NFPA 115
Recommended Practice on Laser Fire Protection

1999 Edition

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

IMPORTANT NOTICE ABOUT THIS DOCUMENT

NFPA codes and standards, of which the document contained herein is one, are developed through a consensus standards development process approved by the American National Standards Institute. This process brings together volunteers representing varied viewpoints and interests to achieve consensus on fire and other safety issues. While the NFPA administers the process and establishes rules to promote fairness in the development of consensus, it does not independently test, evaluate, or verify the accuracy of any information or the soundness of any judgments contained in its codes and standards.

The NFPA disclaims liability for any personal injury, property or other damages of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, use of, or reliance on this document. The NFPA also makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

In issuing and making this document available, the NFPA is not undertaking to render professional or other services for or on behalf of any person or entity. Nor is the NFPA undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

The NFPA has no power, nor does it undertake, to police or enforce compliance with the contents of this document. Nor does the NFPA list, certify, test or inspect products, designs, or installations for compliance with this document. Any certification or other statement of compliance with the requirements of this document shall not be attributable to the NFPA and is solely the responsibility of the certifier or maker of the statement.

NOTICES

All questions or other communications relating to this document and all requests for information on NFPA procedures governing its codes and standards development process, including information on the procedures for requesting Formal Interpretations, for proposing Tentative Interim Amendments, and for proposing revisions to NFPA documents during regular revision cycles, should be sent to NFPA headquarters, addressed to the attention of the Secretary, Standards Council, National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

Users of this document should be aware that this document may be amended from time to time through the issuance of Tentative Interim Amendments, and that an official NFPA document at any point in time consists of the current edition of the document together with any Tentative Interim Amendments then in effect. In order to determine whether this document is the current edition and whether it has been amended through the issuance of Tentative Interim Amendments, consult appropriate NFPA publications such as the *National Fire Codes*® Subscription Service, visit the NFPA website at www.nfpa.org, or contact the NFPA at the address listed above.

A statement, written or oral, that is not processed in accordance with Section 16 of the Regulations Governing Committee Projects shall not be considered the official position of NFPA or any of its Committees and shall not be considered to be, nor be relied upon as, a Formal Interpretation.

The NFPA does not take any position with respect to the validity of any patent rights asserted in connection with any items which are mentioned in or are the subject of this document, and the NFPA disclaims liability of the infringement of any patent resulting from the use of or reliance on this document. Users of this document are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

Users of this document should consult applicable federal, state, and local laws and regulations. NFPA does not, by the publication of this document, intend to urge action that is not in compliance with applicable laws, and this document may not be construed as doing so.

Licensing Policy

NFPA 115

Recommended Practice on

Laser Fire Protection

1999 Edition

This edition of NFPA 115, *Recommended Practice on Laser Fire Protection*, was prepared by the Technical Committee on Laser Fire Protection and acted on by the National Fire Protection Association, Inc., at its May Meeting held May 17–20, 1999, in Baltimore, MD. It was issued by the Standards Council on July 22, 1999, with an effective date of August 13, 1999, 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 115 was approved as an American National Standard on August 13, 1999.

Origin and Development of NFPA 115

In September 1988, a request was received by the NFPA Standards Council to establish a project on laser fire protection. At that time, NFPA documents did not address the fire hazards of lasers. Existing standards, other than NFPA, addressed other laser hazards (primarily health hazards) but did not adequately address the fire hazard involved. In October 1988, the Council published a request for comments on the need for such a project. After reviewing comments submitted, the Council approved the establishment of a laser fire protection project in July 1989. The resultant document (designated NFPA 115) is intended to supplement existing NFPA documents and other standards involving lasers. Where a particular hazard, such as a flammable liquid, is appropriately addressed by another NFPA document, it is referenced.

Lasers can be a significant fire hazard. Class 4 and some Class 3b lasers (classification is from ANSI Z136.1, *Safe Use of Lasers*) are powerful enough that the beam is an ignition hazard. During use, particularly in the medical field, the laser beam is directly adjacent to combustible materials and, in certain clinical procedures, flammable gastrointestinal gases and prepping agents. Fire incidents have occurred when the laser beam has impinged on a material other than the intended target.

Additionally, some lasers use flammable liquids as an integral part of their operation. The flammable liquids are pumped and flow through tubing. The tubing material can be quartz or plastic. Both types of tubing are prone to damage, either by breaking or melting, when exposed to a fire. When this occurs a flammable liquid pool fire is created.

Often materials used to fabricate laser systems are inappropriate with respect to fire safety — that is, manufacturers do not always choose component materials with regard to their ignition and heat release properties. Lasers can involve the use of high-energy power supplies. Motors for use with flammable liquids need to be intrinsically safe or of approved electrical classification.

As part of an ongoing effort to document the fire hazards of lasers, a database of fires involving lasers has been started. (Documented incidents have occurred in hospitals, research laboratories, and industrial applications.) From the data gathered thus far, the majority of incidents involve the laser beam as the ignition source. Materials ignited include adjacent combustibles as well as components of the laser itself. Other incidents have involved components of the laser overheating or igniting due to a failure of the laser system.

In the 1999 edition of this document, most of the changes were made to conform to the NFPA *Manual of Style*. In addition, many of the references to flammable liquids were changed to ignitible liquids because “flammable” was too restrictive.

Technical Committee on Laser Fire Protection

Yadin David, *Chair*
Texas Childrens Hospital, TX [U]

Richard L. P. Custer, Custer Powell, Inc., MA [SE]
Jerome E. Dennis, U.S. Dept. of Health/Human Services, MD [E]
John F. Elwood, III, Hartford Hospital, CT [U]
John P. Heffner, Princeton Insurance Co., NJ [I]
David Eric Lees, Georgetown University Medical Ctr., DC [C]
Rep. American Society of Anesthesiologists
Edward A. Lobnitz, Tilden Lobnitz & Cooper Inc., FL [SE]
Rep. NFPA Health Care Section
Jesse D. Lum, Lawrence Livermore Nat'l Laboratory, CA [E]
Terry G. McIntyre, Arkwright Mutual Insurance Co./FM-RC, NC [I]
Dennis J. Murray, KMS-Medical Gas System Consultants Ltd, MI [SE]
Kenneth Robichaux, Tennessee State Fire Marshal, TN [E]
R. James Rockwell, Jr., Rockwell Laser Industries, OH [M]
Fred P. Seeber, Laser Inst. of Tech, NJ [U]
Jay R. Sommers, Kimberly-Clark Corp., GA [U]

Alternates

Jay R. Crowley, U.S. Dept. of Health/Human Services, MD [E]
(Alt. to J. E. Dennis)
Gerald L. Wolf, SUNY/HCSB, Brooklyn, NY [C]
(Alt. to D. E. Lees)

Craig H. Kampmier, NFPA Staff Liaison

This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of this document.

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 on fire protection for laser equipment, including their safe installation, use, and maintenance.

Contents

NFPA 115

Recommended Practice on

Laser Fire Protection

1999 Edition

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

Information on referenced publications can be found in Chapter 12 and Appendix F.

Chapter 1 General

1-1 Scope. This document covers recommended minimum fire protection criteria for the design, manufacture, installation, and use of lasers and associated equipment. Included are suggested criteria for training and responding to fire emergencies involving lasers.

1-2 Purpose. This document provides recommendations intended to prevent or mitigate the effects of fire involving lasers.

1-3 Application. This document applies to lasers capable of producing a beam ignition hazard, to those lasers utilizing materials or components presenting a fire hazard, or to the areas where such lasers are used.

1-4 Interface with Existing Codes and Standards.

1-4.1 When interface with existing NFPA or other consensus codes and standards occurs, reference is made to the appropriate source in the text.

1-4.2 Due to the unique fire hazards associated with lasers and their operations, this recommended practice provides additional fire safety guidance beyond that of other documents.

Chapter 2 Definitions

2-1 Definitions.

Accessible Emission Limit (AEL). The maximum accessible emission level permitted within a particular class. (ANSI Z136.1; 21 *CFR* 1040.10)

Apparatus. Furniture, laboratory hoods, centrifuges, refrigerators, and commercial or made-on-site equipment used in a laboratory. (NFPA 45)

Approved.* Acceptable to the authority having jurisdiction.

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

Average Power. The total energy imparted during exposure divided by the exposure duration. (ANSI Z136.1)

Beam. A collection of rays that can be parallel, divergent, or convergent. (ANSI Z136.1)

Combustible Liquid. A liquid having a flash point at or above 100°F (37.8°C). Combustible liquids are subdivided as follows: (1) Class II liquids include those having flash points at or above 100°F (37.8°C) and below 140°F (60°C); (2) Class IIIA liquids include those having flash points at or above 140°F (60°C) and below 200°F (93°C); (3) Class IIIB liquids include those having flash points at or above 200°F (93°C). (NFPA 45)

Compressed Gas. Any material or mixture having in the container an absolute pressure exceeding 40 psi (pounds per square inch) at 70°F (275.8 kPa at 21.1°C) or, regardless of the pressure at 70°F (21.1°C), having an absolute pressure exceeding 104 psi at 130°F (717 kPa at 54.4°C), or any flammable liquid having a vapor pressure exceeding 40 psi absolute at 100°F (275.8 kPa at 37.8°C) as determined by ASTM D 323, *Standard Test Method for Vapor Pressure of Petroleum Products (Reid Method).*

Continuous Wave (cw). The output of a laser operated in a continuous rather than a pulsed mode. In this document, a laser operation with a continuous output for a period ≥ 0.25 seconds is regarded as a cw laser. (ANSI Z136.1)

Embedded Laser. An enclosed laser with an assigned class number higher than the inherent capability of the laser system in which it is incorporated, where the system's lower classification is appropriate due to the engineering features limiting accessible emission. (ANSI Z136.1)

Energy.* The capacity for doing work. (ANSI Z136.1)

Explosion.* An effect produced by the sudden violent expansion of gases.

Explosive Material. A chemical compound, mixture, or device, the primary or common purpose of which is to function by explosion. *(For a more complete definition, see NFPA 495, Explosive Materials Code.)*

Flammable Gas. A gas that will burn in air. (NFPA 45)

Flammable Liquid. A liquid having a flash point below 100°F (37.8°C) and having a vapor pressure not exceeding 40 psi (2068 mmHg) at 100°F (37.8°C). Class I liquids are subdivided as follows: (1) Class IA liquids include those having flash points below 73°F (22.8°C) and having boiling points below 100°F (37.8°C); (2) Class IB liquids include those having flash points below 73°F (22.8°C) and having boiling points at or above 100°F (37.8°C); (3) Class IC liquids include those having flash points at or above 73°F (22.8°C) and below 100°F (37.8°C). (NFPA 45)

Flammable Liquid Storage Cabinet.* A cabinet for the storage of flammable and combustible liquids constructed in accordance with Section 4-3 of NFPA 30, *Flammable and Combustible Liquids Code.* (NFPA 45)

Flammable Vapors. A concentration of constituents in air that exceeds 10 percent of its lower flammable limit (LFL).

Flash Point.* The minimum temperature at which a liquid gives off vapor in sufficient concentration to form an ignitible mixture with air near the surface of the liquid within the vessel, as specified by appropriate test procedures and apparatus. (NFPA 45)

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 Fire Hazards of Materials for Emergency Response:* Health — 2, 3, or 4; Flammability — 3 or 4; Reactivity — 2, 3, or 4.

Ignitible Liquid. Any liquid or the liquid phase of any material that is capable of fueling a fire, including a flammable liquid, a combustible liquid, or any material that can be liquefied and burned. (NFPA 921)

Interlock.* A device to prevent an action from occurring where injury or property damage can result. Interlocks are classified into three main types: key-operated, mechanical, and electrical.

Irradiance. The power of a laser divided by the area of the laser beam at the target surface, expressed in W/cm^2.

Joule. A unit of energy (1 joule = 1 watt second).

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.

Laser. A device that produces an intense, coherent, directional beam of light by stimulating electronic or molecular transitions to lower energy levels (an acronym for Light Amplification by Stimulated Emission of Radiation). (ANSI Z136.1; 21 *CFR* 1040.10)

Laser Safety Personnel (LSP). One who has authority to monitor and enforce the control of laser hazards and to effect the knowledgeable evaluation and control of laser hazards. (ANSI Z136.1)

Laser System. An assembly of electrical, mechanical, and optical components that includes a laser. (ANSI Z136.1)

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.* Where not otherwise identified, the term liquid includes both flammable and combustible liquids. (NFPA 326)

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.

Lower Explosive Limit or Lower Flammable Limit. The minimum concentration of combustible vapor or combustible gas in a mixture of the vapor or gas and gaseous oxidant above which propagation of flame will occur on contact with an ignition source. (NFPA 53)

Maintenance. Performance by the user of those adjustments or procedures specified in user information provided by the manufacturer with the laser or laser system to ensure the intended performance of the product. It does not include *operation* or *service* as defined in this document. (ANSI Z136.1; 21 *CFR* 1040.10)

Maximum Allowable Working Pressure (MAWP).* The maximum pressure permissible at the top of a vessel in its normal operating position at the operating temperature specified for that pressure.

Noncombustible.* A material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat.

Operation. The performance of the laser or laser system over the full range of its intended functions (normal operation). It does not include *maintenance* or *service*. (ANSI Z136.1; 21 *CFR* 1040.10)

Oxidizing Material. Any material that readily yields oxygen or other oxidizing gas or that reacts chemically to oxidize combustible materials.

Oxygen-Enriched Atmosphere (OEA). An atmosphere in which the concentration of oxygen exceeds 21 percent by volume or the partial pressure of oxygen exceeds 160 torr (millimeter of mercury), or both. (NFPA 53)

Power. The rate at which energy is emitted, transferred, or received. The units of power are watts (joules/second).

Plasma.* A state of ionization in a gas, solid, or liquid that can be generated by the very high electromagnetic field strengths of focused laser beams or by the impact of high-power laser beams.

Protective Housing.* An enclosure that surrounds the laser or laser system that prevents access to laser radiation above the applicable maximum permissible exposure (MPE) level. (ANSI Z136.1; 21 *CFR* 1040.10)

Pulsed Laser. A laser that delivers its energy in the form of a single pulse or a train of pulses. A single pulse or a train of pulses with a pulse duration of <0.25 second. (ANSI Z136.1)

Q-Switch. A device for producing very short (approximately 30 nanoseconds), intense laser pulses by enhancing the storage and dumping of electronic energy in and out of the lasing medium, respectively. (ANSI Z136.1)

Q-Switched Laser. A laser that emits short (approximately 10 to 250 nanoseconds), high-power pulses by means of a Q-switch. (ANSI Z136.1)

Radiant Exposure. Energy received by the surface in $joules/cm^2$. (ANSI Z136.1)

Reactive Gas. A gas that, by itself, is readily capable of detonation, explosive decomposition, or explosive reaction at normal or elevated temperatures and pressures. Reactive gases can also be corrosive.

Safety Can. An approved container, of not more than 5-gal (19-L) capacity, having a spring-closing lid and spout cover and so designed that it will safely relieve internal pressure when subjected to fire exposure. *(See Section 1-6, "Safety Can," of NFPA 30, Flammable and Combustible Liquids Code.)* (NFPA 45)

Safety Factor. The ratio of the calculated failure pressure (or actual failure pressure, if known) to the MAWP.

Service. The performance of those procedures or adjustments described in the manufacturer's service instructions that can affect any aspect of the performance of the laser or laser system. It does not include *maintenance* or *operation* as defined in this document. (ANSI Z136.1; 21 *CFR* 1040.10)

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

Watt. The unit of power or radiant flux (1 watt = 1 joule/second).

Chapter 3 Classification of Lasers

3-1* Class 1 Lasers and Laser Systems.

3-1.1 Any laser or laser system containing a laser that cannot emit accessible laser radiation levels in excess of the Class 1 AEL for the maximum possible duration inherent in the design or intended use of the laser or laser system is a Class 1 laser or laser system during operation and is exempt from all control measures or other forms of surveillance with the exception of applicable requirements for embedded lasers. The exemption applies strictly to emitted laser radiation hazards and not to other potential hazards.

3-1.2 Lasers or laser systems intended for a specific use can be designated Class 1 by LSP on the basis of that use for a limited exposure duration of T_{max} of less than 3×10^4 seconds, provided that the accessible laser radiation does not exceed the corresponding Class 1 AELs for the maximum possible duration inherent in the design or intended use of the laser or laser system.

3-2* Class 2 and Class 2a Visible Lasers and Laser Systems.

3-2.1 Class 2 lasers and laser systems include the following:

(1) Visible (0.4 to 0.7 micrometers) cw lasers and laser systems that can emit accessible radiant power exceeding the Class 1 AEL for the maximum possible duration inherent in the design or intended use of the laser or laser system but not exceeding 1 mW
(2) Visible (0.4 to 0.7 micrometers) repetitively pulsed lasers and laser systems that can emit accessible radiant power exceeding the appropriate Class 1 AEL for the maximum possible duration inherent in the design or intended use of the laser or laser system but not exceeding the Class 1 AEL for a 0.25-second exposure duration

3-2.2 Visible (0.4 to 0.7 micrometers) laser and laser systems intended for a specific use where the output is not intended to be viewed should be designated Class 2a by the LSP, provided that the accessible radiation does not exceed the Class 1 AEL for an exposure duration less than or equal to 10^3 seconds.

3-3* Class 3a and Class 3b Lasers and Laser Systems.

3-3.1 Class 3a and Class 3b laser and laser systems include the following:

(1) Infrared (1.4 micrometers to 1 mm) and ultraviolet (0.2 to 0.4 micrometers) lasers and laser systems that can emit accessible radiant power in excess of the Class 1 AEL for the maximum possible duration inherent in the design of the laser or laser system but that cannot emit an average radiant power in excess of 0.5 W for ≥ 0.25 seconds or cannot produce a radiant energy greater than 0.125 J within an exposure time < 0.25 seconds.
(2) Visible (0.4 to 0.7 micrometers) cw or repetitively pulsed lasers and laser systems that produce accessible radiant power in excess of the Class 1 AEL for a 0.25-second exposure time (1 mW for a cw laser) but that cannot emit an average radiant power greater than 0.5 W.
(3) Visible and near-infrared (0.4 to 1.4 micrometers) single-pulsed lasers that can emit accessible radiant energy in excess of the Class 1 AEL but that cannot produce a radiant exposure that exceeds 0.03 J for wavelengths less than or equal to 0.7 micrometers or 0.03 C_AJ for wavelengths greater than 0.7 micrometers. The value for C_A varies from 1 to 5 in the 0.4 to 1.4 micrometer range.
(4) Near-infrared (0.7 to 1.4 micrometers) cw lasers or pulsed lasers that can emit accessible radiant power in excess of the Class 1 AEL for the T_{max} inherent in the design or intended use of the laser or laser system but that cannot emit an average power of 0.5 W or greater for a period ≥ 0.25 seconds.

3-3.2 All Class 3 lasers and laser systems that have an accessible output power between 1 and 5 times the Class 1 AELs for wavelengths less than 0.4 micrometers or greater than 0.7 micrometers, or 5 times the Class 2 AELs for wavelengths between 0.4 and 0.7 micrometers, are classified Class 3a.

3-3.3 All Class 3 lasers and laser systems that do not meet the requirements of 3-3.2 are classified as Class 3b.

3-4* Class 4 Lasers and Laser Systems. Class 4 lasers and laser systems include the following:

(1) Ultraviolet (0.18 to 0.4 micrometers) and infrared (1.4 micrometers to 1 mm) lasers and laser systems that emit an average accessible radiant power in excess of 0.5 W for a period ≥ 0.25 seconds or produce a radiant energy greater than 0.125 J within an exposure time of < 0.25 seconds.
(2) Visible (0.4 to 0.7 micrometers) and near-infrared (0.7 to 1.4 micrometers) lasers and laser systems that emit an average accessible radiant power of 0.5 W or greater for periods ≥ 0.25 seconds or produce a radiant energy in excess of 0.03 C_AJ. The value for C_A varies from 1 to 5 in the 0.4 to 1.4 micrometer range.

Chapter 4 Evaluation of Laser Beam Ignition Potential

4-1 General.

4-1.1 The laser classes in ANSI Z136.1, *Safe Use of Lasers*, or Title 21, *Code of Federal Regulations*, Part 1040.10 are based upon biological damage to the eye or skin. The limits of the classes depend on wavelength and duration of emission. These classes should be considered only as an approximate guide for ignition potential.

4-1.2* Continuous wave laser beams producing irradiances in the order of 0.5 W/cm^2 or greater can be considered to be ignition hazards. Lower values can be possible, particularly in an oxygen-enriched atmosphere, depending on the thickness and the physical properties of the material.

4-1.3 Ignition potential of pulsed lasers depend on radiant exposure, pulse duration, and pulse repetition rate. Very high repetition rates can produce ignition hazards similar to cw laser beams.

4-2 Beam Ignition Potential of Laser by Class.

4-2.1 Class 4 lasers should always be considered to be beam ignition hazards.

4-2.2 Lasers in the upper power and energy levels of Class 3b can be beam ignition hazards.

4-2.3 Lasers in the lower power and energy levels of Class 3b are often incapable of being beam ignition hazards.

4-2.4 Class 1, Class 2, and Class 3a lasers typically are not considered to be beam ignition hazards. Class 1 lasers that are an embedded Class 4 laser can present the same beam ignition potential as Class 4 lasers.

4-3 Factors Affecting Ignition Potential.

4-3.1 The ignition potential is a function of the irradiance at the fuel, duration of exposure, and nature of the fuel.

4-3.2 Laser beams that have low irradiance can be capable of being focused to an irradiance sufficient to cause ignition.

4-3.3 Since ignition occurs when enough energy has been absorbed by the fuel to raise it to its ignition temperature, both the irradiance and the exposure time at the target are important.

4-3.4 In oxygen-enriched atmospheres, exposure times for ignition and energy for ignition might be reduced.

4-3.5 In general, for a given fuel, thinner constructions might require less energy or shorter exposure for ignition than thicker constructions.

4-3.6 Certain Q-switched or mode-locked lasers are capable of generating plasma in air or other media. The plasma itself might be an ignition source even if its originating laser is not.

4-4 Ignition Testing. Testing under controlled conditions can be appropriate if it has not been determined whether a particular Class 3b laser is an ignition hazard.

Chapter 5 Laser Beam Ignition

5-1 Scope. This chapter covers the potential fuels and oxidizing gaseous atmospheres that might be present during the use of a laser and that could result in a fire.

5-2 Nature of Hazard. A beam ignition hazard might exist during the use of a laser — for example, in a research, commercial, industrial, military, or health care facility.

5-3 General. Before a laser is used, the beam intensity profile and alignment should be determined, the appropriate beam stop materials should be in place, and the facility, control measures, safety, and training programs should be established using ANSI Z136.1, *Safe Use of Lasers*.

5-4 Health Care.

5-4.1 Facility. The health care facility where the medical laser is used should conform to ANSI Z136.3, *Safe Use of Lasers in Health Care Facilities,* NFPA *101®*, *Life Safety Code®*, and NFPA 99, *Standard for Health Care Facilities*. These documents include requirements on entry and exit access, posted signs, limited access, and beam barriers at all windows and doors.

5-4.2 Combustible Substances. It should be recognized that no materials, excepting the noble metals, can be categorically considered "fire safe" when impinged on by a laser beam in the presence of oxygen-enriched atmospheres. Potential fuels in health care facilities include but are not limited to the following:

(1) *Patients*. Hair, gastrointestinal gases (methane, hydrogen, and hydrogen sulfide)
(2) *Prepping Agents*. Degreasers (ether, acetone, aerosol adhesives, alcohol), tinctures (Hibitane™, Merthiolate™, collodion, benzoin)
(3) *Fabric Products*. Towels, surgical drapes, dressings, gowns, masks, shoe covers, caps/hoods, gauze, sponges, patient warming devices
(4) *Plastic/Rubber Products*. Surgical drapes, gloves, anesthesia masks, tracheal tubes, breathing circuits, patient warming devices
(5) *Ointments*. Petroleum-based jelly
(6) *Laser Circuitry*. Beam tubes, fiber-optic cables

5-4.3 Gases.

5-4.3.1 Flammable Gases. Flammable gastrointestinal gases such as methane, hydrogen, and hydrogen sulfide present a unique hazard. Precautions to eliminate or manage these gases should be taken.

5-4.3.2 Oxidizing Gases. Ignition can be enhanced by the use of oxygen-enriched atmospheres that are created by the use of respiratory or anesthetic gases, or both — for example, oxygen and nitrous oxide.

5-4.3.3 Nonflammable gases. Nonflammable anesthetic gases and vapors have replaced flammable anesthetic gases and vapors in the United States.

5-4.4* Operating Room Environment. If an oxygen-enriched atmosphere exists — that is, exceeds 21 percent oxygen — additional precautions should be taken, as the probability of ignition is increased.

5-4.5 Before Using Laser.

5-4.5.1 Beam Alignment. If an alignment beam is present, proper coincident with the treatment beam should be verified before each use.

5-4.5.2 Beam Intensity Profile. If the laser has been determined to be a beam ignition hazard, the intensity profile should be determined before each use.

5-4.6 Beam Stop Materials. Before the laser is used, it should be determined that the appropriate beam stop materials are in place.

5-4.7 Education. Education should be in accordance with that stated in ANSI Z136.3, *Safe Use of Lasers in Health Care Facilities,* Section 5. Detailed training in laser safety should be required for those health care personnel using a medical laser or responsible for patient care during the use of a medical laser. Those personnel include the surgeon or physician using the laser, the laser safety officer, anesthesia personnel, nursing staff, and other health care personnel as appropriate.

Chapter 6 Design and Fire Safety Features of Laser Equipment

6-1 General. Lasers can operate continuously for long periods of time and might be unattended. The recommendations in this chapter deal with fire safety design and selection of materials used in the construction of the laser, including the following:

(1) Circuit boards and support structures
(2) Acoustical, thermal, and electrical insulation
(3) Cabinetry
(4) Cooling equipment
(5) Control equipment

6-2 Laser Equipment Employing Ignitible Liquids or Flammable Gases.

6-2.1 Laser equipment employing ignitible liquids should have a means to control or contain ignitible liquid spills using noncombustible materials.

6-2.2 When ignitible solvents are used, such as in dye lasers, products with the highest possible flash point consistent with the necessary solvent properties should be used.

6-2.3 Laser equipment having oil-cooled components should employ a nonflammable-fluid or-2.3 a fluid with the highest flash point and ignition temperature that is consistent with the necessary coolant properties.

6-2.4 Pumps, motors, and other electrical components in laser equipment that employ ignitible liquids or flammable gases should be of intrinsically safe design or be appropriately rated for the application. *(See Article 500 of NFPA 70, National Electrical Code®.)*

6-2.5 Metal tubing is recommended for use with ignitible liquids or flammable gases. Where plastic tubing is used, it should have a pressure rating of 1.5 times the maximum allowable working pressure, be of a material with the highest melting point and ignition temperature consistent with other necessary properties, and be the shortest length necessary.

6-3* Materials of Construction. The use of combustible materials should be minimized. Materials used inside the laser equipment enclosure should be evaluated for ignition and heat release properties. Materials having the longest time to ignition and the lowest heat release rate that are consistent with the electrical and mechanical properties needed should be selected.

6-4 Laser Equipment Ventilation. Exhaust from laser enclosures should be directed to an area where it will not cause unacceptable damage if a fire occurs inside the laser enclosure.

6-5 Alarms and Controls.

6-5.1 Laser systems utilizing materials and components that present a fire hazard should incorporate circuitry that can be used for emergency shutdown by fire detection systems, manual, or other means. The design of the circuit should not permit automatic restart with restoration of power following a remote shutdown.

6-5.2 The temperature of coolants and ignitible liquids should be monitored to warn of excessive rate of heating or approach to threshold temperature. Provisions should be made for alarm and automatic shutdown should such conditions be detected.

6-5.3* When appropriate for life safety or property damage purposes, the laser equipment cabinet or exhaust can be monitored for the presence of precombustion products, such as hydrogen chloride or submicron particulate, that can be produced by component overheating or from products of combustion. Multiple alarm thresholds such as "warning," "alarm," and "automatic shutdown" should be considered.

6-5.4 Degradation of components that could lead to a fire can frequently be noted by monitoring various components or functions. Some items that can be monitored include component temperature, device electrical parameters, or the laser power. The frequency or magnitude of power excursions exceeding specified values can be an indicator of incipient fire hazards. When such monitoring is provided, alarm and automatic shutdown levels can then be established.

6-6 Manuals and Training.

6-6.1 Manufacturers' manuals should provide information on the fire safety features of the equipment and on the procedures to be followed for fire-safe operation, as appropriate.

6-6.2 Where manufacturers provide instructions on laser system operations, fire safety features and fire hazards specific to the system should be included, as appropriate.

6-6.3 Manufacturers' manuals should provide guidance for dealing with fire emergencies and the post-fire testing and restoration of the equipment, as appropriate.

Chapter 7 Flammable Gases

7-1 General. The general requirements of NFPA 55, *Standard for the Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders*, should be followed.

7-1.1 To determine if a gas is flammable, the rating as listed in ANSI B57.1, *Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections*, should be used.

7-2 Work Practices.

7-2.1 Laser systems utilizing or containing flammable gas(es) should be so labeled.

7-2.2 Gas shutdown capability should be provided both at the location of use and remotely.

7-2.3 "Flammable Gas — No Smoking" signs should be posted conspicuously near the supply and usage locations of the flammable gases.

7-2.4 When piping for flammable gases is not in use, it should be capped.

7-2.5 No modifications should be made to pressure containers or pressure relief devices by anyone except the supplier.

7-2.6 Systems should be regularly maintained as recommended by the manufacturer.

7-3 Fire Safety.

7-3.1 Appropriate combustible gas sensors should be located near the area of use of the flammable gases except where demonstrated by calculation that 25 percent of the lower explosive limit (LEL) cannot be reached if the entire contents were to discharge.

7-3.2 If the supply of flammable gases is located indoors, appropriate combustible gas sensors should be used except where demonstrated by calculation that 25 percent of the LEL cannot be reached if the entire contents were to discharge.

7-3.3 If possible, combustible gas sensors should be interlocked with the ventilation system and the exhaust ventilation increased at 25 percent of the LEL.

7-3.4 At 25 percent of the LEL, combustible gas sensors should sound an audible alarm.

7-3.5 At 50 percent of the LEL, the combustible gas sensors should sound an audible alarm and automatically shut off the supply of gases.

7-4 Facilities and Equipment.

7-4.1 General.

7-4.1.1 Indoor cylinder use should be limited to lecture bottle size unless the cylinder(s) is kept in an approved ventilated cabinet or unless the room is provided with sufficient ventilation to keep the gas concentration below 25 percent of the LEL if the entire contents of the cylinder(s) in use were to discharge.

7-4.1.2* Outside flammable gas supplies in excess of 400 ft^3 (11.3 m^3) should be separated from oxidizing gases by 20 ft (6.1 m) or a 2-hour fire-rated barrier.

7-4.1.3 Exterior flammable gas supply capacity should be evaluated so as to not exceed combustibility limits if accidentally released into any closed area where supply gas lines are routed. Evaluation of closed areas where combustible gas mixtures might occur should include assessments of installed ventilation system air exchange rates and exhaust systems if present. Enclosed areas where flammable gases could exceed combustibility limits should have combustible gas sensors. General air dynamics within the closed areas should be evaluated for determination of location for combustible gas sensors.

7-4.1.4 Exterior flammable gas supplies capable of exceeding combustibility limits of enclosed areas where gas supply lines are routed should be interlocked with combustible gas sensors. A combustible gas sensor alarm should shut off the gas supply at the source and vent the gas supply lines from the enclosed area(s) to a safe location.

7-4.1.5 Exhaust vents should be located away from air intakes by at least 25 ft (7.6 m), except 50 ft (15.3 m) for hydrogen. If venting above a roof, piping should be high enough to mitigate the chance of flammable gas buildup in an undesirable location.

7-4.2 Piping.

7-4.2.1 Piping should be cleaned and compatible with the gas.

7-4.2.2 Piping should be designed to a safety factor of four and tested to 1.5 times the maximum allowable working pressure.

7-4.2.3 Piping should be pressure tested and then leak checked prior to initial use and periodically thereafter, as appropriate.

7-4.2.4 Flammable gas vent lines should be dedicated and separate from oxidizing gas vent lines and should terminate in a safe location.

7-4.3 Regulators.

7-4.3.1 Regulator diaphragm failures should be considered when locating a flammable gas regulator in an enclosed area. Flammable gas regulators with bonnet fittings for piping external venting should be used in enclosed areas. Standard gas regulators do not have these fittings and release supply gases through vent holes located in the bonnet in the event of a regulator diaphragm failure. Vents should be piped to a safe location.

7-4.3.2 If low pressures are required for use, a two-stage regulator is recommended.

7-4.3.3 Vents from regulators should be piped to a safe location.

7-4.3.4 The regulator should not be used as a flow control. A flow control valve or a supplementary valve downstream of the regulator should be used for control of flow.

7-5 Electrical Requirements. Electrical circuits, devices, fixtures, and grounding in the area of a laser classified as hazardous and for direct connection of the laser are to be installed in accordance with the appropriate sections of NFPA 70, *National Electrical Code®*.

7-6 Training.

7-6.1 Facilities using flammable gases should have a thorough training program in emergency procedures for all employees.

7-6.2 The training program should include drills, awareness of fire protection features, liaison with fire-fighting personnel, and knowledge of remote shutoff for gases.

Chapter 8 Reactive Gases

8-1 General. The general requirements of NFPA 55, *Standard for the Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders*, should be followed.

8-2 Work Practices.

8-2.1 The reactive gas system should be labeled to identify its contents.

8-2.2 Gas shutdown capability should be provided both at the location of use and remotely.

8-2.3 Where possible, the gas cabinet should be located outdoors.

8-2.4 When not in use, compressed gas cylinders containing reactive gases should be capped.

8-2.5 When connecting or disconnecting bottles, the manifold system should be purged to minimize the effect of corrosion of the system.

8-2.6 Systems should be regularly maintained as recommended by the manufacturer. A system data package, including a maintenance log, should be maintained. The data package also should include installed exhaust calibration data.

8-2.7 Reactive gases cylinders should be located in an approved ventilated cabinet. *(See Section 7-4 of NFPA 55, Standard for the Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders.)*

8-2.8 No modifications should be made to pressure containers or pressure relief devices by anyone except the supplier.

8-3 Fire Safety.

8-3.1 Written procedures should be followed for cylinder changing and maintenance.

8-3.2 A limiting orifice should be installed on each cylinder to limit the release rate of the gas.

8-3.3* Gas cabinets should be provided with a sprinkler system inside the cabinet. The sprinkler system should be protected from corrosion where necessary.

8-3.4 Only the smallest quantity or percent of reactive gas necessary should be used. Premixed gases should be used to minimize the need for highly concentrated reactive gases.

8-3.5 The regulator chosen for use should be compatible with the reactive gas.

8-4 Facilities and Equipment.

8-4.1 General.

8-4.1.1 If the ventilated cabinet is located indoors, consideration should be given to connecting the cabinet to emergency power to provide continued exhaust capability.

8-4.1.2 Exhaust from the laser system should be designed to ensure dilution below reactive levels, or the exhaust should be mixed with an inert gas.

8-4.1.3 Exhaust systems should be designed to ensure that the exhaust does not stagnate in exhaust piping.

8-4.1.4 The supply control valve should be a solenoid valve designed to close in the event of loss of electrical power.

8-4.1.5 The piping exhaust should be located away from air intakes by at least 25 ft (7.6 m). If venting above a roof, piping should be high enough to mitigate the chance of flammable gas buildup in an undesirable location.

8-4.2 Piping.

8-4.2.1 Piping should be cleaned and compatible with the gas.

8-4.2.2 Piping should be designed to a safety factor of four and tested to 1.5 times the maximum allowable working pressure.

8-4.2.3 Piping should be pressure tested and then leak checked prior to initial use and periodically thereafter, as appropriate.

8-4.2.4* Piping should be purged with an inert gas during long periods of nonuse, maintenance, or servicing.

8-4.2.5 "Face-seal"-type fittings are acceptable. Threaded or compression fittings should not be used, as they can trap contaminants and be difficult to purge.

8-4.2.6 If there is the possibility of contamination of the system by other gases or foreign material, suitable traps or check valves should be installed.

8-4.3 Regulators.

8-4.3.1 Vents from regulators should be piped to a safe location.

8-4.3.2 If low pressures are required for use, a two-stage regulator is recommended.

8-4.3.3 Regulator diaphragm failures should be considered when locating a reactive gas regulator in an enclosed area. Reactive gas regulators with bonnet fittings for piping external venting should be used in enclosed areas. Standard gas regulators do not have these fittings and release supply gases through vent holes located in the bonnet in the event of a regulator diaphragm failure. Vents should be piped to a safe location.

8-4.3.4 The regulator should not be used as a flow control. A flow control valve or a supplementary valve downstream of the regulator should be used for control of flow.

8-5 Electrical Requirements. Electrical circuits, devices, fixtures, and grounding in the area of a laser classified as hazardous and for direct connection of the laser are to be installed in accordance with the appropriate sections of NFPA 70, *National Electrical Code*.

8-6 Training.

8-6.1 Facilities using reactive gases should have a thorough training program in emergency procedures for all employees.

8-6.2 The training program should include drills, awareness of fire protection features, liaison with fire-fighting personnel, and knowledge of remote shutoff for gases.

Chapter 9 Ignitible Liquids Used in Laser Systems

9-1 General.

9-1.1 Dye lasers normally use a lasing medium composed of a complex fluorescent organic dye dissolved in an organic solvent. Practically all solvents suitable for dye solutions are ignitible. Some dye solutions come premixed from the manufacturer, in which case efforts should be made to determine which solvent was used for the preparation.

9-1.2 To minimize the risk of fire involving ignitible liquids, the precautions in this chapter should be followed.

9-2 Work Practices.

9-2.1 Signs such as "Caution: Flammable Liquids — No Smoking; No Open Flames" should be posted in conspicuous locations in the area and at approaches to the area.

9-2.2 Lines containing flammable or combustible liquid (piping and tubing) should be capped when not in use.

9-2.3 Containers of flammable liquids should be closed and stored in a cool place. Secondary containment for all flammable liquids should be provided. Each container and the flammable liquid circulation hardware should be labeled and include the word "flammable."

9-2.4 Ignitible liquid dye solutions should be transported in closed, labeled containers. Containers should be made of impact-resistant and dye solution–compatible materials.

9-2.5 Flammable and combustible liquids that are to be dispensed should be stored in safety cans. *(See NFPA 30, Flammable and Combustible Liquids Code, Table 4-2.3, for the maximum allowable size of containers.)*

9-3 Fire Safety.

9-3.1 Solutions of ignitible liquids should be kept away from heat, flames, electrical receptacles, and other sources of ignition.

9-3.2 Oxidizing materials should be kept separate from flammable dye mixtures and ignitible liquids.

9-3.3* Flammable and combustible liquid waste should be stored in wide-mouthed safety cans. The container should be labeled "For Flammable Liquid Waste Only." Corrosive materials should not be placed in such waste containers because it could result in a fire or explosion. Waste can be transferred to drums or 5-gal (18.9-L) steel Department of Transportation (DOT) shipping containers where stored in approved locations.

9-3.4 Flammable and combustible liquid containers should be stored in approved flammable liquid storage cabinets. Only a working quantity of liquids should be allowed outside such cabinets.

9-3.5 When flammable liquids are being used, the area should be properly ventilated to prevent buildup of ignitible vapor/air mixtures to a maximum of 25 percent of the LEL.

9-3.6* Equipment or activities likely to produce a static spark should be electrically interconnected (i.e., bonded) to the grounding system in the area.

9-4 Facilities and Equipment.

9-4.1 The ignitible liquid dye work area should be kept clean and orderly to minimize the fuel paths that facilitate the spread of fire. Combustibles should not be located adjacent to the dye circulator pump.

9-4.2 Ignitible liquid dye circulating systems should be leaktight. Connections more rigorous than barb-type fittings or slip-on friction fittings without clamps should be used. Compression-type fittings are recommended for ignitible liquid lines.

9-4.3 Ignitible liquid circulating systems and components should be pressure tested to 1.5 times the MAWP prior to initial use. Special attention should be given to tubing connections. The integrity of all tubing and connections should be checked periodically to ensure that degradation has not occurred.

9-4.4 Noncombustible containment pans should be installed under pumps and reservoirs to prevent a spill from spreading. The pan should be large enough to contain the total volume of the ignitible liquid circulating system.

9-5 Electrical Requirements. Electrical circuits, devices, fixtures, and grounding in the area of a laser classified as hazardous and for direct connection of the laser are to be installed in accordance with the appropriate sections of NFPA 70, *National Electrical Code*.

9-6 Large Volume Ignitible Liquid Systems.

9-6.1 Where large volume ignitible liquid systems [5 gal (18.9 L) or more] are used, NFPA 30, *Flammable and Combustible Liquids Code,* should be followed.

9-6.2 Pressure sensors or flow sensors, or both, should be installed to automatically turn off the circulating pumps in the event of a rupture or leak of the flow system.

9-6.3 Liquid level sensors should be installed on the pump reservoir to detect a decrease in system liquid volume due to leak or rupture. Liquid level sensors should be interlocked with the pumping system to shut down upon activation of the sensors.

9-6.4 Enclosed areas should be ventilated at a rate sufficient to maintain the vapor concentration within the area at or below 25 percent of the LEL. This should be confirmed by one of the following:

(1) Calculations based on the anticipated fugitive emissions
(2) Sampling of the actual vapor concentration under normal operating conditions *(see NFPA 30, Flammable and Combustible Liquids Code, 5-3.4.2.)*

9-6.5 The use of combustible vapor sensors interlocked with room ventilation and with the pumping system is recommended. The exhaust ventilation should switch to high speed at 25 percent of the LEL to prevent the buildup of flammable vapor concentrations. At 50 percent of the LEL, an alarm should sound, and the pumping system should shut down.

9-6.6 A liquid detection device(s) should be installed to detect leaks or spills within laser enclosures.

9-6.7 Remote shutdown capability for the laser pumping system (i.e., crash buttons) should also be provided for personnel to activate in case of emergency. The crash buttons should be located near main exits of the area.

9-6.8 Buildings or structures housing large-volume flammable liquid systems should be of fire-resistive or noncombustible construction.

Exception: Combustible construction can be used where automatic fire sprinklers or equivalent protection is provided, subject to the approval of the authority having jurisdiction.

Where walls are required for separation from other occupancies or property lines, they should have a fire resistance rating of at least 2 hours. *(See NFPA 30, Flammable and Combustible Liquids Code, 5-3.2.1.)*

9-7 Spill Cleanup.

9-7.1 Ignitible liquid spills should be cleaned up promptly. Materials used to clean up spills are to be treated as flammable waste and should be disposed of using approved flammable waste containers.

9-7.2 In the event of a large volume ignitible liquid spill, the fire department should be notified.

9-8 Waste Disposal.

9-8.1* Ignitible liquids absorbed into solids and objects contaminated with ignitible liquids should be disposed of as flammable waste. If only small amounts of waste are generated, they can be placed in safety cans with self-closing lids. The cans should be emptied at least monthly. Some ignitible liquid-soaked materials can undergo self-heating and auto-ignite.

9-8.2 Ignitible liquid dye solutions should be disposed of in approved safety cans.

9-9 Training.

9-9.1 Employees should be apprised of the fire safety hazards of the materials and processes to which they are exposed. *[See OSHA 29 CFR 1910.38(b)(4)(i).]*

9-9.2 Employees should review upon initial assignment those parts of the fire prevention plan that they must know to protect themselves in the event of an emergency. The written plan should be kept in the workplace and made available for employee review.

9-10 Maintenance. All equipment should be properly maintained in accordance with manufacturers' recommendations. Periodic fire safety inspections of those portions of laser systems that could present a fire hazard should be established. A written log of these inspections should be maintained.

Chapter 10 Operations/Administration

10-1 Scope. This chapter covers the operations, housekeeping, maintenance, and service of lasers and laser systems and the training of all persons associated with the installation, operation, maintenance, and service of lasers and laser systems.

10-2 Operations.

10-2.1 Lasers and laser systems should be operated as appropriate in accordance with the following documents:

(1) American National Standards Institute (ANSI)
   a. ANSI Z136.1, *Safe Use of Lasers*, revised
   b. ANSI Z136.3, *Safe Use of Lasers in Health Care Facilities*
(2) Occupational Safety and Health Administration (OSHA) — OSHA Instruction Pub 8-1.7, *Guidelines for Laser Safety and Hazard Assessment*
(3) Center for Devices and Radiological Health (CDRH), Food and Drug Administration (FDA) — Part 1040, Chapter 1, "Performance Standards for Light Emitting Products"
(4) Joint Commission on Accreditation of Healthcare Organizations (JCAHO)
(5) State rules and standards

10-2.2 Laser Safety Personnel (LSP). Where lasers presenting a fire hazard are used, specific personnel should be designated to monitor and enforce the control of laser hazards and effect the knowledgeable evaluation and control of laser hazards.

10-2.3 Laser Modifications. Modifications to certified or uncertified lasers should meet all requirements of the minimum standards and should be reviewed and approved by the LSP. Whenever deliberate modifications are made that could change the laser class and affect the output power, operating characteristics, or fire hazards, the LSP should specify whether any changes in control measures are required.

10-2.4 Fire Extinguishing Agents. Fire extinguishers should be of a type and size to extinguish a fire occurring within the laser equipment and as a result of the laser beam. Extinguishing agents should be readily available to the laser location(s) and should be checked periodically. The LSP should determine the type and quality of extinguishing agents necessary for the specific laser installation(s) and consult with the manufacturers for their suggestions. Training should be provided on the use of portable fire extinguishers.

10-2.5* Fire-Resistant Materials. Materials adjacent to a laser that can be an ignition hazard should be evaluated for their fire properties (e.g., ignition, flame spread, oxygen index).

10-2.6 Notification of Laser Fire Incidents. After an incident, the form shown in Figure C-1 of this document should be filled out and submitted to NFPA. Appropriate local, state, and federal agencies should be notified.

10-3 Housekeeping. Laser equipment, systems, installation, and supporting materials and equipment should be maintained in a clean, neat, and orderly condition. Electrical and mechanical ventilation equipment should be maintained to remain safe and fully operational. The LSP should ensure that the laser installation fully complies with all recommendations of this document and referenced documents so that known hazards are properly controlled.

10-4 Maintenance and Service.

10-4.1 *Maintenance*, for the purpose of this document, means the performance of those adjustments or procedures by the user to keep equipment in its intended operating condition. Maintenance should be performed using appropriate adjustments and procedures.

10-4.2 Service should be performed using adjustments, repairs, or procedures to return equipment to its intended state.

10-4.3 Laser products certified by a manufacturer to be compliant with certain standards, such as the federal laser product performance standards of 21 *CFR*, Part 1040, applicable at the date of manufacture, should be maintained in compliance with such requirements.

10-4.4 The LSP should ensure that regular maintenance schedules for each type of laser are established. Report logs of all maintenance modifications and service performed should be kept. Maintenance checks should include all supporting equipment.

10-4.5 All electrical and mechanical systems should be maintained to be in full compliance with applicable codes and standards and OSHA guidelines. *(See Appendixes B and F.)*

10-5 Training and Education.

10-5.1 A complete training and education program should be established to fully train those personnel actually using and assisting in the use of the specific laser types. In addition, those using and assisting in use of the lasers and all support staff should be fully trained in laser safety issues.

10-5.2 All training should follow the guidelines established in OSHA guidelines, ANSI Z136.1, *Safe Use of Lasers*, and ANSI Z136.3, *Safe Use of Lasers in Health Care Facilities*, as applicable. Users, LSPs, and maintenance personnel should attend certification courses where such courses are established.

10-5.3 Records should be kept of all personnel trained, the type of training, and any additional training or retraining.

10-5.4 All new personnel should be fully trained. When new lasers or modifications of existing lasers are introduced, all personnel should be given additional training as required to maintain a high quality of laser use and safety.

10-5.5 The LSP should be responsible for overseeing that all training and education requirements are fully enforced.

Chapter 11 Emergency Response Preparedness

11-1 Scope. This chapter applies when lasers and laser systems presenting fire hazards are used.

11-2 Pre-Fire Planning.

11-2.1 Prior to the operation of a laser, all appropriate personnel should be familiar with emergency procedures, including exit locations, use of fire extinguishers, and laser shutdown procedures. Efforts should be made to ensure that the responding fire department is aware of the hazards of the lasers.

11-2.2 Emergency response personnel should be familiar with emergency shutdown procedures for the laser.

11-3 Training.

11-3.1 Instruction of personnel in handling fire emergencies is equally as important as providing adequate extinguishing equipment. In most facilities using a laser system, personnel within the affected space can have primary duties quite different from fire fighting.

11-3.2 It is imperative that all persons working with a laser be thoroughly instructed in the nature of the hazards and in the operation of the fire-fighting equipment provided.

11-3.3 Instructions should be augmented by frequent drills so that proper action can be taken immediately upon the occurrence of hazardous conditions. Instructions and drills should be so comprehensive and specific that no time is lost in considering alternative procedures or other decision making.

11-3.4 All personnel working with and using a laser should be trained on how to immediately shut down and de-energize the laser.

11-4 Fire Brigades. Fire brigades should receive training on extinguishing fires involving lasers and on emergency shutdown procedures.

11-5 Fire Department Notification (Internal/External). All personnel working in a room where lasers are used should be familiar with all exits and emergency notification, including fire department notification and sounding the alarm locally.

11-6 Emergency Shutdown/Shutoff.

11-6.1 A master emergency electrical shutdown switch that will immediately de-energize the laser should be located inside the room.

11-6.2 In a hazardous or oxygen-enriched atmosphere, a procedure should be developed to turn off all gases when appropriate.

11-6.3 The last person to leave the room should close the door.

Chapter 12 Referenced Publications

12-1 The following documents or portions thereof are referenced within this recommended practice and should be considered as part of its recommendations. The edition indicated for each referenced document is the current edition as of the date of the NFPA issuance of this recommended practice. Some of these documents might also be referenced in this recommended practice for specific informational purposes and, therefore, are also listed in Appendix F.

12-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 30, *Flammable and Combustible Liquids Code*, 1996 edition.

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 1996 edition.

NFPA 53, *Recommended Practice on Materials, Equipment, and Systems Used in Oxygen-Enriched Atmospheres*, 1999 edition.

NFPA 55, *Standard for the Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders*, 1998 edition.

NFPA 70, *National Electrical Code®*, 1999 edition.

NFPA 99, *Standard for Health Care Facilities*, 1999 edition.

NFPA *101®*, *Life Safety Code®*, 1997 edition.

NFPA 326, *Standard for the Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair*, 1999 edition.

NFPA 495, *Explosive Materials Code*, 1996 edition.

NFPA 704, *Standard System for the Identification of the Fire Hazards of Materials for Emergency Response*, 1996 edition.

NFPA 921, *Guide for Fire and Explosion Investigations*, 1998 edition.

12-1.2 Other Publications.

12-1.2.1 ANSI Publications. American National Standards Institute, 11 West 42nd Street, 13th floor, New York, NY 10036.

ANSI Z136.1, *Safe Use of Lasers*, 1993.

ANSI Z136.3, *Safe Use of Lasers in Health Care Facilities*, 1988.

12-1.2.2 ASTM Publication. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

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

ASTM D 323, *Standard Test Method for Vapor Pressure of Petroleum Products (Rein Method)*, 1990.

12-1.2.3 CGA Publication. Compressed Gas Association, 1725 Jefferson Davis Highway, Arlington, VA 22202-4100.

CGA Pamphlet V-1, *Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections*, 1987.

12-1.2.4 U.S. Government Publications. U.S. Government Printing Office, Superintendent of Documents, Washington, DC 20402.

OSHA Instruction Pub 8-1.7, *Guidelines for Laser Safety and Hazard Assessment*, August 5, 1991.

Title 21, *Code of Federal Regulations*, Part 1040, Chapter 1, "Performance Standards for Light Emitting Products," April 1, 1994.

Title 21, *Code of Federal Regulations*, Part 1040.10.

Title 29, *Code of Federal Regulations*, Part 1910.38(b)(4)(i).

Appendix A Explanatory Material

Appendix A is not a part of the recommendations of this NFPA document but is included for informational purposes only. This appendix contains explanatory material, numbered to correspond with the applicable text paragraphs.

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 that is concerned with product evaluations and is thus 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 Energy. Energy content is commonly used to characterize the output from pulsed lasers, and is generally expressed in joules (J).

A-2-1 Explosion. An explosion can be accompanied by a shock wave or the disruption or enclosing of material or structures, or both. An explosion might result from chemical changes such as rapid oxidation, decomposition, or runaway polymerization (usually detonations); deflagration; or detonation.

A-2-1 Flammable Liquid Storage Cabinet. Some local jurisdictions require bottom-venting of flammable liquid storage cabinets. While this is not required by NFPA 30, *Flammable and Combustible Liquids Code*, some manufacturers provide plugged vent connections to accommodate these local jurisdictions.

A-2-1 Flash Point. The following is taken from A-1-7.2 of the 1993 edition of NFPA 30, *Flammable and Combustible Liquids Code:*

(a) The flash point of a liquid having a viscosity less that 45 SUS at 100°F (37.8°C) and a flash point below 200°F (93°C) should be determined in accordance with ASTM D 56, *Standard Test Method for Flash Point by the Tag Closed Tester.*

(b) The flash point of a liquid having a viscosity of 45 SUS or more at 100°F (37.8°C) or a flash point below 200°F (93°C) or higher should be determined in accordance with ASTM D 93, *Standard Test Method for Flash Point by the Pensky—Martens Closed Tester.*

(c) As an alternate, ASTM D3278, *Standard Test Methods for Flash Point of Liquids by Setaflash Closed-Cup Apparatus,* may be used for paints, enamels, lacquers, varnishes, and related products and their components having flash points between 32°F (0°C) and 230°F (110°C) and having a viscosity lower than 150 stokes at 77°F (25°C).

(d) As an alternate, ASTM D3828, *Standard Test Methods for Flash Point by Small Scale Closed Tester,* may be used for materials other than those for which specific setaflash methods exist.

A-2-1 Hazardous Chemical. For hazard ratings of many chemicals, see NFPA *Fire Protection Guide to Hazardous Materials,* 11th edition.

A-2-1 Interlock. A specific interlock, however, can involve more than one of the types mentioned.

A-2-1 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations 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-2-1 Maximum Allowable Working Pressure (MAWP). For a more complete definition, see Section VIII of the ASME *Boiler and Pressure Vessel Code, Division 1, Appendix 3.*

A-2-1 Noncombustible. Materials that are reported as passing ASTM E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 Degrees C* (formerly *Standard Method of Test for Non-combustibility of Elementary Materials*), are considered noncombustible. *(See NFPA 220, Standard on Types of Building Construction.)*

A-2-1 Plasma. Very high temperatures are associated with laser-generated plasmas that can appear as sparks, plumes, or flames.

A-2-1 Protective Housing. The aperture through which the useful beam is emitted is not part of the protective housing. The protective housing can enclose associated optics and a work station and should limit access to other associated radiant energy emissions and to electrical hazards associated with components and terminals.

A-3-1 Classes of lasers are from ANSI Z136.1, *Safe Use of Lasers,* are based upon biological damage to the eye or skin, and are not directly related to fire hazards.

A-3-2 See A-3-1.

A-3-3 See A-3-1.

A-3-4 See A-3-1.

A-4-1.2 See NBSIR 81-2271,"Will the Second Item Ignite," and ASTM STP 882, "New Concepts for Measuring Flame Spread Properties."

A-5-4.4 Many materials can ignite from contact with a laser beam in ambient air. These precautions include but are not limited to the following:

(1) Laser and fire safety training programs
(2) Selection of appropriate barrier materials
(3) Selection of materials with reduced ignition potential and flame spread
(4) Limitation of oxidizers
(5) Limitation of laser energy

A-6-3 Materials to consider include thermal and acoustical insulation, laminates, hoses, filters, and coil forms. From a fire safety design perspective, materials that have low ignition potential and low rates of heat release if ignited are most desirable. Heat release rate for a material is expressed in terms of kilowatts released for each square meter of material burning and is related to the physical and chemical or combustion characteristics of that material.

ASTM E 1354, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter,* is a useful method for evaluating candidate materials. It is recommended that the materials being evaluated be tested at two different levels of incident flux, a low level (25–30 kW/m^2) and a high level (55–65 kW/m^2). Most materials will have a higher rate of heat release at the high flux. The additional test at a high flux level provides an indication of the expected heat release rate in a well-developed fire in a confined space.

Materials that have the lowest heat release rate at the high flux and the longest ignition time at low flux should be selected. If several candidate materials have similar heat release and ignition characteristics, the material with the lowest smoke production should be considered.

A-6-5.3 Significant particulate production can occur well in advance of smoldering or flaming fire. Increases in background particulate levels can indicate an incipient problem.

A-7-4.1.2 Information is referenced from NFPA 50A, *Standard on Gaseous Hydrogen Systems at Consumer Sites.*

A-8-3.3 Some gases can be incompatible with water. Water reactivity should be evaluated.

A-8-4.2.4 A method for purging piping with inert gas is to have a series of evacuations followed by an inert gas fill.

A-9-3.3 Placing corrosive materials in a flammable liquid container could result in a fire or explosion.

A-9-3.6 For example, nonpolar solvents flowing through plastic tubing can develop a static charge. As another example, a grounding wire should be incorporated into plastic tubing to dissipate static charge that can accumulate when nonpolar solvents flow through non-conducting tubing.

A-9-8.1 See the 18th edition of the NFPA *Fire Protection Handbook* for list of liquids subject to self-heating and auto-ignition.

A-10-2.5 A study on the flammability of surgical drapes has been described *(see F-1.2.5).*

Underwriters Laboratories Inc., has developed a new test method, UL 2154, *Fire Tests for Surgical Fabrics* (Building Materials Catalog — Product Category Guide Designation GPNI). This procedure evaluates the flammability of surgical drapes in ambient air and oxygen-enriched atmospheres (OEAs) with a 20-watt CO_2 laser.

Appendix B Laser Hazards (Reserved)

This appendix is not a part of the recommendations of this NFPA document but is included for informational purposes only.

B-1 Electrical.

B-2 Beam.

B-3 Laser Material.

B-4 Other Materials and Concerns.

Appendix C Laser Fire Incident Form

This appendix is not a part of the recommendations of this NFPA document but is included for informational purposes only.

C-1 Figure C-1 can be used to document and forward information regarding the laser fire incident to NFPA.

Figure C-1 Laser fire incident form.

DATA ON FIRE AND RELATED INCIDENTS INVOLVING LASERS

(Explosions, Electrical, Beam Ignition)
FOR DATA COLLECTION ONLY**
This form can be reproduced.

1. Date of incident: _____ (month) (day) (year)
2. Type of facility where laser was being used (e.g., hospital, research lab, industrial): _____
3. Location of fire origin within facility (e.g., operating room, clean room, laboratory): _____
4. Type/mode of laser (e.g., CO_2, dye, CW, pulsed): _____
5. Class of laser (I, II, IIIA, IIIB, IV): _____
6. Beam power of laser: _____
7. Use at time of ignition (e.g., pre-procedure checkout, alignment checkout): _____
8. Activity/operation at ignition (e.g., pre-procedure checkout, alignment checkout): _____
9. Supporting atmospheric environment (e.g., percent of oxygen, nitrous oxide, flammable vapors, diluent gas): _____
10. Source of ignition (be specific, e.g., laser beam, electrical spark, heated metal): _____
11. First material ignited (e.g., clothes, patient gown, drapes): _____
12. Probable cause of fire: _____
13. Brief description of fire, fire spread, material and components exposed, etc.: _____
14. Action(s) taken to respond to fire (e.g., called fire department, used fire extinguisher):
    Fire department called? _____ Fire extinguisher used? _____ Type of fire extinguisher (if used) _____
    (Describe sequence of actions taken in response to fire): _____
15. Extent of damage/loss/casualties: $ _____ Injuries _____ Death(s) _____
16. Corrective action(s) recommended (e.g., training, survey/inspections, physical changes, change in fire protection features).
    Please elaborate: _____

Submitter of information (OPTIONAL**): _____

Send completed forms to Craig H. Kampmier, National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101. [Contact Mr. Kampmier regarding questions on completing this form. Tel. (617) 770-3000 ext. 7416; Fax (617) 984-7110.]

Laser fire incident reports are available from NFPA upon request.

** Will be held within NFPA.

Appendix D Education and Training

This appendix is not a part of the recommendations of this NFPA document but is included for informational purposes only.

D-1 The LSP, laser users, and maintenance or service personnel should be trained in laser fire safety and in recognition of fire hazards associated with the use of lasers. This training should be updated at least annually and any time there are changes in the laser use that can present different fire safety concerns.

(a) The following issues should be addressed during the training:

(1) Awareness of installed fire protection features in the facility and laser system.
(2) Preplanning for fires, involving the appropriate emergency response personnel such as fire department or plant brigade.
(3) Information on the location and method to shut off power, gases, and flammable liquids.
(4) Understanding the role of employees in the fire safety plan for the facility. (For example, are they expected to extinguish incipient fire? If so, appropriate training should be provided.)
(5) The safety hazards of the materials and procedures to which employees or emergency response personnel are exposed, with proper information and training provided.

(b) The following issues should be addressed during the training provided to health care facility users:

(1) Health care workers using medical lasers should be educated as to the fire safety problems associated with lasers in the surgical suite.
(2) General fire safety information can include an understanding of the classes of fires, extinguishing requirements of those classes of fires, and knowledge of the proper operation of hand-held portable fire-fighting equipment.
(3) Training on the hazards found in the surgical suite with regard to combustible substances, gases, and oxygen-enriched atmospheres should be done on an annual basis.
(4) Training on any changes in equipment or procedures that can affect fire safety should be addressed prior to their use. *(See Chapter 5 for more information.)*
(5) To reduce the incidence of fire, training on special hazards associated with the operative site when using a medical laser should be routinely reviewed and updated as new products or equipment are brought into the arena.
(6) Fire safety training can include the following:
   a. The action(s) to be taken if drapes are burning
   b. Anesthesiologist responsibilities
   c. Responsibilities of each individual in the surgical suite if a patient fire develops
   d. Special extinguishing techniques, such as smothering fire by using fire blankets, cloth wrappers, or other heavy cloth material
(7) Training on the facility's fire safety plan, location of fire alarms, location of fire-fighting equipment, and emergency evacuation should be done on an ongoing basis.

Appendix E An Example of Semi-Annual Checklist for Lasers Used in Health Care Facilities

This appendix is not a part of the recommendations of this NFPA document but is included for informational purposes only.

E-1 The use of a standardized form, such as Figure E-1, provides inspection and documentation continuity.

Figure E-1 An example of a semi-annual laser inspection checklist used in health care facilities.

SEMI-ANNUAL LASER INSPECTION CHECKLIST

Laser: _____

Serial number: _____

Date							
Location							
Laser classification (labeled on unit)							
Area: Laser operation must take place in controlled area posted with suitable warning signs							
Warning signs: Warning logo on laser must state maximum output, pulse duration, and laser median or emitted wavelength							
Housing: No modifications in manufacturer's design							
Date of last calibration							
Safety glasses: Available and appropriate for laser type							
Date of last inspection							

Completed by: _____