NFPA® 115

Standard for Laser Fire Protection

2008 Edition



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

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NFPA® 115

Standard for

Laser Fire Protection

2008 Edition

This edition of NFPA 115, *Standard for Laser Fire Protection,* was prepared by the Technical Committee on Laser Fire Protection. It was issued by the Standards Council on December 11, 2007, with an effective date of December 31, 2007, and supersedes all previous editions.

This edition of NFPA 115 was approved as an American National Standard on December 31, 2007.

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 non-NFPA standards addressed other laser hazards (primarily health hazards) but did not adequately address the fire hazards 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) was intended to supplement existing NFPA documents and other standards involving lasers. Where a particular hazard, such as a flammable liquid, was appropriately addressed by another NFPA document, that document was 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, which 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.

Materials used to fabricate laser systems are often 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, there is a database of fires involving lasers. (Documented incidents have occurred in hospitals, research laboratories, and industrial applications.) According to 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, 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.

In the 2003 edition, the document changed from a recommended practice to a standard. Therefore, all of the language within the body of the document was changed to enforceable language, and any recommendations or advisory information was moved to the annexes.

The 2008 edition has been revised in order to stay current with all other NFPA documents. The definitions have been updated and the language has been changed where appropriate, in order to add clarity. A new requirement has been added, which calls for fire training for health care facilitators wherever a patient may be in contact with lasers.

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

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NFPA 115

Standard for

Laser Fire Protection

2008 Edition

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

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

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex F. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

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

Chapter 1 Administration

1.1 Scope.

1.1.1 This document shall provide minimum fire protection requirements for the design, manufacture, installation, and use of lasers and associated equipment.

1.1.2 Criteria for training for and responding to fire emergencies involving lasers shall be included.

1.2 Purpose. This document shall provide requirements intended to prevent or mitigate the effects of fire involving lasers.

1.3 Application. This document shall apply to lasers capable of producing a beam ignition hazard, lasers utilizing materials or components presenting a fire hazard, and the areas where such lasers are used.

1.4 Retroactivity. The provisions of this standard reflect a consensus of what is necessary to provide an acceptable degree of protection from the hazards addressed in this standard at the time the standard was issued.

1.4.1 Unless otherwise specified, the provisions of this standard shall not apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the standard. Where specified, the provisions of this standard shall be retroactive.

1.4.2 In those cases where the authority having jurisdiction determines that the existing situation presents an unacceptable degree of risk, the authority having jurisdiction shall be permitted to apply retroactively any portions of this standard deemed appropriate.

1.4.3 The retroactive requirements of this standard shall be permitted to be modified if their application clearly would be impractical in the judgment of the authority having jurisdiction, and only where it is clearly evident that a reasonable degree of safety is provided.

1.5 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard.

1.5.1 Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1.5.2 The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

1.6 Interface with Existing Codes and Standards.

1.6.1 When interface with existing NFPA or other consensus codes and standards occurs, reference shall be made in the text to the appropriate source.

1.6.2 Due to the unique fire hazards associated with lasers and their operations, this standard shall provide additional fire safety requirements beyond that of other documents.

Chapter 2 Referenced Publications

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

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

NFPA 10, *Standard for Portable Fire Extinguishers,* 2007 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2007 edition.

NFPA 30, *Flammable and Combustible Liquids Code,* 2008 edition.

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

NFPA 70™, National Electrical Code®, 2008 edition.

NFPA 99, *Standard for Health Care Facilities,* 2005 edition.

NFPA *101®, Life Safety Code®,* 2006 edition.

NFPA 600, *Standard on Industrial Fire Brigades,* 2005 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response,* 2007 edition.

2.3 Other Publications.

2.3.1 ANSI Publications. Laser Institute of America, Secretariat of ANSI Z136, 13501 Ingenuity Drive, Suite 128, Orlando, FL 32826 (www.laserinstitute.org)

ANSI B57.1, *Compressed Gas Cylinder Valve Outlet and Inlet Connections,* 1994.*(Replaced by CGA V-1.)*

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ANSI Z136.1, *Safe Use of Lasers*, 2000.

ANSI Z136.3, *Safe Use of Lasers in Health Care Facilities*, 1998.

ANSI Z136.5, *Safe Use of Lasers in Educational Institutions*, 2000.

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

ASTM D 5, *Standard Test Method for Penetration of Bituminous Materials,* June 1, 2006.

ASTM D 4359, *Standard Test for Determining Whether a Material Is a Liquid or a Solid*, 1999.

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

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

2.3.4 IEC Publications. Available from American National Standards Institute, 25 West 43rd Street, 4th floor, New York, NY 10036, U.S. National Committee for the IEC (www.ansi.org).

IEC 60825-1, Ed 1.2: 2001-08, *Safety of laser products — Part 1: Equipment classification, requirements and user's guide.*

2.3.5 U.S. Government Publications. U.S. Government Printing Office, Superintendent of Documents, Washington, DC 20402.

Center for Devices and Radiological Health, Food and Drug Administration, U.S. Department of Health and Human Services. (Available from U.S. Government Printing Office or from www.fda/gov/cdrh/radhlth/laser.html.)

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, Parts 1040.10 and 1040.11, April 1, 1994.

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

Title 40, Code of Federal Regulations.

Title 49, Code of Federal Regulations.

2.3.6 Other Publications.

Joint Commission on Accreditation of Healthcare Organizations (JCAHO) documents.

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

2.4 References for Extracts in Mandatory Sections.

NFPA 30, *Flammable and Combustible Liquids Code,* 2008 edition.

NFPA 53, *Recommended Practice on Materials, Equipment, and Systems Used in Oxygen-Enriched Atmospheres,* 2004 edition.

NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG),* 2006 edition.

NFPA 99, *Standard for Health Care Facilities,* 2005 edition.

NFPA 306, *Standard for the Control of Gas Hazards on Vessels,* 2003 edition.

NFPA 600, *Standard on Industrial Fire Brigades,* 2005 edition.

NFPA 921, *Guide for Fire and Explosion Investigations,* 2008 edition.

Chapter 3 Definitions

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

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

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

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

3.2.5 Shall. Indicates a mandatory requirement.

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

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

3.3 General Definitions.

3.3.1* Accessible Emission Limit (AEL). The maximum accessible emission level permitted within a particular class.

3.3.2* Beam. A collection of rays that can be parallel, divergent, or convergent.

3.3.3 Beam Intensity Profile (Irradiance Distribution). A description of the variations that can be present in the cross-section of a laser beam or in a focused laser spot.

3.3.4* Continuous Wave (cw). The output of a laser operated in a continuous rather than a pulsed mode.

3.3.5* Energy. The capacity for doing work.

3.3.6* Explosion. The sudden conversion of potential energy (chemical, mechanical, or nuclear) into kinetic energy that produces and violently releases gas.

3.3.7* Flammable Liquid Storage Cabinet. A cabinet for the storage of flammable and combustible liquids.

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

3.3.9* Flash Point. The minimum temperature at which a liquid or a solid emits vapor sufficient to form an ignitible mixture with air near the surface of the liquid or the solid.

3.3.10 Gas.

3.3.10.1 ***Compressed Gas.*** Any material or mixture having, when in its container, an absolute pressure exceeding 40 psia (an absolute pressure of 276 kPa) at 70°F (21.1°C) or, regardless of the pressure at 70°F (21.1°C), having an absolute pressure exceeding 104 psia (an absolute pressure of 717 kPa) at 130°F (54.4°C).

3.3.10.2 ***Flammable Gas.*** Any substance that exists in the gaseous state at normal atmospheric temperature and pressure and is capable of being ignited and burned when mixed with the proper proportions of air, oxygen, or other oxidizers. [**99**, 2005]

3.3.10.3* ***Reactive Gas.*** A gas that, by itself, is readily capable of detonation, explosive decomposition, or explosive reaction at normal or elevated temperatures and pressures.

3.3.11* Hazardous Chemical. A chemical with one or more of the following hazard ratings as defined in NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*: Health — 2, 3, or 4; Flammability — 2, 3, or 4; Reactivity — 2, 3, or 4. [**99**, 2005]

3.3.12 Industrial Fire Brigade. An organized group of employees within an industrial occupancy who are knowledgeable, trained, and skilled in at least basic fire-fighting operations, and whose full-time occupation might or might not be the provision of fire suppression and related activities for their employer. [**600**, 2005]

3.3.13 Irradiance. The power of a laser divided by the area of the laser beam at the target surface, expressed in watts per centimeters squared (W/cm^2).

3.3.14 Joule. The preferred SI unit of heat, energy, or work. A joule is the heat produced when one ampere is passed through a resistance of one ohm for one second, or it is the work required to have a distance of one meter against a force of one newton. There are 4.184 joules in a calorie, and 1055 joules in a British thermal unit (Btu). A watt is a joule/second. [**921**, 2008]

3.3.15 Laboratory Apparatus. Furniture, laboratory hoods, centrifuges, refrigerators, and commercial or made-on-site equipment used in a laboratory.

3.3.16* 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).

3.3.16.1 ***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.

3.3.16.2 ***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.

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

3.3.17* 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.

3.3.18* Laser System. An assembly of electrical, mechanical, and optical components that includes a laser.

3.3.19 Liquid. Any material that (1) has a fluidity greater than that of 300 penetration asphalt when tested in accordance with ASTM D 5, *Standard Test Method for Penetration of Bituminous Materials*, or (2) is a viscous substance for which a specific melting point cannot be determined but that is determined to be a liquid in accordance with ASTM D 4359, *Standard Test for Determining Whether a Material Is a Liquid or a Solid.* [**30**, 2008]

3.3.19.1 ***Combustible Liquid.*** Any liquid that has a closed-cup flash point at or above 37.8°C (100°F). [**306,** 2003]

3.3.19.1.1 ***Combustible Liquid, Class II.*** Any liquid that has a flash point at or above 100°F (37.8°C) and below 140°F (60°C). [**30,** 2008]

3.3.19.1.2 ***Combustible Liquid, Class IIIA.*** Any liquid that has a flash point at or above 140°F (60°C), but below 200°F (93°C). [**30,** 2008]

3.3.19.1.3 ***Combustible Liquid, Class IIIB.*** Any liquid that has a flash point at or above 200°F (93°C). [**30,** 2008]

3.3.19.2 ***Flammable Liquid.*** A liquid that has a closed-cup flash point that is below 37.8°C (100°F) and a maximum vapor pressure of 2068 mm Hg (40 psia) at 37.8°C (100°F)

3.3.19.2.1 ***Flammable Liquid Class I.*** Any liquid that has a closed-cup flash point below 37.8°C (100°F) and a Reid vapor pressure not exceeding 2068.6 mm Hg (40 psia) at 37.8°C (100°F).

3.3.19.2.2 ***Flammable Liquid Class IA.*** Any liquid that has a flash point below 22.8°C (73°F) and a boiling point below 37.8°C (100°F).

3.3.19.2.3 ***Flammable Liquid Class IB.*** Any liquid that has a flash point below 22.8°C (37°F) and a boiling point at or above 37.8°C (100°F).

3.3.19.2.4 ***Flammable Liquid Class IC.*** Any liquid that has a flash point at or above 22.8°C (3°F), but below 37.8°C (100°F).

3.3.19.3 ***Ignitible Liquid.*** Any liquid or the liquid phase of any material that is capable of fueling a fire, including a flammable liquid, combustible liquid, or any other material that can be liquefied and burn.

3.3.20 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.

3.3.21* Maintenance (Laser Products). 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.

3.3.22* Maximum Allowable Working Pressure (MAWP). The maximum gauge pressure permitted at the top of completed equipment, a container, or a vessel in its operating position at a design temperature. [**59A**, 2006]

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3.3.23* Noncombustible. Not capable of igniting and burning when subjected to a fire.

3.3.24* Operation. The performance of the laser or laser system over the full range of its intended functions (normal operation).

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

3.3.26 Oxygen-Enriched Atmosphere (OEA). An atmosphere in which the concentration exceeds 21 percent by volume or its partial pressure exceeds 21.3 kPa (160 torr). [**53,** 2004]

3.3.27* 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.

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

3.3.29 Proper(ly). In accordance with the manufacturer's specifications or as recommended by the manufacturer.

3.3.30* 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.

3.3.31* 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.

3.3.32* Radiant Exposure. Energy received by the surface in joules/cm^2.

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

3.3.34* Service (Laser Products). 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.

3.3.35 Watt (W). Unit of power, or rate of work, equal to one joule per second, or the rate of work represented by a current of one ampere under the potential of one volt. [**921,** 2008]

Chapter 4 Classification of Lasers

4.1 Classification Methods. Lasers shall be classified in accordance with International Electrotechnical Commission (IEC) IEC 60825-1, *Safety of laser products — Part 1: Equipment classification, requirements and user's guide*, or 21 CFR Parts 1040.10 and 1040.11. *(See Annex D.)*

4.2 Application of Requirements. The fire protection requirements provided within this standard shall apply to the following classification of lasers:

(1) Class 3b
(2) Class 4

Chapter 5 Evaluation of Laser Beam Ignition Potential

5.1 General.

5.1.1* Continuous wave (cw) laser beams producing irradiances in the order of 0.5 W/cm^2 or greater shall be considered to be ignition hazards.

5.1.2 Other factors that shall be considered with pulsed lasers include the following:

(1) Radiant exposure
(2) Pulse duration
(3)*Pulse repetition rate

5.1.3 Class 4 lasers shall always be considered to be beam ignition hazards.

5.1.4* Lasers in the upper power and energy levels of Class 3b shall be considered as beam ignition hazards if the irradiance is greater than 0.5 W/cm^2.

5.2 Factors Affecting Ignition Potential. Factors affecting ignition potential shall include the following:

(1) Irradiance at the fuel, duration of exposure, and nature of the fuel
(2) Low irradiance laser beams capable of being focused to an irradiance sufficient to cause ignition
(3) Irradiance and the exposure time at the target
(4) Oxygen-enriched atmospheres
(5) Target thickness
(6) Irradiance modalities capable of generating plasma

Chapter 6 Laser Beam Ignition

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

6.2 Before Using Laser.

6.2.1 Beam Alignment. If an alignment beam is present, proper coincidence with the treatment beam shall be verified before each use.

6.2.2 Beam Intensity Profile. If the laser has been determined to be a beam ignition hazard, the intensity profile shall be determined before each use.

6.2.3 Beam Stop Materials. Before the laser is used, it shall be determined that the appropriate beam stop materials are in place.

6.3 Education.

6.3.1 Health Care.

6.3.1.1 Education shall be in accordance with that stated in ANSI Z136.3, *Safe Use of Lasers in Health Care Facilities.*

6.3.1.2* Detailed training in laser safety shall be required for those health care personnel who use a medical laser or are responsible for patient care during the use of a medical laser.

6.3.1.3 Training shall include extinguishing laser fires when a patient is directly involved in a laser fire event.

6.3.2 Other. Education shall be in accordance with that stated in ANSI Z136.1, *Safe Use of Lasers.*

6.4 Facility.

6.4.1 Health care facilities where laser systems are used shall comply with the following:

(1) ANSI Z136.3, *Safe Use of Lasers in Health Care Facilities*

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(2) NFPA *101*, for detection, suppression, and means of egress
(3) NFPA 99, for electrical systems, electrical equipment, gas and vacuum systems, and gas equipment

6.4.2 Other. Facilities where laser systems are used shall comply with the following:

(1) ANSI Z136.1, *Safe Use of Lasers*
(2) NFPA *101*, for detection, suppression, and means of egress
(3) NFPA 70

6.4.3 Flammable and Combustible Conditions.

6.4.3.1 Nothing shall be considered fire safe when impinged upon by a laser beam in the presence of an oxygen-enriched atmosphere, except for the noble metals.

6.4.3.2 Potential fuels shall include, but not be limited to, the categories listed in 6.4.3.2.1 and 6.4.3.2.2.

6.4.3.2.1 Health care categories shall include 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

6.4.3.2.2 Gas categories shall include the following:

(1) *Flammable Gases.* Flammable gastrointestinal gases such as methane, hydrogen, and hydrogen sulfide present a unique hazard. Precautions to eliminate or manage these gases shall be taken.
(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.
(3) *Nonflammable Gases.* Nonflammable anesthetic gases and vapors have replaced flammable anesthetic gases and vapors in the United States.

Chapter 7 Fire Safety Requirements for Laser Equipment

7.1 General. Selection of materials used in the construction of the laser shall include consideration of fire safety requirements for the following:

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

7.2 Laser Equipment Employing Ignitible Liquids or Flammable Gases.

7.2.1 Laser equipment employing ignitible liquids shall have a means to control or contain ignitible liquid spills using noncombustible materials.

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

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

7.2.4* Pumps, motors, and other electrical components in laser equipment that employ ignitible liquids or flammable gases shall be of intrinsically safe design or shall be appropriately rated for the application.

7.2.5 Tubing.

7.2.5.1 Metal tubing shall be used for ignitible liquids or flammable gases.

7.2.5.2 Plastic tubing shall be permitted provided it has 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 of the shortest length possible.

7.3* Materials of Construction.

7.3.1 The use of combustible materials shall be minimized.

7.3.2 Materials used inside the laser equipment enclosure shall be evaluated for ignition and heat release properties.

7.4 Laser Equipment Ventilation. Exhaust from laser enclosures shall be directed to an area where the exhaust will not cause unacceptable damage if a fire occurs inside the laser enclosure.

7.5 Alarms and Controls.

7.5.1 Circuits.

7.5.1.1 Laser systems utilizing materials and components that present a fire hazard shall incorporate circuitry that can be used for emergency shutdown by fire detection systems, manually, or by other means.

7.5.1.2 The design of the circuit shall not permit automatic restart with restoration of power following a remote shutdown.

7.5.1.3 The design of the circuit shall not allow automatic restart until the fire detection system or manual alarm system has been reset.

7.5.2 Coolants and Ignitible Liquids.

7.5.2.1 The temperature of coolants and ignitible liquids shall be monitored to warn of excessive rate of heating or approach to threshold temperature.

7.5.2.2 Provisions shall be made for alarm and automatic shutdown should such conditions be detected.

7.5.3* Monitors.

7.5.3.1 The laser equipment cabinet or exhaust shall be monitored for the presence of pre-combustion products, such as hydrogen chloride or submicron particulate, that can be produced by component overheating or from products of combustion.

7.5.3.2 Multiple alarm thresholds such as “warning,” “alarm,” and “automatic shutdown” shall be considered.

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7.5.4 Performance Monitoring.

7.5.4.1 Degradation of components that lead to a fire shall be monitored according to parameters that shall include one or more of the following:

(1) Component temperature
(2) Device electrical parameters (current, voltage)
(3) Laser power
(4) Frequency or magnitude of power excursions

7.5.4.2 The monitoring function shall be accomplished by automatic or manual means at time intervals determined by the manufacturer.

7.6 Manuals and Training.

7.6.1 Fire safety features and fire hazards specific to the systems shall be included in manufacturers' instructions on laser system operations.

7.6.2 Manufacturers' instructions shall provide guidance for dealing with fire emergencies and the post-fire testing and restoration of the equipment.

7.6.3 Laser system users and service staff shall be trained on the fire safety features prior to the laser system's first use and at least once per year thereafter.

Chapter 8 Flammable Gases

8.1 General.

8.1.1 The general requirements of NFPA 55 shall be followed.

8.1.2 To determine if a gas is flammable, the rating as listed in CGA V-1, *Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections*, shall be used.

8.2 Work Practices.

8.2.1 Laser systems utilizing or containing flammable gas(es) shall be so labeled.

8.2.2 Gas shutdown capability shall be provided both at the location of use and remotely.

8.2.3 "Flammable Gas — No Smoking" signs shall be posted conspicuously near the supply and usage locations of the flammable gases.

8.2.4 Piping for flammable gases shall be capped when not in use.

8.2.5 No modifications shall be made to pressure containers or pressure relief devices by anyone except the supplier.

8.2.6 Systems shall be regularly maintained as recommended by the manufacturer.

8.3 Fire Safety.

8.3.1 Combustible gas sensors shall 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.

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

8.3.3 When installed, combustible gas sensors shall be interlocked with the ventilation system and the exhaust ventilation increased at 25 percent of the LEL.

8.3.4 At 25 percent of the LEL, combustible gas sensors shall sound an audible alarm.

8.3.5 At 50 percent of the LEL, the combustible gas sensors shall sound an audible alarm and automatically shut off the supply of gases.

8.4 Facilities and Equipment.

8.4.1 General.

8.4.1.1 Indoor cylinder use shall be limited to lecture bottle size unless the cylinder(s) is kept in an approved ventilated cabinet or 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.

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

8.4.1.3 Flammable Gas Supplies.

8.4.1.3.1 Exterior flammable gas supply capacity shall be evaluated so as to not exceed combustibility limits if accidentally released into any closed area where supply gas lines are routed.

8.4.1.3.2 Evaluation of closed areas where combustible gas mixtures might occur shall include assessments of installed ventilation system air exchange rates and exhaust systems, if present.

8.4.1.3.3 Combustible gas sensors shall be installed in enclosed areas where flammable gases could exceed combustibility limits.

8.4.1.3.4 A combustible gas sensor alarm shall shut off the gas supply at the source and vent the gas supply lines from the enclosed area(s) to a safe location.

8.4.1.3.5 General air dynamics within the closed areas shall be evaluated for determination of location for combustible gas sensors.

8.4.1.4 Exhaust Vents.

8.4.1.4.1 Exhaust vents shall be located at least 15.3 m (50 ft) away from air intakes for hydrogen and at least 7.6 m (25 ft) for other exhaust materials.

8.4.1.4.2 When venting above a roof, piping shall be high enough to mitigate the chance of flammable gas buildup in an undesirable location.

8.4.2 Piping.

8.4.2.1 Piping shall be clean and compatible with the gas.

8.4.2.2 Piping shall be designed to a safety factor of 4 and tested to 1.5 times the MAWP.

8.4.2.3 Piping shall be pressure-tested and then leak-checked prior to initial use and after repair and modification.

8.4.2.4 Flammable gas vent lines shall be dedicated and separate from oxidizing gas vent lines and shall terminate in a safe location.

8.4.3* Regulators.

8.4.3.1* Flammable gas regulators with bonnet fittings for piping external venting shall be used in enclosed areas.

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8.4.3.2 If low pressures are required, a two-stage regulator shall be used.

8.4.3.3 Flow Control.

8.4.3.3.1 A flow control valve or a supplementary valve downstream of the regulator shall be used for control of flow.

8.4.3.3.2 The regulator shall not be used as a flow control.

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 shall be installed in accordance with the applicable sections of NFPA 70.

8.6 Training.

8.6.1 A thorough training program in emergency procedures shall be provided for all staff members working with flammable gases.

8.6.2 The training program shall include drills, fire protection features awareness, coordination with fire-fighting personnel, and knowledge of remote shutoff for gases.

Chapter 9 Reactive Gases

9.1 General. The general requirements of NFPA 55 shall be followed.

9.2 Work Practices.

9.2.1 The reactive gas system shall be labeled to identify its contents.

9.2.2 Gas shutdown capability shall be provided both at the location of use and remotely.

9.2.3 Where possible, the gas cabinet shall be located outdoors.

9.2.4 When not in use, compressed gas cylinders containing reactive gases shall be capped.

9.2.5 When connecting or disconnecting bottles, the manifold system shall be purged to minimize the effect of corrosion of the system.

9.2.6 Maintenance.

9.2.6.1 Systems shall be maintained regularly as recommended by the manufacturer.

9.2.6.2 A system data package, including a maintenance log, shall be maintained.

9.2.6.3 The data package shall include installed exhaust calibration data.

9.2.7 Reactive gases cylinders shall be located in an approved ventilated cabinet consistent with NFPA 55.

9.2.8 No modifications shall be made to pressure containers or pressure relief devices by anyone except the supplier.

9.3 Fire Safety.

9.3.1 Written procedures shall be followed for cylinder changing and maintenance.

9.3.2 A limiting orifice shall be installed on each cylinder to limit the release rate of the gas.

9.3.3* Gas Cabinets.

9.3.3.1 Gas cabinets shall be provided with a sprinkler system inside of the cabinet and shall be protected from corrosion where necessary.

9.3.3.2 Sprinkler installation shall comply with NFPA 13.

9.3.4 Gas Quantity and Concentration.

9.3.4.1 Only the smallest quantity or percent of reactive gas necessary shall be used.

9.3.4.2 Premixed gases shall be used to minimize the need for highly concentrated reactive gases.

9.3.5 The regulator chosen for use shall be compatible with the reactive gas.

9.4 Facilities and Equipment.

9.4.1 General.

9.4.1.1 When the ventilated cabinet is located indoors, connecting the cabinet to emergency power shall be considered to ensure continued exhaust capability.

9.4.1.2 Laser system exhaust shall be diluted to below reactive levels or mixed with an inert gas.

9.4.1.3 Exhaust systems shall be designed to ensure that the exhaust does not stagnate in exhaust piping.

9.4.1.4 The supply control valve shall be a solenoid valve designed to close in the event of loss of electrical power.

9.4.1.5 Exhaust.

9.4.1.5.1 The piping exhaust shall be located at least 7.6 m (25 ft) away from air intakes.

9.4.1.5.2 When venting above a roof, piping shall be high enough to minimize the possibility of reactive gas buildup in an undesirable location.

9.4.2 Piping.

9.4.2.1 Piping shall be clean and compatible with the gas.

9.4.2.2 Piping shall be designed to a safety factor of 4 and tested to 1.5 times the MAWP.

9.4.2.3 Piping shall be pressure-tested and leak-checked prior to initial use and after repair and modification.

9.4.2.4* Piping shall be purged with an inert gas during long periods of nonuse, maintenance, or servicing.

9.4.2.5 Fittings.

9.4.2.5.1 "Face-seal"–type fittings shall be considered acceptable.

9.4.2.5.2* Threaded or compression fittings shall not be used.

9.4.2.6 Traps or check valves shall be installed if there is the possibility of system contamination by other gases or foreign material.

9.4.3 Regulators.

9.4.3.1 Vents from regulators shall be piped to a safe location.

9.4.3.2 When low pressures are required, a two-stage regulator shall be used.

9.4.3.3 Regulator diaphragm failures shall be considered when locating a reactive gas regulator in an enclosed area.

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9.4.3.4* Reactive gas regulators with bonnet fittings for piping external venting shall be used in enclosed areas.

9.4.3.5 Vents shall be piped to a safe location.

9.4.4 Flow Control.

9.4.4.1 A flow control valve or a supplementary valve downstream of the regulator shall be used for control of flow.

9.4.4.2 The regulator shall not be used as a flow control.

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 shall be installed in accordance with the appropriate sections of NFPA 70.

9.6 Training.

9.6.1 A thorough training program in emergency procedures shall be provided for all staff members working with reactive gases.

9.6.2 The training program shall include drills, fire protection features awareness, coordination with fire-fighting personnel, and knowledge of remote shutoff for gases.

Chapter 10 Ignitible Liquids Used in Laser Systems

10.1* General. The requirements of this chapter shall be followed to minimize the risk of fire involving ignitible liquids.

10.2 Work Practices.

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

10.2.2 Lines (piping and tubing) containing flammable or combustible liquid shall be capped when not in use.

10.2.3 Flammable Liquids.

10.2.3.1 Containers of flammable liquids shall be closed and stored in a cool place.

10.2.3.2 Secondary containment for all flammable liquids shall be provided.

10.2.3.3 Each container and the flammable liquid circulation hardware shall have a label that includes the word "flammable."

10.2.4 Ignitible liquid dye solutions shall be transported in closed, labeled containers made of impact-resistant and dye solution–compatible materials.

10.2.5 Flammable and combustible liquids that are to be dispensed shall be stored in safety cans as described in NFPA 30, Chapter 9.

10.3 Fire Safety.

10.3.1 Solutions of ignitible liquids shall be kept away from heat, flames, electrical receptacles, and other sources of ignition.

10.3.2 Oxidizing materials shall be kept separate from flammable dye mixtures and ignitible liquids.

10.3.3 Waste Containment.

10.3.3.1 Flammable and combustible liquid waste shall be stored in wide-mouthed safety cans.

10.3.3.2 Containers shall be labeled "For Flammable Liquid Waste Only."

10.3.3.3 Hazardous (flammable, combustible, and corrosive) materials shall be collected and stored pursuant to 40 CFR and 49 CFR.

10.3.4 Cabinets.

10.3.4.1 Flammable- and combustible-liquid containers shall be stored in approved flammable liquid storage cabinets.

10.3.4.2 Only a working quantity of liquids shall be allowed outside such cabinets.

10.3.5 Ventilation shall be provided to prevent a buildup of ignitible vapor/air mixtures in excess of 25 percent of the LEL in areas where flammable liquids are used.

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

10.4 Facilities and Equipment.

10.4.1 Ignitible Liquid Dye Work Area.

10.4.1.1 The ignitible liquid dye work area shall be kept clean and orderly to minimize the fuel paths that facilitate the spread of fire.

10.4.1.2 Combustibles shall not be located adjacent to the dye circulator pump.

10.4.2 Ignitible liquid dye circulating systems shall be leaktight.

10.4.3 Compression-type or clamped fittings shall be used for ignitible liquid lines.

10.4.4 Circulating Systems.

10.4.4.1 Ignitible liquid circulating systems and components shall be pressure tested to 1.5 times the MAWP prior to initial use.

10.4.4.2 Special attention shall be given to tubing connections.

10.4.4.3 The integrity of all tubing and connections shall be checked to ensure that degradation has not occurred.

10.4.5 Noncombustible containment pans shall be installed under pumps and reservoirs of sufficient capacity to contain the total volume of the ignitible liquid circulating system.

10.5 Electrical Requirements. Electrical circuits, devices, fixtures, and grounding in the area of a laser classified as hazardous and for direct connection of the laser shall be installed in accordance with the applicable sections of NFPA 70.

10.6 Large-Volume Ignitible Liquid Systems.

10.6.1 Where large-volume ignitible liquid systems [18.9 L (5 gal) or more] are used, NFPA 30 shall be followed.

10.6.2 Pressure sensors, flow sensors, or both, shall be installed to automatically turn off the circulating pumps in the event of a rupture or leak of the flow system.

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

10.6.4 Enclosed areas shall be ventilated at a rate sufficient to maintain the vapor concentration within the area at or below 25 percent of the LEL, confirmed by one of the following methods:

(1) Calculations based on the anticipated fugitive emissions

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(2) Sampling of the actual vapor concentration under normal operating conditions as described in NFPA 30, Chapters 5 through 8, Chapters 17 through 20, and Chapters 28 and 29

10.6.5 Combustible vapor sensors shall be interlocked with exhaust ventilation and with the pumping system.

10.6.5.1 The exhaust ventilation shall switch to high speed at 25 percent of the LEL to prevent the buildup of flammable vapor concentrations.

10.6.5.2 At 50 percent of the LEL, an alarm shall sound, and the pumping system shall shut down.

10.6.6 A liquid detection device(s) shall be installed to detect leaks or spills within laser enclosures.

10.6.7 Remote Shutdown.

10.6.7.1 Remote shutdown capability for the laser pumping system (i.e., crash buttons) shall also be provided for personnel to activate in case of emergency.

10.6.7.2 The crash buttons shall be located near main exits of the area.

10.6.8 Building Construction.

10.6.8.1 Buildings or structures housing large-volume flammable liquid systems shall be of fire-resistive or noncombustible construction.

10.6.8.2 Combustible construction shall be permitted where automatic fire sprinklers or equivalent protection is provided, subject to the approval of the authority having jurisdiction.

10.6.8.3 Where walls are required for separation from other occupancies or property lines, they shall have a fire resistance rating of at least 2 hours consistent with the requirements of NFPA 30, Chapters 5 through 8, Chapters 17 through 20, and Chapters 28 and 29.

10.7 Spill Cleanup.

10.7.1 Ignitible liquid spills shall be mitigated pursuant to 40 CFR.

10.7.2 In the event of a large-volume ignitible liquid spill, the fire department shall be notified.

10.8* Waste Disposal. Ignitible liquids absorbed into solids, objects contaminated with ignitible liquids, and ignitible liquid dye solutions shall be managed as hazardous waste pursuant to 40 CFR.

10.9 Training.

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

10.9.2 Employees shall review upon initial assignment those parts of the fire prevention plan and the procedures necessary to protect themselves in the event of an emergency.

10.9.3 The written fire prevention plan shall be kept in the workplace and made available for employee review.

10.10 Maintenance.

10.10.1 All equipment shall be maintained in accordance with manufacturers' instructions.

10.10.2 A safety inspection schedule for those portions of laser systems that could present a fire hazard shall be established.

10.10.3 A written log of these inspections shall be maintained.

Chapter 11 Operations/Administration

11.1 Safety Operations and Administration.

11.1.1 Lasers. Lasers and laser systems shall be operated and maintained in accordance with the following documents:

(1) ANSI Z136.1, *Safe Use of Lasers*, revised
(2) ANSI Z136.3, *Safe Use of Lasers in Health Care Facilities*
(3) Occupational Safety and Health Administration (OSHA) Instruction Pub 8-1.7
(4) NFPA 99, pertaining to electrical systems, electrical equipment, gas and vacuum systems, and gas equipment
(5) Joint Commission on Accreditation of Healthcare Organizations (JCAHO) documents
(6) State rules and standards

11.1.2 Laser Safety Officer (LSO). Where lasers presenting a fire hazard are used, specific personnel shall be designated to monitor and enforce the control of laser hazards and effect the knowledgeable evaluation and control of laser hazards.

11.1.3 Laser Modifications.

11.1.3.1 Modifications to certified or uncertified lasers shall meet all requirements of the minimum standards and shall be reviewed and approved by the LSO.

11.1.3.2 Whenever deliberate modifications are made that could change the laser class and affect the output power, operating characteristics, or fire hazards, the LSO shall specify whether any changes in control measures are required.

11.1.4 Fire-Extinguishing Agents.

11.1.4.1 Fire extinguishers shall be of a type and size to extinguish a fire occurring within the laser equipment and as a result of the laser beam.

11.1.4.2 Extinguishing agents shall be readily available to the laser location(s) and shall be maintained in accordance with NFPA 10.

11.1.4.3 The LSO shall determine the type and quality of extinguishing agents necessary for the specific laser installation(s) and shall consult with the manufacturers for their suggestions.

11.1.4.4 Training shall be provided on the use of portable fire extinguishers.

11.1.5* Fire-Resistant Materials. Materials adjacent to a laser that can be an ignition hazard shall be evaluated for their fire properties.

11.2 Housekeeping.

11.2.1 Laser equipment, systems, installation, and supporting materials and equipment shall be maintained in a clean, neat, and orderly condition.

11.2.2 Electrical and mechanical ventilation equipment shall be maintained to remain safe and fully operational.

11.2.3 The LSO shall ensure that the laser installation fully complies with the requirements of this and the referenced documents.

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11.3 Maintenance and Service.

11.3.1 Maintenance shall be performed by trained personnel.

11.3.2 Service shall be performed by trained personnel.

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

11.3.4 The LSO shall ensure that regular maintenance schedules for each type of laser are established.

11.3.5 The LSO shall retain documentation of all maintenance and service performed.

11.3.6 Maintenance checks shall include all supporting equipment.

11.3.7 All electrical and mechanical systems shall be maintained in compliance with the documents listed in 11.1.1.

11.4 Training and Education.

11.4.1 A training program shall be established for staff members using and supporting the safe application of laser systems.

11.4.2 All training shall follow OSHA guidelines, ANSI Z136.1, *Safe Use of Lasers*, ANSI Z136.3, *Safe Use of Lasers in Health Care Facilities*, and ANSI Z136.5, *Safe Use of Lasers in Educational Institutions*.

11.4.3 Training records shall be maintained by the LSO.

11.4.4 New staff members shall be trained.

11.4.5 When new lasers are introduced or existing laser systems are modified, staff members shall receive instruction on these systems.

11.4.6 The LSO shall monitor compliance with all training and education requirements.

Chapter 12 Emergency Preparedness

12.1 Pre-Fire Planning.

12.1.1 Staff members shall be familiar with exit locations and emergency procedures, including use of fire extinguishers and laser shutdown procedures.

12.1.2 Emergency services organizations shall be made aware of location and hazards of lasers.

12.1.3 Facility emergency response personnel shall be familiar with emergency shutdown procedures for the laser(s).

12.2 Training.

12.2.1 All staff members working with lasers shall receive instruction in the hazards of lasers and the use of fire-fighting equipment.

12.2.2 Emergency drills shall be conducted no less than once per year.

12.3 Fire Brigades. Established industrial fire brigades shall receive training on the hazards of lasers, fire-fighting tactics, and emergency shutdown procedures, in conjunction with the requirements of NFPA 600.

12.4 Emergency Shutdown.

12.4.1 A master emergency electrical shutdown switch that will immediately de-energize the laser shall be provided.

12.4.2 The switch shall be located inside or outside of each room, at the facility's discretion.

12.5 Fire Procedure. The following actions shall be considered:

(1) Alert others in the work area upon discovery of a fire.
(2) Whoever is closest to a manual fire alarm pull station, activate the alarm to alert all building occupants and summon the industrial fire brigade or fire department.
(3) Whoever is closest to the master emergency electrical shutdown switch, de-energize the laser.
(4) Use a portable fire extinguisher to contain, control, and extinguish the fire if possible.
(5) If the fire location involves medical oxidizing gases or industrial oxidizing gases, shut off the oxidizing gas supply.
(6) Simultaneously, other staff members evacuate the area of hazard.
(7) Close all doors in fire area.

Annex A Explanatory Material

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

A.3.2.1 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.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, 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.3.2.4 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.

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A.3.3.1 Accessible Emission Limit (AEL). This definition was extracted from ANSI Z136.1, *Safe Use of Lasers,* and 21 CFR 1040.10.

A.3.3.2 Beam. This definition was extracted from ANSI Z136.1, *Safe Use of Lasers.*

A.3.3.4 Continuous Wave (cw). In this document, a laser operation with a continuous output for a period ≥0.25 seconds is regarded as a cw laser. This definition was extracted from ANSI Z136.1, *Safe Use of Lasers.*

A.3.3.5 Energy. Energy content is commonly used to characterize the output from pulsed lasers, and is generally expressed in joules (J). This definition was extracted from ANSI Z136.1, *Safe Use of Lasers.*

A.3.3.6 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.3.3.7 Flammable Liquid Storage Cabinet. The cabinet should be constructed in accordance with NFPA 30. Some local jurisdictions require bottom-venting of flammable liquid storage cabinets. While this is not required by NFPA 30, some manufacturers provide plugged vent connections to accommodate these local jurisdictions.

A.3.3.9 Flash Point. See Annex E.

A.3.3.10.3 Reactive Gas. Reactive gases can also be corrosive.

A.3.3.11 Hazardous Chemical. For hazard ratings of many chemicals, see NFPA *Fire Protection Guide to Hazardous Materials*, 2001.

A.3.3.16 Laser. This definition and definitions in 3.3.16.1 through 3.3.16.3 were extracted from ANSI Z136.1, *Safe Use of Lasers,* and 21 CFR 1040.10.

A.3.3.17 Laser Safety Personnel (LSP). This definition was extracted from ANSI Z136.1, *Safe Use of Lasers.*

A.3.3.18 Laser System. This definition was extracted from ANSI Z136.1, *Safe Use of Lasers.*

A.3.3.21 Maintenance (Laser Products). It does not include *operation* or *service* as defined in this document. This definition was extracted from ANSI Z136.1, *Safe Use of Lasers,* and 21 CFR 1040.10.

A.3.3.22 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.3.3.23 Noncombustible. Materials that are reported as passing ASTM E 136 are considered noncombustible. *(See NFPA 220.)*

A.3.3.24 Operation. It does not include *maintenance* or *service* as defined in this document. This definition was extracted from ANSI Z136.1, *Safe Use of Lasers,* and 21 CFR 1040.10.

A.3.3.27 Plasma. Very high temperatures are associated with laser-generated plasmas that can appear as sparks, plumes, or flames.

A.3.3.30 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 workstation and should limit access to other associated radiant energy emissions and to electrical hazards associated with components and terminals. This definition was extracted from ANSI Z136.1, *Safe Use of Lasers,* and 21 CFR 1040.10.

A.3.3.31 Q-Switch. This definition was extracted from ANSI Z136.1, *Safe Use of Lasers.*

A.3.3.32 Radiant Exposure. This definition was extracted from ANSI Z136.1, *Safe Use of Lasers.*

A.3.3.34 Service (Laser Products). It does not include *maintenance* or *operation* as defined in this document. This definition was extracted from ANSI Z136.1, *Safe Use of Lasers,* and 21 CFR 1040.10.

A.5.1.1 Lower values can be possible, particularly in an oxygen-enriched atmosphere, depending on the thickness and the physical properties of the material. See NSBIR 81-2271 and ASTM STP 882.

A.5.1.2(3) Very high repetition rates can produce ignition hazards similar to cw laser beams.

A.5.1.4 Lasers in the lower power and energy levels of Class 3b are often incapable of being beam ignition hazards.

A.6.3.1.2 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.

A.7.2.4 See Article 500 of NFPA 70.

A.7.3 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 is useful 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 kW/m^2 to 30 kW/m^2) and a high level (55 kW/m^2 to 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.7.5.3 Significant particulate production can occur well in advance of smoldering or flaming fire. Increases in background particulate levels can indicate an incipient problem.

A.8.4.1.2 See NFPA 55 for additional information.

A.8.4.3 Regulator diaphragm failures should be considered when locating a flammable gas regulator in an enclosed area.

A.8.4.3.1 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.

A.9.3.3 Some gases can be incompatible with water. Water reactivity should be evaluated.

A.9.4.2.4 A method for purging piping with inert gas is to have a series of evacuations followed by an inert gas fill.

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A.9.4.2.5.2 These types of fittings can trap contaminants and be difficult to purge.

A.9.4.3.4 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.

A.10.1 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.

A.10.3.6 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 nonconducting tubing.

A.10.8 See the 19th edition of the NFPA *Fire Protection Handbook* for a list of liquids subject to self-heating and autoignition.

A.11.1.5 Examples of fire properties to be evaluated include ignition, flame spread, and oxygen index.

A study on the flammability of surgical drapes has been described in Bauman, "Laser Drape Fires: How Much of a Risk?"

Annex B Nature of Hazards

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

B.1 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.

Annex C Education and Training

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

C.1 The LSO (laser safety officer), laser users, and maintenance or service personnel should be trained in laser fire safety and in recognizing 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. 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

The following issues should be addressed during the training provided to health care facility laser 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 handheld 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 conducted on an annual basis.
(4) Training on any changes in equipment or procedures that can affect fire safety should be addressed prior to the use of such equipment or procedures.
(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) The responsibilities of the anesthesiologist
    (c) Responsibilities of each individual in the surgical suite if a patient fire develops
(7) Training on the facility's fire safety plan, location of fire alarms, location of fire-fighting equipment, and emergency evacuation should be conducted on an ongoing basis.

Annex D Classification of Lasers

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

D.1 This annex contains a brief explanation of the classification schemes for lasers. It is intended only to give an overview. The reader should consult the normative references in Chapter 4 to obtain detailed information about the laser hazard classes.

The laser safety standards in Chapter 4 have been in existence for approximately 30 years. These standards are aimed at preventing or reducing personal injuries resulting from exposure to hazardous levels of laser radiation. These standards operate by establishing hazard classes for lasers and by imposing equipment, informational, and administrative control measures that are appropriate for the degree of hazard.

Although the hazard classes were developed with respect to the potential for causing biological injury, they can also be useful as indicators of the ignition potential of the lasers. The processes by which lasers can cause biological injury are the same as those by which they can cause ignition. The big difference is that for biological injury from lasers in the visible and near-infrared spectral regions, the most sensitive organ is the eye because of the ability to focus laser spots on the retina. Although there are differences between the classes in the standards, there are more similarities than differences. There are four general classes: 1, 2, 3, and 4 (or I, II, III, and IV). With the exception of Class 4, the classes have limits, accessible emission limits (AEL), that consider power, emission duration, and beam propagation properties. Lasers are classified according to the level of laser radiation that is accessible during "operation," that is, when the laser is performing its intended function.

Class 1 (I) lasers either emit radiation at levels so low that they are not recognized to be capable of producing an injury or are more hazardous but are safely contained within a protective housing. Class 1 lasers can emit radiation anywhere in

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the optical spectrum with wavelengths between 180 nanometers and 1 meter. Some Class 1 lasers, however, contain embedded lasers of higher classes. An example would be Class 4 lasers contained within Class 1 laser machine tools.

Class 2 (II) lasers emit in the visible spectrum, between 400 and 700 nanometers, but at levels for which, although recognized to be hazardous to the eyes, a person's aversion to looking into a bright light source is sufficient to avoid an injury to the retina of the eye.

IEC 60825-1, *Safety of laser products — Part 1: Equipment classification, requirements and user's guide*, has, in its latest version, two subclasses, Classes 1M and 2M. These M classes mean that a biological hazard could be created for Class 1M, or increased for Class 2M, if a collecting optical instrument such as a telescope or loupe were used to view the laser radiation. It is likely that the ANSI Z136 Committee and the U.S. Food and Drug Administration (FDA) will adopt a similar classification scheme in the near future.

Class 3a [IIIa in FDA (21 CFR 1040), 3R in IEC] lasers are less than 5 times the level of either Class 1 or Class 2. They are recognized to be hazardous, but the degree of risk of a radiation injury is considered to be too low to justify severe control measures.

In addition to the biological hazard, Classes 3b and 4 possess potential for ignition.

Class 3b (IIIb) has a large range. At the low end, Class 3b lasers are considered to have a reasonable potential for retinal injury and at the high end to be a skin hazard as well.

Class 4 (IV) has no upper limit. Class 4 lasers are considered to be hazardous not only by direct exposure but also by exposure to laser radiation scattered by diffuse targets.

Since the laser hazard classes are already in place, the ignition potential of the classes can be considered. The potential for ignition involves many factors, including the following:

(1) Power or energy
(2) Irradiance or radiant exposure
(3) Size of the laser spot on the target
(4) Duration of exposure
(5) Environmental factors such as the presence of fabric drapes, volatile solvents, or oxygen-enriched atmospheres (OEAs) in health care facilities
(6) Thickness of the target material
(7) Thermal conductivity of the target material

A general assessment of the ignition potential for the classes is given in Table D.1.

Table D.1 Laser Ignition Potential

Classification	Examples	Ignition Potential	Remarks
1, 2 (I, II)	CD players, laser printers, fiber-optic telecommunications, bar code scanners	Negligible	Not considered in NFPA 115
1M, 2M	Distance-measuring instruments, police radar, infrared telecom	Conceivable but improbable	Unlikely that one would position a lens in front of such a laser and focus it to cause ignition; not considered in NFPA 115
3a (IIIa), 3R	Laser pointers, laboratory lasers	Possible under extreme circumstances	Necessitates a deliberate attempt to cause ignition; not considered in NFPA 115
3b (IIIb) 3B	Industrial machine vision, laboratory lasers, medical lasers (e.g., for tattoo removal)	Possible at the high end of the class	Focusing optics or an irradiance >0.5 W/cm^2; requirements in NFPA 115
4 (IV)	Surgical lasers, industrial lasers, commercial light shows, laboratory lasers	Probable for highly absorbent materials	Requirements in NFPA 115

Annex E Flash Point

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

E.1 The following is taken from the 2008 edition of NFPA 30.

Flash point is a direct measure of a liquid's ability to emit flammable vapors. The lower the flash point, the greater the risk of fire. Flash point is determined using one of several different test procedures and apparatus that are specified in Section 4.4 of NFPA 30.

A liquid that has a flash point at or below ambient temperature is easy to ignite and will burn quickly. On ignition, the spread of flame over the surface of such a liquid will be rapid, because it is not necessary for the fire to expend energy heating the liquid to generate more vapor. Gasoline is a familiar example. A liquid with a flash point above ambient temperature presents less risk because it must be heated to generate enough vapor to become ignitible; it is more difficult to ignite and presents less potential for the generation and spread of vapor. A common example is home heating oil (Fuel Oil No. 2). Home heating oil must be atomized to a fine mist in order for it to be easily ignited.

Certain solutions of liquids in water exhibit a flash point using the standard closed-cup test procedures but will not burn and could even extinguish a fire. To assist identifying such solutions, the following standards are helpful:

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(1) ASTM D 4207, *Standard Test Method for Sustained Burning of Low Viscosity Liquid Mixtures by the Wick Test*
(2) ASTM D 4206, *Standard Test Method for Sustained Burning of Liquid Mixtures Using the Small Scale Open-Cup Apparatus*

Liquid mixtures that do not sustain combustion for a specified time at a specified temperature are considered to be noncombustible. The tests described in the references listed in (1) and (2) provide additional data for determining proper storage and handling of such mixtures. In a confined space, such mixtures could still create an ignitible vapor–air mixture, depending on the amount of flammable liquid in the mixture and the quantity of the spill.

Related to the flash point is the *fire point*. The fire point of a liquid is the temperature at which ignition of vapors will result in continued burning. As the term *flash point* suggests, the vapors generated at that temperature will flash but will not necessarily continue to burn. The difference between flash point and fire point has some significance when conducting flash point tests *[see 9.1.4 of NFPA 30 for references to ASTM D 92, Standard Test Method for Flash and Fire Points by Cleveland Open Cup, and 49 CFR (U.S. Department of Transportation Hazardous Materials Regulations), Method of Testing for Sustained Combustibility]*. However, a closed-cup flash point is used to classify the liquid and characterize its hazard.

For more information, see ASTM E 502, *Standard Test Method for Selection and Use of ASTM Standards for the Determination of Flash Point of Chemicals by Closed Cup Methods*, and the *ASTM Manual on Flash Point Standards and Their Use*.

Annex F Informational References

F.1 Referenced Publications. The documents or portions thereof listed in this annex are referenced within the informational sections of this standard and are not part of the requirements of this document unless also listed in Chapter 2 for other reasons.

F.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 30, *Flammable and Combustible Liquids Code*, 2008 edition.

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

NFPA 70™, *National Electrical Code*®, 2008 edition.

NFPA 220, *Standard on Types of Building Construction*, 2006 edition.

NFPA *Fire Protection Guide to Hazardous Materials*, 2001.

NFPA *Fire Protection Handbook*®, 19th edition, 2003.

F.1.2 Other Publications.

F.1.2.1 ANSI Publications. American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036.

ANSI Z136.1, *Safe Use of Lasers*, 2000.

F.1.2.2 ASME Publications. American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

Boiler and Pressure Vessel Code, 1992.

F.1.2.3 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM D 92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup*, July 1, 2005.

ASTM D 4206, *Standard Test Method for Sustained Burning of Liquid Mixtures Using the Small Scale Open-Cup Apparatus*, 2001.

ASTM D 4207, *Standard Test Method for Sustained Burning of Low Viscosity Liquid Mixtures by the Wick Test*, 1991.

ASTM E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 Degrees C*, 1993.

ASTM E 502, *Standard Test Method for Selection and Use of ASTM Standards for the Determination of Flash Point of Chemicals by Closed Cup Methods*, 2000.

ASTM E 1354, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*, 2003.

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ASTM Manual on Flash Point Standards and Their Use, 1992.

F.1.2.4 IEC Publications. International Electrotechnical Commission. Available from American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, U.S. National Committee for the IEC (www.ansi.org).

IEC 60825-1, Ed. 1.2: 2001-8, *Safety of laser products—Part 1: Equipment classification, requirements and user's guide.*

F.1.2.5 NIST Publications. National Institute of Standards and Technology, 100 Bureau Drive, Gaithersburg, MD 20899-1070.

NSBIR 81-2271, Babrauskas, V., "Will the Second Item Ignite?," 1982.

F.1.2.6 U.S. Government Publications. U.S. Government Printing Office, Washington, DC 20402.

Title 21, Code of Federal Regulations, Part 1040.

Title 49, Code of Federal Regulations.

F.1.2.7 Additional Publications.

Bauman, N., "Laser Drape Fires: How Much of a Risk?," *Laser Medicine & Surgery, News & Advances*, Vol. 7, No. 4, August 1989.

F.2 Informational References. The following documents or portions thereof are listed here as informational resources only. They are not a part of the requirements of this document.

F.2.1 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM D 56, *Standard Test Method for Flash Point by the Tag Closed Tester,* 2002.

ASTM D 93, *Standard Test Method for Flash Point by the Pensky-Martens Closed Tester,* 2002.

ASTM D 3278, *Standard Test Methods for Flash Point of Liquids by Setaflash Closed-Cup Apparatus,* 1996.

ASTM D 3828, *Standard Test Methods for Flash Point by Small Scale Closed Tester,* 2002.

F.2.2 Published Articles on Fires Involving Lasers and Related Equipment.

Bean, A. K., MD, and Ceilley, R.I., MD, "Reducing Fire Risks in the Flashlamp Pumped 585-nm Pulse Dye Laser," *Journal of Dermatology Surgical Oncology*, Vol. 20, p. 224, 1994.

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Ossof, R. H., DMD, MD, and Kaplan, M.S., MD, "Safe Instrumentation in Laser Surgery," *Otolaryngology, Head & Neck Surgery*, Vol. 92, No. 6, December 1984.

Rupke, G., RN,"Vigilance, Education Are Keys to Overcoming Laser Safety Complacency," *AORN Journal*, Vol. 56, No. 3, p. 523, September 1992.

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Smalley, P. J., RN, "Clinical Laser Safety Issues Survey," *Journal of Laser Applications*, Winter 1991.

Wagner, M., "Accidents Detract from Laser's Potential," *Modern Healthcare*, March 25, 1991.

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NFPA 30, *Flammable and Combustible Liquids Code*, 2008 edition.

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- Committee votes by written ballot on Proposals. If two-thirds approve, Report goes forward. Lacking two-thirds approval, Report returns to Committee.
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