gas Cylinders without Reserve Supply.

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

- (1) If located outdoors, be installed in an enclosure used only for this purpose and sited to comply with minimum distance requirements in Figure 5.1.3.4.10.1
- (2) If located indoors, be installed within a room used only for this purpose

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

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

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

- (1) Two equal headers in accordance with 5.1.3.4.9, 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 may supply the system
- (2) Vent valves, if fitted on a header, vented outside of the building per 5.1.3.4.6.1(5) through 5.1.3.4.6.1(9) and 5.1.3.4.6.2
- (3) An intermediate relief valve(s), piped to the outside in accordance with 5.1.3.4.6.1(5) through 5.1.3.4.6.1(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

5.1.3.4.10.5 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.

5.1.3.4.10.6 The manifolds in this category shall actuate a local signal 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.

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

5.1.3.4.11 Manifolds for Gas Cylinders with Reserve Supply. See Figure 5.1.3.4.10.1.

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

- (1) If located outdoors, be installed in an enclosure used only for this purpose and sited to comply with minimum distance requirements in Figure 5.1.3.4.10.1
- (2) If located indoors, be installed within a room used only for this purpose

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

5.1.3.4.11.3 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 5.1.3.4.11.1.

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

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

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

- (1) Two equal headers per 5.1.3.4.9 each having 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 may supply the system
- (2) A reserve header per 5.1.3.4.9 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) An intermediate relief valve(s), piped to the outside in accordance with 5.1.3.4.6.1(5) through 5.1.3.4.6.1(9), that protects the line pressure regulators from overpressure in the event of a header regulator failure

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

- (1) One gas cylinder header is the primary and the other is the secondary, with either 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 serve the system.

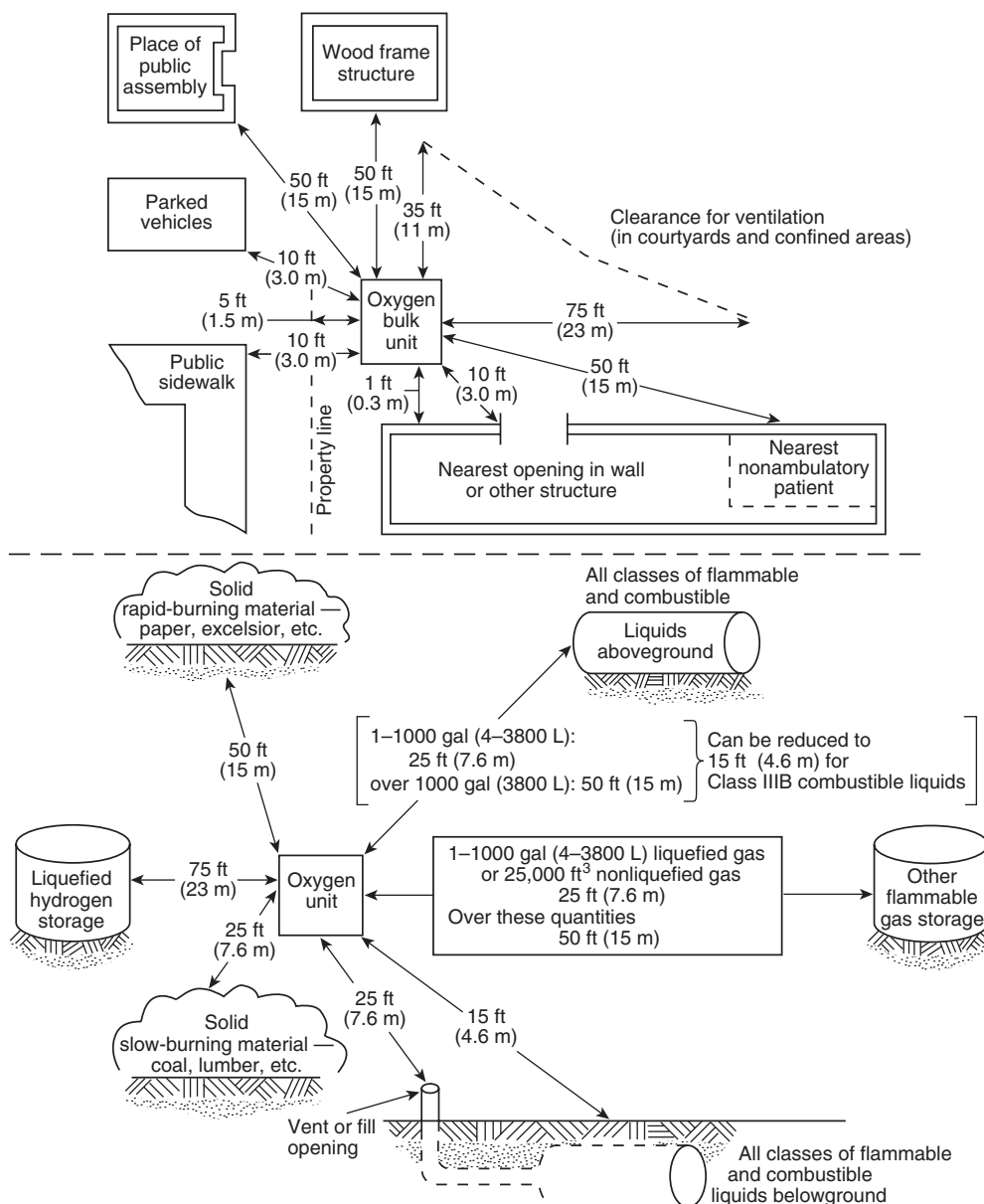


FIGURE 5.1.3.4.10.1 Distance Between Bulk Oxygen Systems and Exposures.

5.1.3.4.11.8 The manifolds in this category shall include a manual or automatic means to place either header into the role as primary header and the other in the role of secondary header.

5.1.3.4.11.9 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.

5.1.3.4.11.10 The manifolds in this category shall actuate a local signal and shall activate 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) When or at a predetermined set point before the reserve header begins to supply the system, indicating reserve is in use

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

5.1.3.4.11.11 If manifolds in this category are located outdoors, they shall be installed per manufacturer's requirements.

5.1.3.4.12* Manifolds for Cryogenic Liquid Containers.

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

- (1) If located outdoors, be installed in an enclosure used only for this purpose and sited to comply with minimum distance requirements in Figure 5.1.3.4.10.1
- (2) If located indoors, be installed within a room used only for this purpose

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

5.1.3.4.12.3 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 5.1.3.4.12.1.

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

- (1) Two equal headers, per 5.1.3.4.9, 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 may supply the system
- (2) A reserve header, per 5.1.3.4.9, 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) A 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

5.1.3.4.12.5 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 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.

5.1.3.4.12.6 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.

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

5.1.3.4.12.8 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.

5.1.3.4.12.9 The manifolds in this category shall actuate a local signal and shall activate 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

5.1.3.4.12.10 A variant on the cryogenic liquid container manifold shall be permitted having three headers of cylinders. Such a variant shall comply with all requirements of 5.1.3.4.12, except:

- (1) The minimum number of cylinder connections required for each header under 5.1.3.4.12.4(1) shall be two.
- (2) Paragraph 5.1.3.4.12.6 shall not apply.

5.1.3.4.13* Bulk Cryogenic Liquid Systems.

5.1.3.4.13.1 Bulk cryogenic liquid systems shall have the following protections:

- (1) Oxygen systems compliant with NFPA 50, *Standard for Bulk Oxygen Systems at Consumer Sites*; NFPA 55, *Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks*; or Chapter 9, Bulk Oxygen Systems, of NFPA 50, 1996 edition.
- (2) Location in an enclosure constructed per 5.1.3.3.2(1) through 5.1.3.3.2(3) and 5.1.3.3.2(5), 5.1.3.3.2(8), and 5.1.3.3.2(9)
- (3) Location in an enclosure ventilated per 5.1.3.3.3
- (4) Location in compliance with CGA M-1, *Guide for Medical Gas Installations at Consumer Sites*
- (5) Design such that the items noted in 5.1.3.4.13.2 and items located in trailer unloading area are readily visible to delivery personnel during filling operations
- (6) Protection against overpressurization of the pressure vessel during filling operations
- (7) Installation per 5.1.10.1 through 5.1.10.5.7
- (8) Installation by personnel qualified to meet CGA M-1, *Guide for Medical Gas Installations at Consumer Sites*
- (9) Installation in compliance with Food and Drug Administration (FDA) Current Good Manufacturing Practices as found in 21 CFR 210 and 21 CFR 211

5.1.3.4.13.2 The following components of the bulk system shall be readily accessible to delivery personnel:

- (1) Fill connection
- (2) Top and bottom fill valves
- (3) Hose purge valve
- (4) Vent valve
- (5) Full try/cock
- (6) Liquid level gauge
- (7) Tank pressure gauge

5.1.3.4.13.3 Bulk cryogenic liquid system sites shall include the following:

- (1) A poured concrete pad, designed for the weight, dynamic loads, wind loads, and surface loading, and complying with local seismic requirements
- (2) Permanent anchors holding the components to the pad in accordance with the design requirements
- (3) A complete enclosure as per 5.1.3.3.2(3)
- (4) Concrete or crushed stone completely filling the enclosed space.
- (5) A vehicle pad for the delivery vehicle that is compliant with NFPA 50, *Standard for Bulk Oxygen Systems at Consumer Sites*, and readily accessible for refilling supply as stated in CGA M-1, *Guide for Medical Gas Installations at Consumer Sites*

- (6) Allowance for at least 1 m (3 ft) of clearance around storage container, vaporizer(s), and pressure-regulating manifold for system maintenance and operation

5.1.3.4.13.4 The equipment pad and vehicle pad shall:

- (1) Be sloped to provide that all drainage run away from any building, parked vehicles, or combustible materials.
- (2) Have no drain located within the pad or closer than 2450 mm (8 ft) from the edge of the pad.

5.1.3.4.13.5 Bulk cryogenic liquid sources shall consist of the following:

- (1) One or more main supply vessel(s), whose capacity shall be determined after consideration of the customer usage requirements, delivery schedules, proximity of the facility to alternate supplies, and the emergency plan
- (2) A contents gauge on each of the main vessel(s)
- (3) A reserve supply sized for greater than an average day's supply, with the appropriate size of vessel or number of cylinders being determined after consideration of delivery schedules, proximity of the facility to alternate supplies, and the facility's emergency plan
- (4) At least two main vessel relief valves and rupture discs installed downstream of a three-way (three-port) valve
- (5) A check valve located in the primary supply piping upstream of the intersection with a secondary supply or reserve supply

5.1.3.4.13.6 Bulk cryogenic liquid sources shall include a reserve supply, as follows:

- (1) A second cryogenic liquid vessel or a cylinder header per 5.1.3.4.9 having sufficient gas cylinder connections for an average day's supply, but not fewer than three
- (2) An actuating switch/sensor monitoring internal pressure of the reserve cryogenic liquid vessel (if provided)
- (3) A contents gauge monitoring liquid level in the reserve cryogenic liquid vessel (if provided)
- (4) A check valve to prevent backflow into the reserve system
- (5) A pressure switch monitoring the pressure in the cylinder header (if provided)

5.1.3.4.13.7 Bulk cryogenic liquid sources shall include a fill circuit consisting of the following components:

- (1) A nonremovable product-specific fill connection in compliance with CGA V-6, *Standard Cryogenic Liquid Transfer Connection*
- (2) A means to cap and secure the fill connection inlet
- (3) A minimum 100 mesh strainer of Monel® or brass construction
- (4) A check valve to prevent product backflow from the fill inlet
- (5) A fill hose purge valve
- (6) Supports that hold the fill piping off the ground
- (7) A secure connection between the bulk tank and the fill piping
- (8) Supports as necessary to hold the fill line in position during all operations associated with the filling procedure

5.1.3.4.13.8 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 5.1.3.4.12 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, providing an operating cascade (primary-secondary-reserve) as required in 5.1.3.4.12.4 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 5.1.3.4.12.6.

5.1.3.4.13.9 The bulk systems shall actuate a local signal 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

5.1.3.4.13.10 Where vaporizers are required to convert cryogenic liquid to the gaseous state, the vaporizer units shall conform to the following:

- (1) Be permitted to operate by either ambient heat transfer or external thermal source (e.g. electric heater, hot water, steam)
- (2) Be designed to provide adequate capacity for the customer's peak and average flowrates under local conditions, seasonal conditions for weather and humidity, and structures that obstruct air circulation flow and sunlight
- (3) Have piping and manual/automatic valving configured in such a manner that operating vaporizer(s) or sections of the vaporizer can be switched to nonoperating vaporizer or section of the vaporizer to de-ice through a valving configuration that assures continuous flow to the facility through either or both vaporizers and/or sections of the vaporizer if valving switchover partially hangs up or fails

5.1.3.4.13.11 Where a vaporizer requires an external thermal source, the flow from the source of supply shall be unaffected by the loss of the external thermal source through either of the following:

- (1) Reserve ambient heat transfer vaporizers of sufficient capacity for at least one day's average supply and piped so as to be unaffected by flow stoppage through the main vaporizer
- (2) A reserve noncryogenic source capable of providing at least one day's average supply

5.1.3.4.14* Emergency Oxygen Supply Connection (EOSC). EOSCs shall be installed to permit connection of a temporary auxiliary source of supply for emergency or maintenance situations under the following conditions:

- (1) Where the bulk cryogenic liquid central supply system is outside of and remote from the building that the oxygen supply serves
- (2) Where there is not in the building a connected oxygen reserve sufficient for an average day's supply (*See 5.1.3.4.15 for requirements for such reserves.*)
- (3) Where 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 this situation, each building shall be provided with a separate emergency connection.

5.1.3.4.14.1 EOSCs shall be located as follows:

- (1) 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

5.1.3.4.14.2 EOSCs shall consist of the following:

- (1) Physical protection to prevent unauthorized tampering
- (2) A 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) A 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) A 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

5.1.3.4.15 In-Building Emergency Reserves.

5.1.3.4.15.1 In-building emergency reserves shall not be used as substitutes for the bulk gas reserves that are required in 5.1.3.4.13.4.

5.1.3.4.15.2 If a reserve is provided inside the building as a substitute for the EOSC, 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

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

- (1) A gas cylinder header per 5.1.3.4.9 with sufficient cylinder connections to provide for at least an average day's supply
- (2) A manifold for gas cylinders complying with 5.1.3.4.10

5.1.3.4.15.4 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.

5.1.3.4.15.5 In-building emergency reserves shall actuate a local signal and an alarm at all master alarms when or just before it begins to serve the system.

5.1.3.5* Level 1 Medical Air Supply Systems.

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

- (1) Be supplied from cylinders, bulk containers, medical air compressor sources, or be reconstituted from oxygen USP and oil-free, dry Nitrogen NF
- (2) Meet the requirements of medical air USP
- (3) Have no detectable liquid hydrocarbons
- (4) Have less than 25 ppm gaseous hydrocarbons
- (5) Have equal to or less than 5 mg/m³ of permanent particulates sized 1 micron or larger in the air at normal atmospheric pressure

5.1.3.5.2* 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.

5.1.3.5.3* Medical Air Compressor Sources.

5.1.3.5.3.1 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, etc.)
- (2) In a room constructed per 5.1.3.3.2
- (3) In a room ventilated per 5.1.3.3.2
- (4) For air-cooled equipment, in a room designed to maintain the ambient temperature range as recommended by the manufacturer

5.1.3.5.3.2 Medical air compressor systems shall consist of the following:

- (1) Components complying with 5.1.3.5.4 through 5.1.3.5.10, arranged per 5.1.3.5.11
- (2) An automatic means to prevent backflow from all on-cycle compressors through all off-cycle compressors
- (3) A manual shutoff valve to isolate each compressor from the centrally piped system and from other compressors for maintenance or repair without loss of pressure in the system
- (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 5.1.3.5.3.2(1) through 5.1.3.5.3.2(6), materials and devices used between the medical air intake and the medical air source valve shall be permitted to be of any design or construction appropriate for the service as determined by the manufacturer.

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

5.1.3.5.4 Compressors for Medical Air.

5.1.3.5.4.1* 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) The facility operators to confirm 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 provides 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) The facility operators to confirm proper seal operation by direct visual inspection of the atmospheric vents

5.1.3.5.4.2 For liquid ring compressors, service water and seal water of a quality recommended by the compressor manufacturer shall be used.

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

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

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

5.1.3.5.5 Aftercoolers. Aftercoolers, where required, shall be provided with individual condensate traps. The receiver shall not be used as an aftercooler or aftercooler trap.

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

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

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

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

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

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

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

- (1) Be appropriate for the intake air conditions
- (2) Be located upstream (source side) of the final line regulators
- (3) 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) Be equipped with a continuous visual indicator showing the status of the filter element life
- (5) Be constructed of materials deemed suitable by the manufacturer

5.1.3.5.8.1 Compressors complying with 5.1.3.5.4.1(2) and 5.1.3.5.4.1(3) shall be provided with the following:

- (1) Coalescing filters with element change indicators
- (2) Charcoal absorbers with colorimetric hydrocarbon indicators

5.1.3.5.9 Medical Air Regulators. Medical air regulators shall meet the following requirements:

- (1) Be sized for 100 percent of the system peak calculated demand at design condition
- (2) Be constructed of materials deemed suitable by the manufacturer
- (3) Be equipped with a pressure indicator indicating delivery pressure

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

5.1.3.5.11 Piping Arrangement and Redundancies.

5.1.3.5.11.1 Component arrangement shall be as follows:

- (1) Components shall be arranged to permit 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 an equal level of operating redundancy and medical air quality is maintained.

5.1.3.5.11.2 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 2 (two) compressors.

5.1.3.5.11.3 When aftercoolers are provided, they shall be 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 permit repair or replacement with that compressor out of service but without shutting down supply of medical air

5.1.3.5.11.4* 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.

5.1.3.5.11.5 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.

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

5.1.3.5.11.7 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 5.1.3.5.11.3, 5.1.3.5.11.4, 5.1.3.5.11.5, and 5.1.3.5.11.6.

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

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

5.1.3.5.11.10 If the relief valve required in 5.1.3.5.3.2(5) and 5.1.3.5.6(3) can be isolated from the system by the valve arrangement used to comply with 5.1.3.5.11.6, then redundant relief valve(s) shall be installed in the parallel sequence.

5.1.3.5.11.11 A DN8 (NPS ¼) 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.

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

5.1.3.5.11.13 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.

5.1.3.5.12 Electrical Power and Control.

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

5.1.3.5.12.2 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.

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

- (1) A 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, at least two such devices shall be installed
- (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 compressor(s) will restart after power interruption without manual intervention

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

5.1.3.5.12.5 Emergency electrical service for the compressors shall conform to the requirements of the essential electrical system as described in Chapter 4 of this document.

5.1.3.5.13 Compressor Intake.

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

5.1.3.5.13.2 The compressor air intake shall be located outdoors above roof level, at a minimum distance of 3.05 m (10 ft) from any door, window, exhaust, other intake, or opening in the building and a minimum distance of 6.1 m (20 ft) above the ground.

5.1.3.5.13.3 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 air stream shall not be used as a source of medical air intake.

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

- (1) ASTM B 819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems*, medical gas tube
- (2) ASTM B 88, *Standard Specification for Seamless Copper Water Tube*, water tube (Type K or L)
- (3) ASTM B 280, *Standard Specification for Seamless Copper Tubing for Air Conditioning and Refrigeration Field Service*, 280 ACR tube

5.1.3.5.13.5 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 compressor(s) are removed for service and consequent backflow of room air into the other compressor(s).

5.1.3.5.13.6 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.

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

5.1.3.5.14.1 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).]

5.1.3.5.14.2 Where liquid ring compressors are used, each compressor shall have a liquid level sensor in each air–water separator, which, 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).]

5.1.3.5.14.3 Where nonliquid ring compressors compliant with 5.1.3.5.4.1(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.

5.1.3.5.14.4 Where compressors compliant with 5.1.3.5.4.1(2) and 5.1.3.5.4.1(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(9).] The temperature setting shall be as recommended by the compressor manufacturer.
- (2) Coalescing filters with element change indicator shall be provided.
- (3) Charcoal filters with colorimetric hydrocarbon indicator shall be provided.
- (4) Liquid hydrocarbons shall be monitored on a continuous basis by pigment indicator or other type of instrument permanently installed downstream of each compressor and shall be inspected and documented daily.
- (5) Gaseous hydrocarbons shall be monitored on a quarterly basis.

5.1.3.5.14.5 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.

5.1.3.5.15 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 pressure exceeds +4°C (+39°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 the individual monitor's signal at all master alarm panels if the monitor loses power.

5.1.3.6* Medical–Surgical Vacuum Supply Systems.

5.1.3.6.1 Medical–Surgical Vacuum Sources.

5.1.3.6.1.1 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 constructed per 5.1.3.3.2
- (3) In a room ventilated per 5.1.3.3.2
- (4) For air-cooled equipment, in a room designed to maintain the ambient temperature range as recommended by the equipment manufacturer

5.1.3.6.1.2 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) An automatic means to prevent backflow from any on-cycle vacuum pumps through any off-cycle vacuum pumps
- (3) A shutoff valve or other isolation means to isolate each vacuum pump from the centrally piped system and other vacuum pumps for maintenance or repair without loss of vacuum in the system
- (4) A vacuum receiver
- (5) Piping between the vacuum pump(s), discharge(s), receiver(s), and the vacuum source shutoff valve shall be in accordance with 5.1.10.2 except that stainless, galvanized, or black steel pipe shall be permitted to be used.
- (6) Except as defined in 5.1.3.6.1.2(1) through 5.1.3.6.1.2(5), materials and devices used between the medical vacuum exhaust and the medical vacuum source shall be permitted to be of any design or construction appropriate for the service as determined by the manufacturer.

5.1.3.6.2 Vacuum Pumps.

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

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

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

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

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

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

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

5.1.3.6.5 Piping Arrangement and Redundancies.

5.1.3.6.5.1 Piping arrangement shall be as follows:

- (1) Piping shall be arranged to permit 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 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, research, or teaching laboratory vacuum system, such laboratories shall be connected separate from the medical–surgical system directly to the receiver tank through its own isolation valve and fluid trap located at the receiver. Between the isolation valve and fluid trap, a scrubber shall be permitted to be installed.

5.1.3.6.5.2 The medical–surgical vacuum receiver(s) shall be serviceable without shutting down the medical–surgical vacuum system by any of the following methods:

- (1) By providing an isolation valve where the receiver is tee'd into the main line
- (2) By piping the receiver at the end of a valved isolation line
- (3) By providing a three-valve bypass

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

5.1.3.6.6 Electrical Power and Control.

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

5.1.3.6.6.2 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.

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

- (1) A 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 are required
- (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 pump(s) will restart after power interruption without manual intervention

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

5.1.3.6.6.5 Emergency electrical service for the pumps shall conform to the requirements of the essential electrical system as described in Chapter 4 of this document.

5.1.3.6.7 Medical-Surgical Vacuum Source Exhaust.

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

5.1.3.6.7.2 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
- (3) At a level different from air intakes
- (4) Where prevailing winds, adjacent buildings, topography, or other influences that would not divert the exhaust into occupied areas or prevent dispersion of the exhaust

5.1.3.6.7.3 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.

5.1.3.6.7.4 The exhaust shall be piped of materials approved for medical-surgical vacuum piping under 5.1.10.2.

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

5.1.3.6.7.6 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 pump(s) is removed for service and consequent flow of exhaust air into the room.

5.1.3.6.8 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.

5.1.3.7* Waste Anesthetic Gas Disposal (WAGD).

5.1.3.7.1* 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.

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

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

- (1) The medical-surgical vacuum source shall comply with 5.1.3.6.
- (2) Flammable anesthetics or other flammable vapors shall be diluted below the lower flammable limit prior to disposal into the medical-surgical vacuum system or the vacuum pumps shall comply with 5.1.3.7.2.1(2).
- (3) The medical-surgical vacuum source shall be sized to accommodate the additional volume.

5.1.3.7.1.3 If WAGD is produced by a dedicated WAGD producer with a total power 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 indoors in a dedicated mechanical equipment area with any required utilities.
- (3) The WAGD source shall be in a room constructed per 5.1.3.3.2.
- (4) The WAGD source shall be ventilated per 5.1.3.3.3.2.
- (5) For air-cooled equipment, the WAGD source shall be located to maintain the ambient temperature range as recommended by the manufacturer.
- (6) The WAGD producers shall comply with 5.1.3.7.2.

5.1.3.7.1.4 If WAGD is produced by a dedicated WAGD producer with a total power less than 1 horsepower in total (both producers), the following shall be permitted to 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.

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

5.1.3.7.1.6 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) An automatic means to prevent backflow from any on-cycle WAGD producers through any off-cycle WAGD producers