99B

NFPA 99B Standard for Hypobaric Facilities 1996 Edition

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An International Standards-Making Organization

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Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

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NFPA 99B

Standard for

Hypobaric Facilities

1996 Edition

This edition of NFPA 99B, *Standard for Hypobaric Facilities*, was prepared by the Technical Committee on Hyperbaric and Hypobaric Facilities, released by the Technical Correlating Committee on Health Care Facilities, and acted on by the National Fire Protection Association, Inc., at its Fall Meeting held November 13-15, 1995, in Chicago, IL. It was issued by the Standards Council on January 12, 1996, with an effective date of February 2, 1996, and supersedes all previous editions.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

This edition of NFPA 99B was approved as an American National Standard on February 2, 1996.

Origin and Development of NFPA 99B

In 1965, when the then Subcommittee on Hyperbaric Facilities was appointed, several hospitals were employing hypobaric therapy to treat respiratory diseases. Additionally, NASA and the US Air Force were working with hypobaric chambers for space and air flight. The name of the Subcommittee was then changed to Hyperbaric and Hypobaric Facilities, and the initial version of a document on this subject was prepared. A tentative standard on the subject, NFPA 56E-T, was adopted at the 1971 Annual Meeting. In May 1972, the document was adopted as an official standard. The document was revised again for the 1977 NFPA Annual Meeting.

A complete review of NFPA 56E was accomplished for the 1981 Fall Meeting. That edition was designated NFPA 56E-1982.

In 1984, NFPA 56E, along with 11 other health care documents, was combined to form NFPA 99, *Standard for Health Care Facilities*. NFPA 56E essentially became Chapter 11 of NFPA 99. In that revision, the major change made to the 1982 edition of NFPA 56E was a complete revision of requirements for Class D chambers to reflect their use for high-altitude training purposes. (Such chambers do not require as extensive safety precautions as research and clinical chambers.)

During the revision for the 1987 edition of NFPA 99, it was brought to the attention of the Subcommittee on Hyperbaric and Hypobaric Facilities that hypobaric chambers were no longer used for medical purposes. As such, the material on hypobaric facilities really did not belong in NFPA 99. Thus, the Subcommittee proposed that this material be separated from NFPA 99 and again published as a distinct NFPA document. It was designated NFPA 99B.

Minor revisions were made to editions adopted in 1987 and 1990.

For the 1993 edition of Hypobaric Facilities, the one significant change was the identification of the safety director as the person responsible for disseminating hazards associated with operating hypobaric facilities.

For this 1996 edition, the major changes include: 1) clarifying the application of the document (1-4), and 2) deleting a Class F-type chamber since the committee is unaware of hypobaric techniques involving artificial atmospheres.

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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 that contain criteria for safeguarding patients and health care personnel in the delivery of health care services within health care facilities: a) from fire, explosion, electrical and related hazards resulting either from the use of anesthetic agents, medical gas equipment, electrical apparatus, and high frequency electricity, or from internal or external incidents that disrupt normal patient care; b) from fire and explosion hazards associated with laboratory practices; c) in connection with the use of hyperbaric and hypobaric facilities for medical purposes; d) through performance, maintenance, and testing criteria for electrical systems, both normal and essential; and e) through performance, maintenance, and testing and installation criteria: 1) for vacuum systems for medical or surgical purposes, and 2) for medical gas systems.

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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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NFPA 99B

Standard for

Hypobaric Facilities

1996 Edition

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

Information on referenced publications can be found in Chapter 5 and Appendix B.

Chapter 1 General

1-1 Introduction.

1-1.1 There is currently a widespread interest in high-altitude flight and space exploration. For this purpose, high-altitude chambers and space simulators have been developed and put to use. Equipment, experimental animals, and humans have been exposed to various artificial atmospheres under varying pressures ranging from 760 mm Hg atmospheric pressure to close to 0 mm Hg.

1-1.2 In some chambers the atmosphere might be enriched with oxygen or contain 100 percent oxygen. The increased combustibility of materials in those oxygen-enriched atmospheres has resulted in several fires in such chambers, with loss of life.

NOTE: See NFPA 53, *Guide on Fire Hazards in Oxygen-Enriched Atmospheres*, for descriptions of some of these accidents.

1-1.2.1 There is continual need for human diligence and expertise in the establishment, operation, and maintenance of hypobaric facilities.

1-1.2.2 The partial pressure of oxygen present in the atmosphere of a hypobaric facility is one of the determining factors of the amount of available oxygen. This pressure will rise if the percentage of oxygen increases proportionately more than the fall in total pressure. Even more important than partial pressure of oxygen from the standpoint of fire hazards compared with normal air, however, is the decrease in percentage of nitrogen available. The absence of the inerting effect of this nitrogen will generally lower the ignition energy and markedly elevate the burning rate of combustible and flammable substances. (*See Appendix C-1.2.2.1 and C-1.2.2.2.*)

1-1.2.3 It is the responsibility of the chief administrator or commanding officer of the facility possessing a hypobaric chamber to adopt and enforce appropriate regulations for hypobaric facilities. In formulating and administering the program, full use should be made of technical personnel highly qualified in hypobaric facility operations and safety.

1-1.2.4 It is essential that hypobaric chamber personnel having responsibility for the hypobaric facility establish and enforce appropriate programs to fulfill the provisions of this standard.

1-1.3 Potential hazards can be controlled only when continually recognized and understood by all pertinent personnel. The Technical Committee on Hyperbaric and Hypobaric Facilities realizes that such facilities are not normally used to treat patients. Nevertheless, human beings are being exposed; hence the need for preparation of this standard.

1-1.4 This standard was prepared with the intent of offering standards for the design, maintenance, and operation of such facilities.

1-2 Purpose.

1-2.1 The purpose of this standard is to set forth minimum safeguards for the protection of personnel involved in the use of hypobaric facilities that might contain an oxygen-enriched atmosphere (*see Section 2-2*), and that are operated at pressures less than 760 mm Hg. Its purpose is also to offer some guidance for rescue personnel who might not ordinarily be involved in the operation of hypobaric facilities, but who would become so involved in an emergency.

1-3 Scope.

1-3.1 This standard applies to all hypobaric facilities in which humans will be occupants or are intended to be occupants. Facilities employed for animal experimentation are not included if the size of the facility precludes human exposure.

1-3.1.1 This standard covers the recognition of, and protection against, hazards of an electrical, explosion, and implosion nature, as well as fire hazards.

1-3.1.2 Medical complications of hypobaric procedures are discussed primarily to acquaint rescue personnel with these problems.

1-4 Application of This Standard. This standard shall be applied only to the following: new construction; new equipment added to new facilities; and new equipment added to existing facilities. It shall not require the alteration or replacement of existing construction or equipment. Existing construction or equipment shall be permitted to be continued in use where such use does not constitute a distinct hazard to life as determined by the authority having jurisdiction.

1-5 Classification of Chambers.

1-5.1 General. Chambers shall be classified according to occupancy in order to establish appropriate minimum essentials in construction and operation.

1-5.2 Occupancy.

(a) Class D — Human rated, air atmosphere not oxygen-enriched.

(b) Class E — Human rated, oxygen-enriched atmosphere (partial pressure of oxygen is above 0.235 atmospheres absolute).

NOTE 1: Chapter 19, Hyperbaric Facilities, in NFPA 99, *Standard for Health Care Facilities*, classifies hyperbaric chambers as A, B, or C. To avoid confusion, hypobaric facilities are classified D and E.

NOTE 2: Chambers designed for animal experimentation equipped for access of personnel to care for the animals are classified as Class D and E for the purpose of this chapter depending upon atmosphere. Animal chambers of a size that cannot be entered by humans are not included in this standard.

NOTE 3: Chambers used for high-altitude training are classified as Class D for the purpose of this standard.

1-6 Nature of Hazards.

1-6.1 This standard for the use of hypobaric facilities is intended to provide protection against fire, implosion, and other hazards without unduly limiting the activities of professional personnel involved in training or research. This principle, without minimizing the hazards, recognizes that all involved personnel should be aware of the hazards to life that are inherent in and around hypobaric facilities.

1-6.2 Potential hazards involved in the design, construction, operation, and maintenance of hypobaric facilities are formidable. For further information on the nature of these hazards, see Appendix C-1.

Chapter 2 Definitions

For purposes of this standard, the following definitions apply as indicated.

NOTE: "(HHF)" at the end of a definition indicates that term is the responsibility of the NFPA Technical Committee on Hyperbaric and Hypobaric Facilities.

2-1 Official NFPA Definitions.

Approved*. Acceptable to the authority having jurisdiction.

Authority Having Jurisdiction*. The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

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

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.

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.

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

Shall. Indicates a mandatory requirement.

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

Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements, 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, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

2-2 Definitions of Terms Used in the Standard.

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

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

Atmosphere. The pressure exerted by, and gaseous composition of, an environment.

NOTE: As employed in this standard, atmosphere can refer to the environment within or outside of the hypobaric facility. When used as a measure of pressure, atmosphere is expressed as a fraction of standard air pressure [14.7 psi (101.4 kPa)]. (*See Appendix C-3, Pressure Table, Column 1.*) (HHF)

Atmosphere, Absolute (ATA). (*See definition of atmosphere.*) Two ATA = two atmospheres. (HHF)

Atmosphere, Ambient. The pressure and composition of the environment surrounding the chamber. (HHF)

Atmosphere, Chamber. The environment inside the chamber. (HHF)

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, i.e.,

$$\frac{23.45}{\sqrt{T.P._{atmos}}}$$

where $T.P._{atmos}$ = total pressure in atmospheres.

(*See Appendix A-2-2.*) (HFF)

Bends. Decompression sickness, caisson worker's disease. (HHF)

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

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

Flame Resistant. Where flame resistance of a material is required by this standard, that material shall pass successfully the small-scale test described in NFPA 701, *Standard Methods of Fire Tests for Flame-Resistant Textiles and Films*, except that the test shall be conducted in the gaseous composition and maximum pressure at which the chamber will be operated. (HHF)

NOTE: A source of ignition alternate to the gas burner specified in NFPA 701 might be required for this test if it is to be performed in 100 percent oxygen at several atmospheres pressure.

Flame Retardant. (*See definition of flame resistant.*) (HHF)

Hood, Oxygen. A device encapsulating the patient's head and used for a purpose similar to a mask. (*See definition of mask.*) (HHF)

Hyperbaric. An adjective referring to pressures above atmospheric pressure. (HHF)

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

Hypobaric. An adjective referring to pressures below atmospheric pressure. (HHF)

Hypoxia. A state of inadequate oxygenation of the blood and tissue. (HHF)

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. Abnormal conditions include accidental damage to any part of the equipment, wiring, or insulation, other failure of electrical components, application of overvoltage, adjustment and maintenance operations, and other similar conditions. (HHF)

Mask, Oronasal. A device that fits over the mouth and nose to deliver therapeutic gases to the user. (HHF)

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

Noncombustible (Hyperbaric). Within the context of Chapter 19, "Hyperbaric Facilities," in NFPA 99, *Standard for Health Care Facilities*, an adjective describing a substance that will not burn in 95 + 5 percent oxygen at pressures up to 3 ATA (44.1 psia). (HHF)

Noncombustible (Hypobaric). Within the context of this standard, an adjective describing a substance that will not burn in 95 + 5 percent oxygen at pressures of 760 mm Hg. (HHF)

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

Oxidizing Gas. A gas that supports combustion. Oxygen and nitrous oxide are examples of oxidizing gases. There are many others, including halogens. (HHF)

Oxygen-Enriched Atmosphere. An atmosphere in which the concentration of oxygen exceeds 23.5 percent by volume. (HHF)

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, *Method for Measuring the Minimum Oxygen Concentration to Support Candle-like Combustion of Plastics*. (HHF)

Oxygen Toxicity (Hyperbaric). Physical impairment resulting from breathing gaseous mixtures containing oxygen-enriched atmospheres at elevated pressures for extended periods of time. Under the pressures and times of exposure normally encountered in hyperbaric treatments, toxicity is a direct function of concentration and time of exposure. (HHF)

Oxygen Toxicity (Hypobaric). Physical impairment usually resulting from breathing gaseous mixtures containing oxygen-enriched atmospheres at elevated pressures for extended periods of time; it might occur under the pressures and duration of exposure normally encountered in long-duration hypobaric exposures, since toxicity is a direct function of concentration and time of exposure, and involves toxicity of the lung. (HHF)

Pressure, Absolute. The total pressure in a system with reference to zero pressure. (HHF)

Pressure, Ambient. Refers to total pressure of the environment referenced. (HHF)

Pressure, Gauge. Refers to total pressure above (or below) atmospheric. (HHF)

Pressure, Partial. The pressure, in absolute units, exerted by a particular gas in a gas mixture (the pressure contributed by other gases in the mixture is ignored). For example, oxygen is one of the constituents of air; the partial pressure of oxygen in standard air, at a standard air pressure of 14.7 psia, is 3.06 psia or 0.208 ATA or 158 mm Hg. (HHF)

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

Psig. Pounds per square inch gauge, a unit of pressure measurement with atmospheric pressure as the base or reference pressure (under standard conditions, 0 psig is equivalent to 14.7 psia). (HHF)

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. (HHF)

Chapter 3 Construction and Equipment

3-1 Housing for Hypobaric Facilities.

3-1.1 Hypobaric chambers and all ancillary service equipment shall be housed in fire-resistant construction of not less than one-hour classification that shall be a building either isolated from other buildings or separated from contiguous construction by one-hour noncombustible (under standard atmospheric conditions) wall construction.

NOTE: This standard does not restrict the number of chambers that can be placed in the same room or building.

3-1.1.1 If there are connecting doors through such common walls of contiguity, they shall be at least B label, one-hour fire doors. All construction and finish materials shall be noncombustible under standard atmospheric conditions.

NOTE: Characteristics of building construction housing hypobaric chambers and ancillary facilities are no less important to safety from fire hazards than are the characteristics of the hypobaric chambers themselves. It is conceivable that a fire emergency occurring immediately outside a chamber, given sufficient fuel, could seriously endanger the life or lives of those inside the chamber. Service facilities will in all probability be within the same building. These will also need protection while in themselves supplying life-maintaining service to those inside.

3-1.1.2 The room or rooms housing the hypobaric chambers and service equipment, such as described in 3-1.1, shall have an automatic sprinkler system installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*.

Exception: The sprinkler requirement in 3-1.1.2 is not applicable if the air intake for the emergency repressurization valve cannot be exposed to smoke or fumes.

3-1.2 The room housing the hypobaric chamber shall be vented sufficiently to the outside or be equipped with

blow-in paneling so that the execution of the emergency "dump" procedure (*see Appendix C-2*) will not disrupt the integrity of the walls of the building. As an alternative, the piping for the "dump" valve shall be permitted to be exteriorized (*see 3-2.5*) provided that the valve will function within the parameters set forth in 3-2.5 and provided that the source of repressurization air cannot be contaminated.

3-2 Fabrication of the Hypobaric Chamber.

3-2.1 Hypobaric chambers shall be designed and fabricated to comply with the ASME *Boiler and Pressure Vessel Code*, Section VIII, Unfired Pressure Vessels, Division 1 or Division 2, by personnel qualified to fabricate vessels under such codes. Metal cutting and welding shall be done only by certified welders.

3-2.2 Flooring of Class E chambers shall be noncombustible.

3-2.2.1 If the procedures to be carried out in a Class E hypobaric chamber require antistatic flooring, the flooring shall be installed in accordance with Section 2-6.3 of Annex 2 in NFPA 99, *Standard for Health Care Facilities*.

3-2.2.2 In a hypobaric chamber, if a bilge pump is installed, the floor overlying it shall be removable for cleaning the bilge.

NOTE: Where feasible, it is recommended that hypobaric chambers be constructed without a bilge or other enclosures that will collect dirt, dust, or liquids. It might not be feasible or practical to construct certain chambers without a bilge.

3-2.3 The interior of Class E chambers shall be unfinished or treated with a finish that is either (1) inorganic zinc based, (2) high-quality epoxy or equivalent, or (3) flame resistant.

3-2.3.1 If sound-deadening materials are employed within a hypobaric chamber, they shall be flame resistant.

3-2.4 A sufficient number of viewing ports and access ports for piping and monitoring and related leads shall be installed during initial fabrication of the chamber. Prudent design considerations suggest that at least 150 percent excess pass-through capacity be provided.

3-2.4.1 Electrical circuits that are compromised by water extinguishing agents from the external sprinkler fire extinguishing system shall be weather/drip protected.

3-2.4.2 Viewports shall be designed and fabricated according to ANSI/ASME PVHO-1, *Safety Standard for Pressure Vessels for Human Occupancy*.

3-2.5 Hypobaric chambers shall have capability for emergency repressurization of locks and chamber. Repressurization schedules shall be compatible with requirements for subject safety and with emergency rescue modes. Redundant means for repressurization shall be provided.

3-3 Illumination.

3-3.1 Wherever possible, all power sources for illumination shall be mounted outside the chamber and chamber lock.

Exception: Class D chambers are exempt from this requirement.

3-3.1.1 Lighting fixtures used in conjunction with viewports shall be designed as specified in ANSI/ASME PVHO-1, *Safety Standard for Pressure Vessels for Human Occupancy*. Means shall be provided for changing lamps outside the chamber without disturbing inner gaskets or seals.

3-3.1.2 Wherever a tungsten filament lamp is employed for illumination of a hypobaric chamber or chamber lock, a heat shield or other suitable means shall be incorporated in the fixture to prevent excessive surface temperatures.

3-3.1.3 Gasket material shall be of a type that permits thermal expansion and shall be suitable for the temperatures and vacuum involved. Gasket material for Class E chambers shall be fire resistant.

3-3.2 Permanent lighting fixtures installed within Class E and F chambers or locks shall comply with the requirements of NFPA 70, *National Electrical Code®*, Articles 500 and 501, Class I, Division 1, Group C atmospheres and shall be approved for the maximum vacuum and oxygen concentration attainable within the chamber.

3-3.3 Portable spot illumination, if used, shall comply with 3-7.2.3. In addition, the flexible cord (1) shall be of the type designated for extra-hard usage as defined in NFPA 70, *National Electrical Code*, Section 501-11; (2) shall contain a grounding conductor; and (3) shall be manufactured of fire-resistive materials approved for use in the presence of 95 + 5 percent oxygen.

NOTE: Flexible cord can be hazardous in the limited confines of the chamber, and its use should be avoided.

3-4 Ventilation.

3-4.1 Whenever a hypobaric chamber is occupied, it shall be ventilated to avoid concentrating CO_2 and O_2 levels inside the chamber.

3-4.2 Individual breathing apparatus should be supplied for each occupant of the chamber for use in case air in the chamber is fouled by combustion or other means. Each breathing apparatus shall be available for immediate use, and the source of the breathing mixture shall be independent of chamber atmosphere. The breathing gas supply shall be sufficient for simultaneous use of all breathing apparatus. Such apparatus shall function at all pressures that might be encountered in the chamber.

3-4.3 Sources of air for the Class D and E chamber atmosphere and for individual breathing apparatus, if these do not have self-contained supplies, shall be such that toxic or flammable gases are not introduced. Intakes shall be located so as to avoid air contaminated by exhaust from vehicles, stationary engines, or building exhaust outlets.

3-4.3.1 Warming or cooling of the atmosphere within the chamber can be accomplished by circulating the ambient air within the chamber over or past coils through which a constant flow of warm or cool water is circulated. Dehumidification can be accomplished through the use of cold coils; humidification, by the use of a gas-powered water nebulizer. Suitable noncombustible packing and nonflammable lubricant shall be employed on the fan shaft.

Exception: Class D chambers are exempt from this requirement.

3-5 Fire Extinguishment Requirements for Class E Hypobaric Facilities.

3-5.1 Detection of fire shall be automatic, using either an ultraviolet or infrared detection system. The detection system shall be capable of discriminating between normal chamber illumination and fire radiation. Detectors shall be located to provide constant surveillance of all areas of the

chamber, its equipment, and its occupants. Electronic devices shall be housed and constructed of materials compatible with expected atmospheres and ambient pressures.

3-5.1.1 A fixed automatic extinguishing system shall be installed within all Class E chambers. The system shall discharge automatically within one-half second of sensible flame development and shall be manually operable as well.

3-5.1.2 Each electrohydraulic or electromechanical control device should respond in less than 80 milliseconds. Each shall be furnished and installed in duplicate so as to provide redundancy of control device for even greater rapidity of system operations.

3-5.1.3 All chambers, manways, and air locks that communicate with each other shall be equipped with detectors, manual actuation means, and water spray systems. If the communicating chambers are each to be protected by separate extinguishing systems, the water supply's hydraulic characteristics shall be capable of simultaneous operation of all systems.

3-5.2 A suitable control panel shall be provided to control each fire extinguishing system.

3-5.2.1 Standby power shall be composed of trickle-charged batteries with sufficient capacity to furnish necessary system operating energy for four continuous hours if the charging source should fail. A trouble signal shall sound if the charging voltage fails.

3-5.2.2 Detector wiring shall be electrically supervised to determine continuity. Integrity of all components shall be regularly checked manually with a portable or fixed radiation source at each detection device. A disenabling "test" switch shall be provided in the panel to prevent discharge of water from nozzles during tests.

3-5.2.3 Circuitry to solenoid valves or other remote system actuators shall be equipped with necessary end-of-line resistors and/or relays to assure maintenance of continuity. An indicating light shall be operated and an audible trouble signal shall sound if standby circuitry fails.

3-5.2.4 The automatic control system shall provide for double complements of remote electrohydraulic or mechanical devices, which shall be connected in a redundant manner.

3-5.2.5 A timer shall be furnished and adjusted to allow actuation of the fire protection system for 20-second consecutive intervals, so long as the flame detectors report a fire condition.

3-5.2.6 The design of the control panel shall preclude use of all time delay relays and other time-consuming devices in the system actuation circuitry.

3-5.2.7 Supervisory lights and audible signals shall be provided to monitor the position of water supply main control valves.

3-5.2.8 Audible signals shall be initiated by the control panel upon either the actuation of any flame detector or initiation of water flow into the chamber.

3-5.2.9 Auxiliary contacts shall be made available to actuate relays or contactors in lighting and power circuits.

3-5.3 Suitable supervisory monitor switches shall be attached to all main water supply gate valves and connected to the fire protection control panel.

3-5.3.1 Audible signals shall be located exterior to the chamber at the fire protection control panel and at other designated points in the facility to alert all concerned personnel of fire or water flow in the chamber. Only water or water containing thickening or wetting agents shall be used in hypobaric chambers for fire fighting.

3-5.3.2 Total water demand shall be determined by multiplying total chamber floor area by 7.5 gal/ft^2/min (202.9 L/m^2/min). Thirty (30) psi (206.8 kPa) minimum operating water pressure at the nozzle shall be provided. The water supply shall be constantly and fully available and shall not be delayed by the starting of fire pumps. The total quantity of water available for exclusive fire protection of chambers shall be adequate to furnish water for at least a one-minute duration (three consecutive 20-second applications).

NOTE: The quantities and pressure of water for fire extinguishing indicated above are based on limited testing and should be considered subject to change as additional data become available.

3-5.3.3 Spray nozzles shall be placed to produce overlapping cones of water spray covering all chamber areas. They shall be equipped with remotely controlled internal valve mechanisms that will accommodate priming all piping fully with operating standby water pressure.

3-5.3.4 Connecting piping systems shall be proven by calculation to be hydraulically adequate to produce uniform distribution of water.

3-5.3.5 The system design shall be such that, prior to activation of the water deluge system, whether operated in the automatic or manual mode, interior chamber power shall be automatically deactivated and the emergency lighting and communication system activated.

3-6 Fire Extinguishment Requirements for Class D Chambers.

3-6.1 A manual, portable, or fixed extinguishing capability shall be provided inside Class D chambers.

3-6.1.1 If installed, spray nozzles shall be capable of producing directed full-cone patterns and shall be so located to impinge from all directions on all surfaces of chamber, equipment, and occupants.

3-6.2 Only water or water containing thickening or wetting agents shall be used in hypobaric chambers for fire fighting.

3-6.3 Provisions shall be made to manually disconnect all power in the chamber by providing a control switch in the operator panel.

3-6.4 Manual fire alarm switches shall be located at the operator console or at other designated points in the facility to alert all concerned personnel of fire in or around the chamber.

3-7 Electrical Systems.

NOTE: It is the intention of this chapter that no electrical equipment be installed or used within the chamber that is not intrinsically safe or designed and tested for use under hypobaric conditions. Control devices, wherever possible, should be installed outside of the chamber.

3-7.1 Source of Power to Hypobaric Chambers.

3-7.1.1 All hypobaric chamber service equipment, switchboards, and panelboards shall be installed outside of the chamber enclosure and be so arranged as to readily permit manual supervisory control by operators in visual contact with the chamber interior.

3-7.1.2 All critical electrical equipment and circuits associated with the hypobaric chamber, whether within or outside of the chamber, shall have a minimum of two independent sources of electric power.

3-7.1.3 All critical electrical circuits contained within the chamber, all emergency lighting, whether within or outside of the chamber, and all circuits used for communication and alarm systems shall be connected to the emergency system, according to Chapter 3 of NFPA 99, *Standard for Health Care Facilities.*

3-7.1.4 The circuits and equipment listed in 3-5.1.2, 3-5.3.1, and 3-7.1.3 shall be so installed and connected to an alternate source of power that they will be automatically restored to operation within 10 seconds after interruption of the normal source.

Exception: Class D chambers with an emergency power manual switch on the operator console are exempt from this requirement.

3-7.2 Electrical Wiring and Equipment.

3-7.2.1 All electrical equipment installed or used in a hypobaric chamber or lock shall be approved for use in Class I, Division 1, Group C locations at the highest oxygen partial pressure and lowest total pressure and oxygen concentration attainable in the chamber or lock. Electrical equipment approved as intrinsically safe shall be constructed with noncombustible insulation. (*See NFPA 70, National Electrical Code, Article 500.*)

Exception: Class D chambers are exempt from this requirement.

NOTE: Electrical equipment that has been tested and found suitable for explosive atmospheres at ambient pressure and normal oxygen concentration might not be suitable when used in the presence of explosive atmospheres below ambient pressure and/or above normal oxygen concentrations.

3-7.2.2 All electrical circuits serving equipment located adjacent to, or in the vicinity of, hypobaric chambers, the housing for which is sprinkler-protected as per 3-1.1.2, shall be installed to prevent water from interfering with the operation of the equipment or be equipped with a power drop capability should the sprinkler system be activated.

3-7.2.3 All power and light electrical circuits contained within the chamber shall be supplied from an ungrounded electrical system, fed from isolating transformers located outside of the chamber, and equipped with a line isolation monitor with appropriate signal lamps as specified in Chapter 3, Electrical Systems, in NFPA 99, *Standard for Health Care Facilities.* It is desirable that this monitor be capable of sensing single or balanced capacitive-resistive faults, as well as leakage of current to ground.

Exception: Class D chambers are exempt from this requirement.

3-7.2.4 All electrical wiring installed in the hypobaric chamber shall comply with the requirements of NFPA 70, *National Electrical Code,* Articles 500 and 501, Class I, Division 1. Equipment installed therein shall be approved for use in Class I, Group C atmospheres at the maximum proposed vacuum and oxygen concentration. Either threaded rigid metal conduit or Type MI cable with termination fittings approved for the location shall be the wiring method employed. All boxes, fittings, and joints shall be explosion-proof. (*See Article 501, NFPA 70, National Electrical Code.*)

Exception: Class D chambers are exempt from this requirement.

3-7.2.5 Fixed electrical equipment within the chamber enclosure shall comply with the requirements of NFPA 70, *National Electrical Code,* Articles 500 and 501, Class I, Division 1. Equipment installed therein shall be approved for use in Class I, Group C atmospheres at the maximum vacuum and oxygen concentration attainable.

Exception: Class D chambers are exempt from this requirement.

3-7.2.6 Overcurrent protective devices shall comply with the requirements of NFPA 70, *National Electrical Code,* Article 240, and shall be installed outside of, and adjacent to, the hypobaric chamber. Equipment used inside the chamber is permitted to have its own individual overcurrent devices incorporated within the equipment, provided this device is approved for Class I, Division 1, Group C atmospheres at the maximum vacuum and oxygen concentration attainable. Each circuit shall have its own individual overcurrent protection in accordance with Article 240-11 of NFPA 70.

Exception: Class D chambers are exempt from this requirement.

3-7.2.7 Each ungrounded circuit within or partially within the chamber or lock shall be controlled by a switch outside the enclosure having a disconnecting pole for each conductor. These poles shall be ganged.

3-7.2.8 Switches, receptacles, and attachment plugs designed for electrical systems used in ordinary locations shall be prohibited from use in hypobaric chambers or locks because of the frequent sparks or arcs that result from their normal use. All receptacles and attachment plugs shall conform to Section 2-2.4 of Annex 2 in NFPA 99, *Standard for Health Care Facilities.*

Exception: Class D chambers are exempt from these requirements.

NOTE: Because of the corona problem, if switches are to be used, it is recommended that they be hermetically sealed.

3-8 Intercommunications and Monitoring Equipment.

3-8.1 Intercommunications equipment is mandatory to the safe operation of hypobaric chambers.

3-8.1.1 All intercommunications equipment shall be approved as intrinsically safe.

3-8.1.2 Microphones, loudspeakers, and hand phones located in the chamber and personnel locks shall be approved as intrinsically safe at the maximum proposed vacuum and oxygen concentration. All other components of the intercommunications equipment including audio output transformers shall be located outside of the hypobaric facility.

Exception: Oxygen mask microphones with external relays designed to operate on 28 volts or less and not exceed a current of 0.25 ampere, provided they qualify as intrinsically safe for the condition of use. If push-to-talk or toggle switches are used in Class E chambers, they shall be of the hermetically sealed, pressure-tested type, with arc-suppressed circuits incorporated in the switch.

3-8.1.3 Voice sensors, where part of an oxygen mask, shall be approved as intrinsically safe for 95 + 5 percent oxygen at atmospheric pressure.

3-8.1.4 All electrical conductors inside Class E chambers, or personnel locks immediately adjacent thereto, shall be insulated with insulation that is flame resistant.

Exception: Grounds through the piping system shall not be required to be insulated.

3-8.1.5 The intercommunications system shall connect all chamber personnel areas and the chamber operator's control panel. All hypobaric chambers shall be equipped with a communications system with redundant capabilities.

3-8.2 All personnel monitoring equipment shall be located on the outside of the chamber and the monitoring leads conveyed through appropriate pass-throughs. As an alternative, approved monitors continuously purged with inert gas and designed so as not to exceed maximum safe operating temperatures and pressure changes shall be permitted.

3-8.2.1 The conductors or patient leads extending into the chamber shall be intrinsically safe at the maximum vacuum and oxygen concentration that can be encountered in the chamber or system.

3-8.3 Any other electrically operated equipment brought into a Class E hypobaric chamber, or installed in the chamber, including monitoring and intercommunications equipment, shall be approved for use in Class I, Division 1, Group C hazardous locations at the maximum altitude and oxygen concentration that can be encountered in the chamber or system.

NOTE: Because of the corona problem, if switches are to be used, it is recommended that they be hermetically sealed.

3-8.4 Sensors shall be installed to detect levels of carbon dioxide above 0.2 percent and carbon monoxide above 15 ppm in Class E chambers.

Chapter 4 Administration and Maintenance

4-1 General.

4-1.1 Purpose. Chapter 4 contains requirements for administration and maintenance that shall be followed as an adjunct to the physical precautions specified in Chapter 3.

4-1.2 Recognition of Hazards. The hazards involved in the use of hypobaric facilities can be successfully minimized only when the hazards are recognized. All operations and maintenance personnel shall make conscious efforts to remove these hazards. The nature and degree of the hazards involved are outlined in Appendix C and shall be reviewed by the safety director. Since Chapter 4 is expected to be used as a reference by those responsible for preparing local guidelines for hypobaric facilities, the requirements set forth herein are frequently accompanied by explanatory text.

4-1.3 Responsibility.

4-1.3.1 Responsibility for the maintenance of safe conditions and practices both in and around hypobaric facilities falls mutually upon the governing body of the institution, all personnel using or operating the hypobaric facility, and the administration of the institution.

4-1.3.2 A safety director shall be appointed who shall be responsible for the safety of the operations of the hypobaric facility. (*See 4-7.5.*)

4-1.3.3 The complexity of hypobaric chambers is such that one person shall be designated as flight supervisor, as the one in a position of responsible authority. Prior to commencing the hypobaric profile, the chamber flight supervisor shall ensure that the chamber has been appropriately preflighted and is staffed for the type of profile to be conducted.

4-1.3.4 In meeting its responsibilities for safe practices in hypobaric facilities, the administration of the facility shall adopt and correlate regulations and standard operating procedures to ensure that both the physical qualities and the operating methods pertaining to hypobaric facilities meet the requirements of this standard.

4-1.4 Rules and Regulations.

4-1.4.1 General. In facilities where governing directives have not been established, it is recommended that administrative, technical, and professional staffs jointly consider and agree upon necessary rules and regulations for the use of hypobaric facilities. Upon adoption, copies of the rules and regulations shall be prominently posted in and around the hypobaric chamber.

4-1.4.2 All personnel who are to be exposed to hypobaric atmospheres shall be given physical examinations to ensure that they have no physical condition that would make exposure more hazardous for them than it would be if they were normal healthy persons.

4-1.4.3 All chamber operating personnel shall become familiar with emergency equipment — its purpose, applications, operations, and limitations.

4-1.4.4 Emergency procedures best suited to the needs of the individual facility shall be established. All operating and maintenance personnel shall become thoroughly familiar with these procedures and the methods of implementing them. Operating personnel shall be trained to safely return the chamber to normal atmospheric pressure when all powered equipment has been rendered inoperative.

NOTE: A suggested outline for emergency action in the case of fire is contained in Appendix C-2.

4-1.4.5 Fire training drills shall be carried out at regular intervals.

NOTE: A calm reaction to an emergency situation can be expected only if the above guidance is familiar to, and rehearsed by, all concerned.

4-1.5 General Requirements.

4-1.5.1 Open Flames and Hot Objects. Smoking, open flames, hot objects, and ultraviolet sources, which would cause premature operation of flame detectors (when installed), shall be prohibited in hypobaric facilities, both inside and outside (in the vicinity of the chamber). The immediate vicinity of the chamber is defined as the general surrounding area from which activation of the flame detector can occur.

4-1.5.2 The use of flammable agents inside a hypobaric chamber shall be forbidden. Burners employing natural or

LP-Gas for laboratory purposes, cigarette lighters, and flammable anesthetic gases fall into this category. The use of flammable hair sprays, hair oils, and facial makeup by chamber occupants shall be prohibited in Class E chambers.

Exception: When potentially flammable agents are required inside the chamber (e.g., alcohol swabs, parenteral alcohol-based pharmaceuticals, topical creams), such agents shall be approved by the safety director.

4-1.5.3 Parts of this chapter deal with the elements required to be incorporated into the structure of the chamber to reduce the possibility of electrostatic spark discharges, which are a possible cause of ignition in hypobaric atmospheres. The elimination of static charges is dependent on the vigilance of administrative activities in materials purchase, maintenance supervision, cleaning procedures, and periodic inspection and testing. It cannot be emphasized too strongly that an incomplete chain of precautions generally will increase the electrostatic hazard. For example, in research chambers where use of flammable gases is planned, conductive flooring (*see 3-2.2.1*) might contribute to the hazard unless all personnel wear conductive shoes and unless all objects in the room are electrically continuous with the floor and humidity is maintained. Maximum precautions within reason shall be taken.

4-1.6 Personnel.

4-1.6.1 All personnel entering Class E hypobaric chambers in which use of flammable gases is planned shall be in electrical contact with the conductive floor through the wearing of conductive footwear or an alternative method of providing a path of conductivity.

4-1.6.2 If a patient is brought into a chamber, electrical connection to the conductive floor shall be ensured by the provision of a conductive strap in contact with the patient's skin, with one end of the strap fastened to the metal frame of the table (or other equipment) meeting the requirements of Section 2-6.3 of Annex 2 in NFPA 99, *Standard for Health Care Facilities*.

Exception: When a subject is in direct contact with a conductive mattress that is appropriately grounded.

4-1.6.3 Because of the possibility of percussion sparks, shoes having ferrous nails that can make contact with the floor shall not be permitted to be worn in Class E chambers.

4-1.6.4 Equipment of cerium, magnesium, magnesium alloys, and similar manufacture shall be prohibited. (*Also see Note under 4-3.2.*)

4-1.6.5 The number of occupants of the chamber shall be kept to the minimum number necessary to carry out the procedure.

4-1.7 Textiles.

4-1.7.1 Cotton, silk, wool, or synthetic textile materials shall not be permitted in Class E chambers, unless the fabric meets the requirements of 4-1.7.3.

4-1.7.2 Any paper and plastic devices or otherwise restricted materials shall be permitted to be used in Class E chambers at the direction of the person in charge with the concurrence of the safety director. This permission shall be stated in writing for all restricted materials employed (*see 4-1.3.2*).

4-1.7.3 Fabric used in Class E chambers shall meet the requirements set forth for the small-scale test in NFPA 701, *Standard Methods of Fire Tests for Flame-Resistant Textiles and Films*, except that the test atmosphere shall be 95 + 5 percent oxygen at the pressure equivalent to the maximum rating of the chamber.

4-1.7.4 All Class E chamber personnel shall wear garments completely covering all skin areas possible. They shall be as tight-fitting as possible, especially at the wrists, neck, and ankles.

4-1.7.5 All other fabrics used in Class E chambers such as sheets, drapes, and blankets shall be inherently flame-resistant materials.

4-2 Denitrogenation. Personnel entering hypobaric chambers for periods of prolonged activity therein generally must be denitrogenated before exposure to reduced barometric pressure. Since fire fighting and rescue techniques require repressurization of the chamber, denitrogenation is not required for fire and rescue personnel.

4-3 Equipment.

4-3.1 All equipment used in the hypobaric facility shall comply with Chapter 3 of this standard. This includes all electrical and mechanical equipment necessary for the operation and maintenance of the hypobaric facility, as well as any medical devices and instruments used in the facility. Use of unapproved equipment shall be prohibited.

NOTE: For cleaning of equipment, see 4-7.5.2.

4-3.1.1 Unmodified portable X-ray devices, electrocautery equipment, and other similar high-energy devices shall not be operated in the hypobaric chamber. Photographic equipment employing photoflash, flood lamps, or similar equipment shall not remain in the hypobaric chamber when the chamber is depressurized.

4-3.1.2 Equipment known to be, or suspected of being, defective shall not be introduced into any hypobaric chamber or used in conjunction with the operation of such chamber until repaired, tested, and accepted by qualified personnel and approved by the safety director (*see 4-1.3.2*).

4-3.1.3 The use of paper shall be kept to a minimum. Combustible paper items such as cups, towels, or tissues shall not be brought into a Class E hypobaric chamber.

4-3.2 Oxygen piping systems, containers, valves, fittings, and interconnecting equipment shall be all metal to the extent possible. Valve seats, gaskets, hoses, and lubricants shall be selected carefully for oxygen compatibility under service conditions.

NOTE: Users should be aware that many items, if ignited in oxygen-enriched atmospheres, are not self-extinguishing. Iron alloys, aluminum, and stainless steel are, to various degrees, in that category, as well as human skin, muscle, and fat, and plastic tubing such as polyvinyl chloride. Testing for oxygen compatibility is very complicated. Very little data exist and many standards still have to be determined. Suppliers do not normally have facilities for testing their products in controlled atmospheres. Both static conditions as well as impact conditions are applicable. Self-ignition temperatures normally are unknown in special atmospheres.

4-3.3 Equipment in support of Class E chambers requiring lubrication shall be lubricated with oxygen-compatible, flame-resistant materials.

Exception: The vacuum pumps used by Class D chambers shall be permitted to be exempted from this requirement, depending on user requirements.

4-4 Handling of Gases.

4-4.1 Flammable gases shall not be piped into, used, or stored within or in the immediate vicinity of Class D or E hypobaric chambers. Nonflammable medical gases and breathing air shall be permitted to be piped into the hypobaric chambers, provided the container and contents are approved. The institution's administrative personnel shall ensure that rules and regulations are provided to ensure the safe handling of gases in the hypobaric facility (*see 4-1.3.1*).

4-4.2 Quantities of oxygen stored in the chamber shall be kept to a minimum. Oxygen and other gases shall not be introduced into the chamber in the liquid state.

4-5 Maintenance.

4-5.1 The hypobaric safety director ultimately shall be responsible for ensuring that all valves, regulators, meters, and similar equipment used in the hypobaric chamber are properly compensated for safe use under hypobaric conditions and tested periodically. Life support systems, valves, controls, gauges, and pressure relief valves shall be tested and calibrated periodically.

4-5.1.1 The hypobaric safety director ultimately shall be responsible for ensuring that all gas outlets for piped systems in the chambers are properly labeled or stenciled in accordance with CGA Pamphlet C-4, *Standard Method of Marking Portable Compressed Gas Containers to Identify the Material Contained*; Chapter 4, "Gas and Vacuum Systems," of NFPA 99, *Standard for Health Care Facilities*; or a comparable Department of Defense (DOD) standard. Class D chambers that are equipped with only oxygen gas sources are exempt from this requirement.

4-5.1.2 Before piping systems are initially put into use, it shall be ascertained that the gas delivered at the outlet is identified on the outlet label and that proper connecting fittings are checked against their labels, in accordance with Chapter 4 of NFPA 99, *Standard for Health Care Facilities*, or a comparable DOD standard.

4-5.1.3 Protection of inlets and outlets against animals, birds, insects, and other foreign matter shall be adequate. Location of these openings shall be such as to ensure protection from damage for fire safety.

4-5.1.4 The guidelines set forth in Chapter 4, Gas and Vacuum Systems, in NFPA 99, *Standard for Health Care Facilities*, or a comparable DOD standard concerning the storage, location, and special precautions required for compressed gases shall be followed.

4-5.1.5 All storage areas shall be located remotely from the hypobaric environment.

4-5.2 Roentgen radiation equipment shall not be employed inside hypobaric chambers.

4-5.3 Maintenance Logs.

4-5.3.1 Installations, repairs, modifications of equipment, etc., related to the chamber should be evaluated by engineering or maintenance personnel, tested under operating pressure, and approved by the safety director. Records of the various tests shall be maintained.

4-5.3.2 Maintenance equipment records shall be maintained by maintenance personnel. Operating or maintenance personnel shall certify in writing that the chamber has been appropriately preflighted prior to chamber operation.

4-5.3.3 Cleaning routines shall be established.

4-5.3.4 Operating equipment logs shall not be taken inside the chamber.

4-6 Electrical Safeguards.

4-6.1 Electrical equipment shall be installed and operated in accordance with Section 3-7 of this standard.

4-6.1.1 All electrical circuits shall be operationally tested before chamber depressurization. (*See 3-7.2.3.*)

4-6.1.2 In the event of fire, all nonessential electrical equipment within the chamber shall be deenergized insofar as possible before extinguishing the fire. Smoldering, burning electrical equipment shall be deenergized before a localized fire involving only the equipment is extinguished.

4-7 Electrostatic Safeguards.

NOTE: The elimination of static charges is dependent on the vigilance of administrative activities in materials purchased, maintenance supervision, and periodic inspection and testing.

4-7.1 Textiles. Textiles used or worn in the hypobaric chamber shall conform to 4-1.7 of this chapter.

4-7.2 Maintenance.

4-7.2.1 Conductive Floors where Applicable. (*See Section 2-6.3 of Annex 2 in NFPA 99, Standard for Health Care Facilities.*)

4-7.2.2 Furniture.

(a) In Class E chambers equipped with conductive floors, periodic inspection shall be made of leg tips, tires, casters, or other conductive devices on furniture and equipment to ensure that they are maintained free of wax, polish, lint, or other extraneous material that might insulate them and defeat the purpose for which they are used and also to avoid transporting to conductive floors such materials from other areas. Metals capable of impact sparking shall not be allowed for casters or furniture leg tips.

NOTE: Ferrous metals can cause such sparking. So can magnesium or magnesium alloys if contact is made with rusted steel.

(b) Casters shall not be lubricated with oils or other flammable materials. Such lubricants shall be oxygen compatible and flame resistant.

4-7.3 Testing. Conductive testing, if required, shall be in accordance with requirements in Section 2-6.3 of Annex 2 in NFPA 99, *Standard for Health Care Facilities*.

NOTE: Material such as rubber that might deteriorate in oxygen-enriched atmospheres should be inspected regularly, especially at points of high stress.

4-7.4 Fire Protection Equipment. Electrical switches, valves, and electrical monitoring equipment associated with fire detection and extinguishing shall be visually inspected before each chamber depressurization. Fire detection equipment shall be tested each week or prior to use, and full testing, including discharge of extinguishing media, conducted at least annually. Testing shall include activation of trouble circuits and signals. Discharge of extinguishant may be limited to 10 percent of the system capacity provided simultaneous discharge of all systems is demonstrated.

Where portable pressurized water fire extinguishers are provided inside Class D chambers, they shall be inspected prior to each depressurization. Testing of these portable units shall be in accordance with NFPA 10, *Standard on Portable Fire Extinguishers.*

4-7.5 Housekeeping.

4-7.5.1 A regular housekeeping program shall be implemented whether or not the facility is in regular use. The persons assigned to this task shall be thoroughly indoctrinated in the hazards to occupants under normal operation.

NOTE: It is absolutely essential that all areas of, and components associated with, the hypobaric chamber be kept meticulously free of grease, lint, dirt, and dust.

4-7.5.2 In Class E chambers, cleaning materials that leave a flammable film shall not be used in the chamber or on any material entering the chamber; cloths and brushes that might catch and leave flammable strands shall be used with extreme care to prevent this from happening. The area of the facility around the chamber shall be kept tidy and clear of all unnecessary material.

Intakes and exhausts of piping within the facility or passing through exterior walls of the facility shall be inspected regularly to ensure that animal, bird, and insect guards are adequate and clean and that the area is suitably protected and has no rubbish or other storage posing a threat to proper and safe operation.

NOTE 1: Vacuum cleaning of walls, floors, underflooring, shelves, cabinets, etc., of the chamber and its contents is recommended.

NOTE 2: Equipment to be used in the chamber should be cleaned, not only on the exterior, but on the interior of its cabinet where fine flammable dust can collect.

Chapter 5 Referenced Publications

5-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

5-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers*, 1994 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1994 edition.

NFPA 70, *National Electrical Code*, 1996 edition.

NFPA 99, *Standard for Health Care Facilities*, 1996 edition.

NFPA 701, *Standard Methods of Fire Tests for Flame-Resistant Textiles and Films*, 1996 edition.

5-1.2 Other Publications.

5-1.2.1 ASME Publications. American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

ANSI/ASME PVHO-1-1993, *Safety Standard for Pressure Vessels for Human Occupancy.*

ASME *Boiler and Pressure Vessel Code*, 1995.

5-1.2.2 CGA Publication. Compressed Gas Association, Inc., 1235 Jefferson Davis Highway, Arlington, VA 22202.

Pamphlet C-4-1990, *Standard Method of Marking Portable Compressed Gas Containers to Identify the Material Contained* (ANSI Z48.1).

5-1.2.3 ASTM Publication. American Society for Testing and Materials, 1416 Race Street, Philadelphia, PA 19103.

ASTM D 2863-91, *Method for Measuring the Minimum Oxygen Concentration to Support Candle-like Combustion of Plastics.*

Appendix A Explanatory Material

This Appendix is not a part of the requirements of this NFPA document but is included for information purposes only.

A-2-1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations that is in a position to determine compliance with appropriate standards for the current production of listed items.

A-2-1 Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A-2-1 Code. The decision to designate a standard as a "Code" is based on such factors as the size and scope of the document, its intended use and form of adoption, and whether it contains substantial enforcement and administrative provisions.

A-2-1 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A-2-2 Atmosphere of Increased Burning Rate. The degree of fire hazard of an oxygen-enriched atmosphere varies with the concentration of oxygen and diluent gas, and the total pressure. The definition contained in the current edition of NFPA 53, *Guide on Fire Hazards in Oxygen-Enriched Atmospheres,* and in editions of NFPA 56D, *Standard for Hyperbaric Facilities,* prior to 1982, did not necessarily reflect the increased fire hazard of hyperbaric and hypobaric atmospheres.

The definition for atmosphere of increased burning rate in Chapter 19, "Hyperbaric Facilities," in NFPA 99, *Standard for Health Care Facilities,* and for this standard defines an oxygen-enriched atmosphere with an increased fire hazard, as it relates to the increased burning rate of material in the atmosphere. It is based upon a 1.2 cm/second burning rate (at 23.5 percent oxygen at 1 atmosphere absolute) as described in Figure A-2-2 from "Technical Memorandum UCRI-721, Chamber Fire Safety," by Schmidt, Dorr & Hamilton (Ocean Systems, Inc., Research & Development Lab, Tarrytown, NY 10591). (*See Figure A-2-2.*)

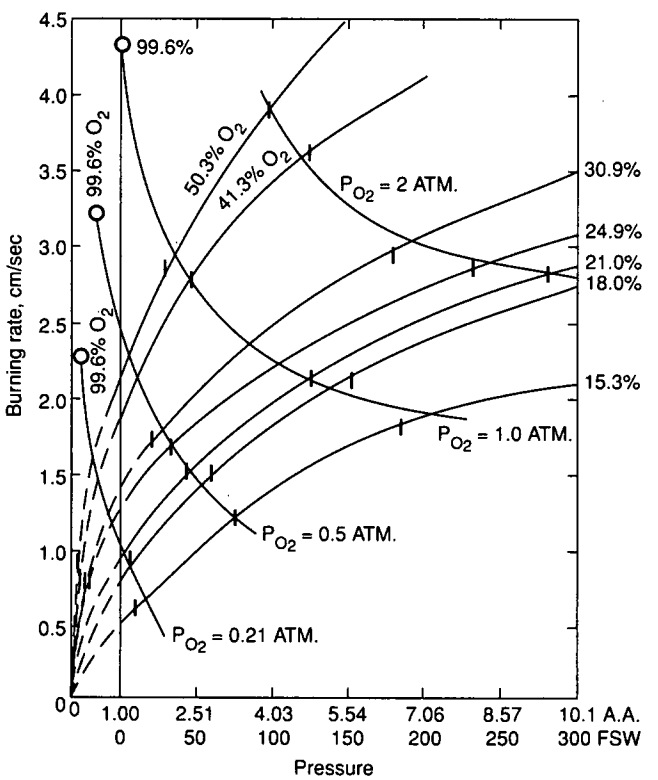

Figure A-2-2 Burning rates of filter paper strips at an angle of 45 degrees in N_2-0_2 mixtures. (From Figure 4, "Technical Memorandum UCRI-721, Chamber Fire Safety," T. C. Schmidt, V. A. Dorr, and R. W. Hamilton, Jr., Ocean Systems, Inc., Research and Development Laboratory, Tarrytown, NY 10591. Work carried out under US Office of Naval Research, Washington, DC, Contract No. N00014-67-A-0214-0013.) (Cook, G. A., Meierer, R. E., Shields, B. M., Screening of Flame-Resistant Materials and Comparison of Helium with Nitrogen for Use in Dividing Atmospheres. First summary report under ONR Contract No. 0014-66-C-0149. Tonawanda, NY: Union Carbide, 31 March 1967. DDC No. Ad-651583.)

Appendix B Referenced Publications

B-1 The following documents or portions thereof are referenced within this standard for informational purposes only and thus are not considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

B-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 53, *Guide on Fire Hazards in Oxygen-Enriched Atmospheres*, 1994 edition.

NFPA 70, *National Electrical Code*, 1996 edition.

NFPA 99, *Standard for Health Care Facilities*, 1996 edition.

NFPA 325, *Guide to Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids*, 1994 edition.

B-1.2 Other Publications.

B-1.2.1 ASME Publication. American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

ANSI/ASME PVHO-1-1993, *Safety Standard for Pressure Vessels for Human Occupancy.*

B-1.2.2 Oceans Systems, Inc., Research and Development Laboratory, Tarrytown, NY 10591. Work carried out under U.S. Office of Contract No. N00014-67-A-0214-0013.

"Technical Memorandum UCRI-721, Chamber Fire Safety."

Appendix C Additional Explanatory Information to Chapters 1 through 4

C-1 Nature of Hazards.

C-1.1 General.

C-1.1.1 There are several hazards involved in the design, construction, operation, and maintenance of hypobaric facilities. Some equipment might prove to be extremely hazardous in oxygen-enriched atmospheres compared with similar use in air. Under small-scale test conditions, some materials that are self-extinguishing in air, for example, have horizontal burning rates of more than 20 inches per second in oxygen at atmospheric pressure.

C-1.1.2 Material Control. All items brought into a hypobaric chamber should comply with acceptance criteria. Waivers should be granted in accordance with clearly defined criteria that include both ignitibility and propagation rates and, furthermore, are subject to periodic review. It should also be an accepted fact that, despite great care, some materials in a hypobaric chamber will be flammable and a fire, once started, can quickly become catastrophic.

C-1.1.3 Ventilation in a hypobaric chamber is significantly different than in normal atmospheres. For example, if a hypobaric chamber atmosphere is cycled through a purifier to remove only excess carbon dioxide or water vapor, flammable gas levels could build up to excessive levels as in any closed breathing circuit.

C-1.1.4 The quantity of oxygen in the atmosphere of a hypobaric chamber can be related to the number of pounds of fuel that would burn, the number of Btu released in such a reaction, and the pressure rise. Typically, for four pounds of oxygen, one pound of a hydrocarbon fuel is consumed, liberating approximately 20,000 Btu per pound.

C-1.2 Fire and Explosion.

C-1.2.1 The occurrence of a fire requires the presence of a combustible material, an oxidizer, and a source of energy to provide ignition.

C-1.2.2 Under hypobaric conditions, the oxygen content of the atmosphere can be increased from 21 percent to as much as 100 percent. Both the increased partial pressure of oxygen and the reduction in diluent inert or nonoxidizing gas contribute to an increased fire hazard. (*See Figure C-1.2.2.*)

C-1.2.2.1 Material self-extinguishing in air at atmospheric pressure can burn vigorously in an oxygen-enriched atmosphere. The specific rates, or ability to continue burning once an igniter is removed, depend on the composition of the material and the geometry of the system. Examples include wool, leather, polyvinyl chloride, silicone rubber, neoprene, epoxy adhesives, and many fire-retardant compounds. The resulting higher flame temperature from materials burning in oxygen also plays a significant role, as it enables things that are harder to burn to enter into combustion, such as metals that have high heats of combustion. There is also a slight reduction in ignition energy. Thus, the following effects are produced in an oxygen-enriched hypobaric atmosphere:

(a) Reduced inert gas.

(b) Increased partial pressure of oxygen giving increased available oxygen.

(c) Slightly reduced ignition energy.

(d) Increased burning rates.

(e) Higher flame temperature and lower flash point than at 14.7 psia.

C-1.2.2.2 There is a change in "flash point" and "fire point" as pressure is reduced. Published data obtained in air at 14.7 psia are therefore not reliable for hypobaric atmospheres, nor is there a clear-cut way to estimate the change.

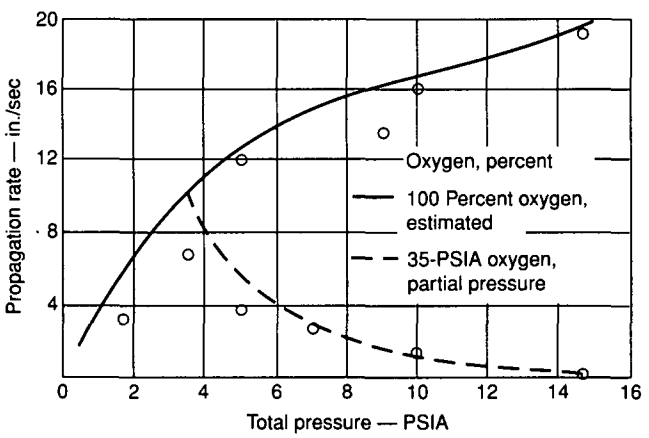

Figure C-1.2.2 Horizontal flame propagation rate on open polyurethane foam.

C-1.2.2.3 The flammability of petroleum products and other compounds containing carbon and hydrogen is well known. Hazards of liquids and gases that are flammable in air are apparent in hypobaric chambers. Some guidelines to their use in oxygen are documented in Chapter 4, Gas and Vacuum Systems, and Section 2-6.3 of Annex 2 in NFPA 99, *Standard for Health Care Facilities*. (*See also NFPA 53, Guide on Fire Hazards in Oxygen-Enriched Atmospheres, and NFPA 325, Guide to Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids.*) Lubricants, cleaning agents, and sterilization agents (such as ethylene oxide) are also in this category. They should be avoided unless data are available to verify their safety in the chamber.

C-1.2.3 Garments used by occupants of a hypobaric chamber produce a special hazard. All conventional fabrics used as clothing are highly combustible under oxygen-enriched conditions, except while saturated with water. Dependence must not be placed on fire-retardant treatments for service in oxygen-enriched atmospheres. Bedding, including mattresses, sheets, pillows, and blankets, is combustible. All conventional waterproof fabrics are combustible, including gloves. All bandages and dressings, including wooden splints, canvas, and much conventional medical equipment, are combustible. Other combustible products include name tags, check lists, notebooks, towels, sponges, and dry food products.

C-1.2.3.1 Choice of construction materials is based on many factors including availability, ease of cleaning, toxic properties, and cost, to name a few. Approved materials for use elsewhere in an institution normally are the basis for selection in hypobaric facilities. For Class D chambers this is normally adequate. However, Class E chambers raise the difficult question of oxygen compatibility. As this document is a standard, not a handbook, complete guidelines or design tips are not appropriate. Flammable liquids and gases are covered in the preceding section. The criteria in selecting solids, both metals and nonmetals, are not so easily dealt with. (*See 4-1.6.4, 4-1.7, and Section 4-3.*)

C-1.2.3.2 Metal screens, woven wire shields on cables, and braided wire coverings on electrical or pneumatic tubing can present unusual fire hazards. Whether aluminum, stainless steel, or other alloys containing iron, titanium, nickel, chromium, or silver, etc., are involved, a fire started by an electric arc can produce considerable heat and is difficult to extinguish.

C-1.2.4 Sources of Ignition.

C-1.2.4.1 Sources of ignition that might be encountered in a hypobaric chamber include, but are not necessarily limited to: defective electrical equipment (including failure of high-voltage equipment), heated surfaces in broken vacuum tubes or broken lamps used for general illumination, open or arcing switches (including motor switches), overheated motors, electrical thermostats, and communications equipment.

C-1.2.4.2 Sources of ignition that should not be encountered in a hypobaric facility, but that might be introduced by inept practice, include: lighted matches or tobacco; static sparks from improper use of personal attire; electrical wiring not complying with Section 3-7, including convenience outlets and brushes on motor rotors; photographic flash equipment; cigarette lighters; and any animal or vegetable oil-contaminated materials, which present a spontaneous heating hazard.

C-1.2.4.3 In oxygen-enriched atmospheres as defined in Section 2-2, the minimum energy necessary to ignite flammable or combustible materials is generally reduced below the energy required in atmospheres of ambient air in most instances.

NOTE: Items previously sterilized and packaged within biological barriers can be charged with significant levels of static energy. Upon opening such packages the neutralization of the static charge can release sufficient energy to cause ignition. The situation is worse if the inside atmosphere is dried by the use of a package of desiccant, and, if packaged in a sterilized atmosphere containing ethylene oxide, an explosion could result as the static electricity is released as a spark. The force of the explosion will probably be at a low level but the resulting flame could ignite adjacent material including the arm of the person opening the package.

C-1.3 Mechanical Hazards.

C-1.3.1 A vacuum vessel is subject to implosion and/or sudden inlet of surrounding atmosphere. As a result, inlets into the chamber must be protected from harming exterior personnel and chamber occupants by the vacuum action, and structures surrounding the chamber must be vented to allow pressure equalization. Inlet valves should be protected.

C-1.3.2 A particular hazard can be created if individuals attempt to drill, cut, or weld the vessel in a manner contrary to ASME PVHO-1, *Safety Standard for Pressure Vessels for Human Occupancy*.

C-1.3.3 The restriction on escape, and the impedance to efforts at rescue and fire fighting posed by the chamber, create a significant hazard to life in case of fire or other emergency.

C-1.3.3.1 A particular hazard to chamber personnel exists in the event of a fire within the structure housing the chamber. Inability to escape from the chamber and loss of services of the chamber operator would pose serious threats to life of all occupants of the chamber.

C-1.3.3.2 All occupants of hypobaric chambers should be aware that accidental fires are extremely dangerous but can be avoided by exercising due care in restricting burnables, reducing oxygen concentration, and eliminating ignition sources.

C-1.3.4 Viewing ports, if of small size, limit the vision of chamber operators and other observers, reducing their effectiveness as safety monitors.

C-1.3.5 Containers, including aerosol cans, and enclosures are subjected to rupture or collapse in consequence of the changing pressures in the hypobaric chamber. Items containing entrained gas include, but are not necessarily limited to: ampuls; partially filled syringes; stopped or capped bottles; cuffed endotracheal catheters; and pneumatic cushions employed for breathing masks or as aids in positioning patients. The rupture of such containers having combustible or flammable liquids would also constitute a severe fire or explosion hazard, and they should be excluded from the chamber.

C-1.3.5.1 Containers sealed in a hypobaric environment can implode and containers sealed at atmospheric pressure can explode when pressure is elevated or reduced, respectively. The fracture of a container of flammable liquid would constitute a severe fire or explosion hazard from the spill and vaporization of the liquid. (*See 4-1.5.2, 4-4.1, and Appendix C-1.2.2.3.*)

C-1.3.5.2 The pressure rise due to fire can cause the chamber interior to reach high pressures.

C-1.3.5.3 The hot gases vented in an emergency should be ducted to atmosphere. Care must be exercised in the location of such a vent, in that flame propagation will be enhanced by the flow of gases.

C-1.3.6 Other mechanical hazards relate to the malfunction, disruption, or inoperativity of many standard items when placed in service under evacuated atmospheres. Hazards that might be encountered in this regard are: explosion of containers that are normally hermetically sealed at atmospheric pressure such as condensers, batteries, tin cans, and the like; and overheating of devices that require convection to remove heat such as motors, lamps, transistors, and the like. Corona effects (ionization flashover) are more likely to occur in vacuum than at pressure, resulting in arcs, destruction of electrical apparatus, and possible fire in an oxygen-enriched atmosphere.

C-1.3.6.1 Sealed electrical equipment or convectively cooled apparatus can be a source of ignition.

C-1.4 Physiological and Medical Hazards.

C-1.4.1 Medical hazards that can be encountered routinely include compression problems and the direct effects of sudden pressure changes, such as dysbarism, anoxia, hypoxia, etc.

C-1.4.1.1 Inability to equalize pressure differentials between nasopharynx (nose) and nasal sinuses or middle ear can result in excruciating pain and can cause rupture of the ear drum or hemorrhage into the ear cavity or nasal sinus.

C-1.4.1.2 Direct effects of reduction in pressure include inability to equalize pressures between the nasopharynx and sinuses or middle ear, expansion of gas pockets in the gastrointestinal tract, and expansion of trapped gas in the lungs.

C-1.4.1.3 The presence of personnel within the cramped confines of the hypobaric chamber in close proximity to grounded metallic structures on all sides creates a definite shock hazard if contact is made with a live electrical conductor or a defective piece of electrical equipment. Such contact also could be a source of ignition of flammable or combustible materials. (*See Appendix C-1.2.4.*)

C-1.4.2 Medical hazards that are not ordinarily encountered during use of hypobaric facilities, but that might arise during malfunction, fire, or other emergency conditions, include electric shock and fouling of the atmosphere of the chamber with carbon dioxide, carbon monoxide pyrolysis products from overheated materials, or the toxic products of combustion from any fire.

C-1.4.2.1 Increased concentrations of carbon dioxide within the chamber, as might result from malfunction of the systems responsible for monitoring or removal thereof, can be toxic under decreased pressures.

C-1.4.2.2 The development of combustion products or gases evolved from heated substances, particularly organic materials, within the closed space of the hypobaric chamber can be extremely toxic to life because of the confining nature of the chamber and the increased hazards of breathing such products under reduced pressure.

NOTE: Extreme pressure rises have accompanied catastrophic fires in confined atmospheres. These pressures have driven hot, toxic gases into the lungs of victims as well as exceeding the structural limits of the vessel.

C-1.4.3 Physiological hazards include exposure to high noise levels and decompression sickness. Rapid release of pressurized gases can produce shock waves and loss of visibility.

C-1.4.3.1 During rapid changes in pressure, the noise level within the chamber becomes quite high. Such a level can be hazardous because it is distractive, interferes with communication, and, if prolonged, may be injurious, produce headaches, or cause other problems to susceptible individuals.

C-1.4.3.2 Decompression sickness (bends) results from the formation of bubbles in the blood stream or extravascular tissues from the dissolved inert gas (mainly nitrogen). The bubbles might form when the chamber pressure is reduced below atmospheric.

C-1.4.3.3 Decompression sickness can result if any personnel are exposed to a hypobaric atmosphere without prior denitrogenation. (*See Section 4-2.*)

NOTE: There is a potential for nitrogen in leakage in any closed oxygen system.

C-1.4.3.4 The sudden release of gas, whether by rupture of a container, a medical gas or breathing air piping system, or operation of a device such as used in fire fighting, will produce noise, possibly shock waves, reduced or obscured visibility, and temperature changes.

C-2 Suggested Fire Response Procedures.

The occurrence of a fire within a hypobaric chamber presents a different problem than in the case of hyperbaric chamber during pressurization. A depressurized hypobaric chamber can be repressurized within minutes without endangering personnel within the chamber, utilizing the emergency "dump" valve (*see 3-2.5*). Response might differ, however, if there is a fire in the vicinity of the chamber and if products of combustion are drawn into the chamber during rapid repressurization. Therefore, two distinct fire response procedures are required.

All personnel shall memorize the steps to be taken in these or similar procedures.

NOTE: This part of the appendix is included for guidance only in the drafting of fire response procedures appropriate to the specific facility. (*See 4-1.4.4.*)

C-2.1 Fire in the Chamber.

C-2.1.1 Response of Chamber Operator and Personnel Outside Chamber.

(a) Notify chamber occupants that dump repressurization will be accomplished by shouting "Dump" over intercom.

(b) Operate dump valve.

(c) Sound institutional fire alarm.

(d) Notify fire department.

(e) Open chamber access door and assist in removal of occupants.

(f) Initiate fire fighting procedures as indicated and feasible.

C-2.1.2 Response of Chamber Personnel.

(a) Notify chamber operator of fire.

(b) Don emergency breathing apparatus if feasible.

(c) Be prepared for dump procedure.

(d) Initiate fire fighting procedures if feasible (*see 3-6.1*) and evacuate chamber.

C-2.2 Fire in Vicinity of Chamber.

C-2.2.1 Response of Chamber Operator and Personnel Outside the Chamber.

(a) Sound the institutional fire alarm.

(b) Notify chamber occupants of the fire and request that they don breathing masks (*see 3-4.2*).

(c) Chamber operator remains at chamber controls and directs others to initiate fire fighting procedures.

(d) Notify fire department.

(e) Once the occupants have indicated that all have donned breathing apparatus, raise the chamber pressure at a rate commensurate with circumstances.

NOTE: The emergency operation of the dump valve might draw dangerous products of combustion into the chamber. It might also serve to fan the flames and intensify the fire.

(f) Assist chamber occupants to leave the chamber.

C-2.2.2 Response of Chamber Occupants.

(a) Don breathing apparatus when apprised to do so.

(b) Notify chamber operator after all occupants have donned breathing apparatus.

(c) Remain calm and prepare to leave chamber after repressurization.

C-3 Pressure Table. (*See Table C-3.*)

Table C-3 Total Pressures, Altitude, and Oxygen Partial Pressure or Concentration in Hypobaric Chamber

Total Absolute Pressure			Altitude Above Sea Level	Partial Pressure of Oxygen in Class D Chamber (mm Hg)	Concentration of Oxygen in Class E Chamber if Partial Pressure is 160 mm Hg (Percent by vol.)
(Atmospheres)	(mm Hg)	(psia)	(ft of air)		
1	760	14.7	sea level	160	20.9
4/5	608	11.7	6,000	128	26.5*
2/3	506	9.8	11,000	106	31.3*
3/5	456	8.8	13,500	96	35.0*
1/2	380	7.3	18,000	80	42.8*
2/5	304	5.9	23,000	64	52.6*
1/3	253	4.9	27,500	52	62.7*
1/5	152	2.9	38,500	32	100.0*

*Oxygen-enriched atmosphere.

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Ventilation 3-1.2, 3-4, 4-7.5.2, C-1.1.3
Viewing ports 3-2.4
Lighting fixtures used with 3-3.1.1
Voice sensors ..... *see* Sensors, voice

-W-

Water supply, extinguishing system 3-5.3, 3-6.2
Waterproof fabric C-1.2.3
Wetting agents 3-5.3.1, 3-6.2

-X-

X-ray equipment 4-3.1.1

The NFPA Codes and Standards Development Process

Since 1896, one of the primary purposes of the NFPA has been to develop and update the standards covering all areas of fire safety.

Calls for Proposals
The code adoption process takes place twice each year and begins with a call for proposals from the public to amend existing codes and standards or to develop the content of new fire safety documents.

Report on Proposals
Upon receipt of public proposals, the technical committee members meet to review, consider, and act on the proposals. The public proposals – together with the committee action on each proposal and committee-generated proposals – are published in the NFPA's Report on Proposals (ROP). The ROP is then subject to public review and comment.

Report on Comments
These public comments are considered and acted upon by the appropriate technical committees. All public comments – together with the committee action on each comment – are published as the Committee's supplementary report in the NFPA's Report on Comments (ROC).

The committee's report and supplementary report are then presented for adoption and open debate at either of NFPA's semi-annual meetings held throughout the United States and Canada.

Association Action
The Association meeting may, subject to review and issuance by the NFPA Standards Council, (a) adopt a report as published, (b) adopt a report as amended, contingent upon subsequent approval by the committee, (c) return a report to committee for further study, and (d) return a portion of a report to committee.

Standards Council Action
The Standards Council will make a judgement on whether or not to issue an NFPA document based upon the entire record before the Council, including the vote taken at the Association meeting on the technical committee's report.

Voting Procedures
Voting at an NFPA Annual or Fall Meeting is restricted to members of record for 180 days prior to the opening of the first general session of the meeting, except that individuals who join the Association at an Annual or Fall Meeting are entitled to vote at the next Fall or Annual Meeting.

"Members" are defined by Article 3.2 of the Bylaws as individuals, firms, corporations, trade or professional associations, institutes, fire departments, fire brigades, and other public or private agencies desiring to advance the purposes of the Association. Each member shall have one vote in the affairs of the Association. Under Article 4.5 of the Bylaws, the vote of such a member shall be cast by that member individually or by an employee designated in writing by the member of record who has registered for the meeting. Such a designated person shall not be eligible to represent more than one voting privilege on each issue, nor cast more than one vote on each issue.

Any member who wishes to designate an employee to cast that member's vote at an Association meeting in place of that member must provide that employee with written authorization to represent the member at the meeting. The authorization must be on company letterhead signed by the member of record, with the membership number indicated, and the authorization must be recorded with the President of NFPA or his designee before the start of the opening general session of the Meeting. That employee, irrespective of his or her own personal membership status, shall be privileged to cast only one vote on each issue before the Association.

Sequence of Events Leading to Publication of an NFPA Committee Document

Call for proposals to amend existing document or for recommendations on new document.

▼

Committee meets to act on proposals, to develop its own proposals, and to prepare its report.

▼

Committee votes on proposals by letter ballot. If two-thirds approve, report goes forward. Lacking two-thirds approval, report returns to committee.

▼

Report is published for public review and comment. (Report on Proposals - ROP)

▼

Committee meets to act on each public comment received.

▼

Committee votes on comments by letter ballot. If two-thirds approve, supplementary report goes forward. Lacking two-thirds approval, supplementary report returns to committee.

▼

Supplementary report is published for public review. (Report on Comments - ROC).

▼

NFPA membership meets (Annual or Fall Meeting) and acts on committee report (ROP and ROC).

▼

Committee votes on any amendments to report approved at NFPA Annual or Fall Meeting.

▼

Complaints to Standards Council on Association action must be filed within 20 days of the NFPA Annual or Fall Meeting.

▼

Standards Council decides, based on all evidence, whether or not to issue standard or to take other action, including hearing any complaints.

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Appeals to Board of Directors on Standards Council action must be filed within 20 days of Council action.