NFPA 160

Standard for the Use of Flame Effects Before an Audience

2006 Edition

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

IMPORTANT NOTICES AND DISCLAIMERS CONCERNING NFPA DOCUMENTS

NOTICE AND DISCLAIMER OF LIABILITY CONCERNING THE USE OF NFPA DOCUMENTS

NFPA codes, standards, recommended practices, and guides, 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.

ADDITIONAL NOTICES AND DISCLAIMERS

Updating of NFPA Documents

Users of NFPA codes, standards, recommended practices, and guides should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of Tentative Interim Amendments. An official NFPA document at any point in time consists of the current edition of the document together with any Tentative Interim Amendments and any Errata then in effect. In order to determine whether a given document is the current edition and whether it has been amended through the issuance of Tentative Interim Amendments or corrected through the issuance of Errata, 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 below.

Interpretations of NFPA Documents

A statement, written or oral, that is not processed in accordance with Section 6 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.

Patents

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 NFPA codes, standards, recommended practices, and guides, and the NFPA disclaims liability for the infringement of any patent resulting from the use of or reliance on these documents. Users of these documents 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.

NFPA adheres to applicable policies of the American National Standards Institute with respect to patents. For further information contact the NFPA at the address listed below.

Law and Regulations

Users of these documents should consult applicable federal, state, and local laws and regulations. NFPA does not, by the publication of its codes, standards, recommended practices, and guides, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

For Further Information

All questions or other communications relating to NFPA codes, standards, recommended practices, and guides 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, NFPA, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

For more information about NFPA, visit the NFPA website at www.nfpa.org.

NFPA 160

Standard for the

Use of Flame Effects Before an Audience

2006 Edition

This edition of NFPA 160, *Standard for the Use of Flame Effects Before an Audience*, was prepared by the Technical Committee on Special Effects and acted on by NFPA at its June Association Technical Meeting held June 6–10, 2005, in Las Vegas, NV. It was issued by the Standards Council on July 29, 2005, with an effective date of August 18, 2005, and supersedes all previous editions.

This edition of NFPA 160 was approved as an American National Standard on August 18, 2005.

Origin and Development of NFPA 160

NFPA 160, *Standard for Flame Effects Before an Audience*, was developed by the Technical Committee on Special Effects, which was established in 1994, in response to a recognized need for a document to provide guidance to public safety officials, designers, and operators of flame effects. The purpose of this standard is to provide requirements for reasonable protection for viewing audiences and performers of flame effects.

For the 2001 edition, the Committee completed a partial revision of the standard. Revisions included amendments to standardized definitions, harmonization with the pyrotechnics special effects document, and editorial changes according to the *Manual of Style for NFPA Technical Committee Documents*.

The 2006 edition represents a complete revision of the standard by the Committee. Key changes found in the new edition include revisions to Chapter 3, Definitions; clarification of the document applicability by modifying the document title; definitions for temporary and permanent installations to correlate with the effect classifications based upon those terms; a new requirement for inspection intervals; and a new Annex C on inspection guidelines.

This edition of the standard also incorporates editorial changes according to the *Manual of Style for NFPA Technical Committee Documents*.

Technical Committee on Special Effects

G. Clark Parkhurst, Jr., *Chair*
Bristol, CT [SE]

Edgar C. Buckingham, *Secretary*
Honeywell Inc., CA [M]

Robert Bauer, The Doyle Street Group, CA [IM]
Glenn A. Birket, Birket Engineering, Inc., FL [M]
Jose R. Colon, Connecticut Department of Public Safety, CT [E]
Rep. International Fire Marshals Association
Steve A. Coman, RES Specialty Pyrotechnics Inc., MN [M]
Rep. Pyrotechnics Guild International, Inc.
Ettore Contestabile, Natural Resources Canada, Canada [RT]
Randall W. A. Davidson, Risk International & Associates, Inc. CA [SE]
June M. Fields, Henderson, NV [SE]
Jon G. Fuller, Universal Studios, FL [U]
Steven A. Giovagnoli, GE Global Asset Protection Services, IL [I]
Reuben Goldberg, Technic Services, CA [U]
Rep. The Alliance of Special Effects & Pyrotechnic Operators, Inc.
Jeremiah Harris, Harris Production Services/PRG, NY [U]
Kenneth L. Kosanke, PyroLabs, Inc. CO [SE]
Joshua Lazarus, State of New Jersey, NJ [E]
Dave McCulloch, Natural Resources Canada, Canada [E]
Thaine Morris, MP Associates, Inc., CA [M]
Andrew T. Nicholls, Orlando Special Effects, Inc., FL [M]
John T. Rodgers, John T. Rodgers, P.E., CA [M]
Monona Rossol, Arts, Crafts & Theater Safety, Inc., NY [SE]
R. Scott Schaffner, RADCO, CA [RT]
Larry Schoeneman, Interesting Products, IL [SE]
Rep. Entertainment Services and Technology Association (ESTA)
David S. Shatzer, U.S. Bureau of Alcohol, Tobacco, Firearms, and Explosives, DC [E]
James H. Stannard, Jr., Stannard & Company, GA [SE]
Martin E. Steinke, Busch Entertainment Corporation, FL [U]
Charles P. Weeth, Weeth & Associates, LLC, WI [SE]
Lawrence Weinman, Luna Tech/Schneier-Weinman Consultants, AL [M]
Tylor A. Wymer, WOW!Works[SM], A Buckley/Wymer Company, FL [U]
William J. Young, Superior Energy Systems, Ltd., OH [M]
Rep. National Propane Gas Association

Alternates

Damon H. Andrew, Busch Entertainment Corporation, MO [U]
(Alt. to M. E. Steinke)
Gary R. Barnes, Universal Studios, FL [U]
(Alt. to J. G. Fuller)
Daniel Birket, Birket Engineering, Inc., FL [M]
(Alt. to G. A. Birket)
Gregory V. Dumansky, GE Global Asset Protection Services, CA [I]
(Alt. to S. A. Giovagnoli)
Bonnie J. Kosanke, Journal of Pyrotechnics, Inc., CO [SE]
(Alt. to K. L. Kosanke)
Gregory Meeh, Jauchem & Meeh Inc., NY [U]
(Alt. to J. Harris)
Robert B. Nicholson III, Eastern Propane Corporation, NJ [M]
(Alt. to W. J. Young)
Mark C. Orellana, Penn Township, Indiana Fire Department, IN [E]
(Alt. to J. R. Colon)
David J. Pier, MP Associates, Inc., CA [M]
(Alt. to T. Morris)
Elia P. Popov, J.E.M. F/X Inc., CA [M]
(Alt. to E. C. Buckingham)
Karl G. Ruling, Entertainment Services & Technology Association, NY [SE]
(Alt. to L. Schoeneman)
John R. Steinberg, Pyrotechnics Guild International, Inc., MD [M]
(Alt. to S. A. Coman)
Michael L. Zieman, RADCO, CA [RT]
(Alt. to R. S. Schaffner)

Nonvoting

Virginia M. Gilman, U.S. Department of Labor, DC [E]
Rep. Occupational Safety & Health Administration
(Alt. to M. W. Hagemann)
Mark W. Hagemann, U.S. Department of Labor, DC [E]
Rep. Occupational Safety & Health Administration

Guy R. Colonna, NFPA Staff Liaison

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 the controlled use of flame, pyrotechnics, or other means of special effects for entertainment, exhibition, demonstration, or simulation before a proximate audience; and the design, fabrication, installation, testing, control, operation, and maintenance of user equipment, fuel storage, and sources for special effects before a proximate audience. This Committee does not have responsibility for documents on hazards other than those involving a proximate audience and the life safety considerations of the audience.

Contents

NFPA 160

Standard for the

Use of Flame Effects Before an Audience

2006 Edition

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

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

Chapter 1 Administration

1.1* Scope. This standard shall provide requirements for the protection of the audience, support personnel, performers, the operator, assistants, and property where flame effects are used.

1.2 Purpose. The purpose of this standard shall be to provide minimum requirements for the design, manufacture, and operation of flame effects.

1.3 Application.

1.3.1* This standard shall apply to flame effects for entertainment, exhibition, demonstration, or simulation before an audience, including their design, fabrication, installation, testing, control, operation, and maintenance.

1.3.2 This standard shall apply to the following:

(1) Use of flame effects before an audience *(see 3.3.11, Flame Effect)*
(2) Design, fabrication, installation, testing, control, operation, and maintenance of equipment, materials, procedures, and systems used to produce flame effects
(3) Rehearsal, videotaping, audiotaping, or filming of any television, radio, or movie production if such production is before an audience and includes the use of flame effects
(4) Rehearsal of any production incorporating flame effects intended to be presented before an audience
(5) Storage and holding at a venue where flammable and combustible materials are to be used to create flame effects

1.3.3 This standard shall not apply to the following:

(1) Flame effects produced solely by pyrotechnic special effects devices
(2)* Use of pyrotechnic special effects
(3)* Storage of flammable solids, liquids, and gases not to be used to create flame effects
(4) Manufacture, off-site storage, and transportation of materials and equipment used to produce flame effects
(5) Use of flame effects in fire training, except where there is an audience that is not part of the training
(6)* Manufacture, transportation, storage, sale, or use of model or high-power rocket motors
(7) Traditional nontheatrical public display of flames such as the following:
  (a) Use of lighted candles in restaurants or religious services
  (b) Fireplaces in areas open to the public
  (c) Restaurant cooking visible to the patrons
  (d) Listed Group II flame effects
(8) Use of consumer fireworks by the public
(9) Use of motor vehicles in races or sanctioned competitive sporting events

1.3.4* This standard shall not be used as a product standard.

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.

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 Publication. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 10, *Standard for Portable Fire Extinguishers,* 2002 edition.

2.3 Other Publications.

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

ASME *Boiler Pressure Vessel Code*, 1992.

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

2.4 References for Extracts in Mandatory Sections. (Reserved)

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.

3.3 General Definitions.

3.3.1 Accumulator. A container or piping that holds a predetermined volume of fuel that is ready for use in a flame effect.

3.3.2 Area.

3.3.2.1 ***Hazard Area.*** The area made hazardous by the operation of the flame effect.

3.3.2.1.1 ***Accessible Hazard Area.*** That area made hazardous by the flame effect that is normally accessible to a person without the deliberate use of an additional means of access that is not normally in place.

3.3.2.2 ***Holding Area.*** An area where flame effect material or loaded flame effect devices are held prior to use.

3.3.2.3 ***Storage Area.*** An area where flame effect material or flame effect devices are stored prior to use or movement to a holding area.

3.3.3* Arm. That sequence of control system functions for the establishing of a source of ignition that must be complete and verified immediately before the firing of the flame effect.

3.3.4 Cast Members. Performers involved in a production involving the use of flame effects that may or may not be employees. (Many amusement employees are also referred to as "cast members.")

3.3.5 Direct Ignition. An automatic or manual ignition system that ignites fuel without a pilot.

3.3.6 Emergency Stop [Emergency Shutdown (ESD) System]. A circuit or other mechanism that when actuated, results in the complete shutdown and extinguishment of all flame effects that are controlled by it.

3.3.7* Enable. The final set of control system functions that must be verified to be in a specific control mode immediately before the arming and firing of a flame effect may be implemented.

3.3.8 Enable Button. The control operator that is manually actuated by the operator prior to and during the arming and firing of the effect.

3.3.9 Fail-Safe. A state or an attribute of a system such that every single point failure in the system results in all controlling parts of the system with the ability to do harm to humans, animals, or equipment being disconnected from all sources of power and stored energy at the primary disconnect point.

3.3.10* Fire. The sequence of control system functions that result in the deliberate release of fuel for ignition.

3.3.11 Flame Effect. The combustion of flammable solids, liquids, or gases to produce thermal, physical, visual, or audible phenomena before an audience.

3.3.11.1 ***Automatic Flame Effect.*** A flame effect that is supervised and fired by an automatic control system.

3.3.11.2 ***Manual Flame Effect.*** A flame effect that is operated manually without the use of an automatic control system.

3.3.11.3 ***Portable Flame Effects.*** Flame effects that are designed and installed, either in a permanent or temporary installation, that are designed to move or be moved, in the course of operation or installation.

3.3.12 Flame Effect Appliance. The complete assembly of components and devices that controls and generates a flame effect.

3.3.13 Flame Effect Assistant. A person who works under the supervision of the flame effect operator.

3.3.14 Flame Effect Burner. A burner designed to produce specific sizes and configurations of flames for flame effects.

3.3.15 Flame Effect Material. A flammable material that is used as fuel to create a flame effect.

3.3.16 Flame Effect Operator. The single person with overall responsibility for flame effect operations and safety.

3.3.17 Flame Effect Safety Controller. A control system that is part of a flame effect appliance that is used to prove that the source of ignition is present ("flame safeguard control").

3.3.18* Flame Effect System. The complete assembly of interconnected components, devices, and/or appliances that provides all of the functions necessary to fuel, monitor, supervise, generate, and control flame effects, including the emergency shutdown of the flame effects and, where necessary, the monitoring of external conditions that affect operation.

3.3.19* Flame Effect Systems, Classifications.

3.3.19.1 ***Group I Flame Effect.*** An attended, manually controlled flame effect.

3.3.19.2 ***Group II Flame Effect.*** An individual or group flame effect designed for unattended operation that is temporarily or permanently installed outside any structure.

3.3.19.3 ***Group III Flame Effect.*** An attended, temporarily installed flame effect for a specific production with limited operation and fixed time for removal.

3.3.19.4 ***Group IV Flame Effect.*** A large individual or group flame effect that is permanently installed inside or outside any structure designed for unattended operation without a main show supervisory control system.

3.3.19.5 ***Group V Flame Effect.*** A large individual or group flame effect that is temporarily or permanently installed inside or outside any structure and is designed for intermittent or continuous operation under the supervision of a main show control system but without full-time supervision by a technician.

3.3.19.6 ***Group VI Flame Effect.*** A large individual or group flame effect that is temporarily or permanently installed inside or outside any structure and is designed for intermittent operation under the supervision of a main show control system and a technical director, with cast members in close proximity to the effect at the time of operation.

3.3.19.7 ***Group VII Flame Effect.*** An individual flame effect that can be temporarily or permanently installed inside or outside any structure that, due to its unique operating requirements, does not fit into any other classification.

3.3.20 Installation, Term of.

3.3.20.1 ***Permanent Installation.*** An installation of flame effects for which the governing use permit has a duration longer than 180 days.

3.3.20.2 ***Temporary Installation.*** An installation of flame effects for which the governing use permit has a duration of 180 days or less within a twelve-month period in a single venue.

3.3.21 Permit. A document issued by the AHJ for the purpose of authorizing performance of a specified activity. Unless otherwise specified, the word *permit,* when used in this document, refers to a use permit.

3.3.21.1 ***Use Permit.*** A document issued by the AHJ for the purpose of authorizing the use of specific flame effects in a specific venue on a specified date and time or within a specified period.

3.3.22 Plan.

3.3.22.1 ***Design Plan.*** The plan for a flame effect appliance or design that presents the design criteria and/or assumptions used in the design, along with complete design information.

3.3.22.2 ***Flame Effect Plan.*** The document that is used to convey to the AHJ the information needed to evaluate the flame effect for the purpose of applying for a permit.

3.3.23* Primary Safety Control. A control with a sensor that is directly responsive to the ignition device attributes necessary for the safe operation of the effect.

3.3.24 Proven Pilot. A pilot flame supervised by a primary safety control.

3.3.25 Rated. A description of performance derived from testing or evaluation that guides appropriate selection, installation, and use of equipment that is not listed.

3.3.26* Safety Shutdown (Lockout). The safe shutdown of the flame effect in the event of the actuation of any flame effect primary safety control or limit switch.

3.3.27 Safety-Critical. The failure of a device, component, system, or mechanism, which results in a situation that is immediately dangerous to life, health, or property.

3.3.28 Supervisory Cock. A manually actuated valve with two double-pole, double-throw switches that prove the valve position.

3.3.29* Supervisory Control System. A manual or automatic control system that supervises the operation of the flame effect.

3.3.30 Valve.

3.3.30.1 ***Accumulator Charge Valve.*** A valve used to control the flow of fuel into an accumulator.

3.3.30.2 ***Effect Valve.*** The last fuel shutoff valve before the flame effect burner.

3.3.30.3 ***Proof-of-Closure Valve.*** A safety shutoff valve equipped with an interlock switch that is actuated only when the valve is fully closed.

3.3.30.4 ***Safety Shutoff Valve.*** A fast-closing valve that automatically and completely shuts off the fuel supply in response to a normal or safety shutdown.

3.3.30.5 ***Vent Valve.*** A normally open, power-closed valve, normally located between the two safety shutoff valves.

3.3.31* Venue. The property, facility, building, or room within a building where flame effects are used, intended to be used, or are prohibited.

Chapter 4 Holding Areas for Flame Effect Materials and Devices

4.1* General. All flame effect materials and devices not connected for use shall be stored in accordance with applicable codes and standards and any state and local regulations.

4.2 Holding Areas. All flammable flame effect materials and loaded devices that have been removed from storage areas in anticipation of use shall be stored in a holding area acceptable to the authority having jurisdiction.

4.2.1 Quantity Limitations.

4.2.1.1 The maximum quantity of flammable flame effect materials and loaded devices stored in a holding area shall be that quantity used in one day.

4.2.1.2 Quantities of flammable flame effect materials and devices in excess of those used in one day shall be permitted to be stored in holding areas with the approval of the authority having jurisdiction.

4.2.2 Flammable flame effect materials and loaded devices in holding areas shall be secured or supervised continuously by an attendant trained in emergency response procedures.

Chapter 5 Permit and Approval Requirements and Terms of Installation

5.1 Permit Requirements.

5.1.1* Permit Required. Except when otherwise required by the jurisdiction, a use permit shall be required for the use of flame effects before an audience.

5.1.2* Terms of Installation.

5.1.2.1 Permanent Installation. An installation of flame effects for which the governing use permit has a duration longer than 180 days shall be considered a permanent installation.

5.1.2.2 Temporary Installation. An installation of flame effects for which the governing use permit has a duration of 180 days or less within a 12-month period in a single venue shall be considered a temporary installation.

5.1.3 Use Permits.

5.1.3.1 A use permit shall authorize the use of only the number and types of flame effects in the venue as specified in the flame effect plan, as described in Section 5.3.

5.1.3.2 Use permits shall have a specified expiration date.

5.1.3.2.1 Use permits for temporarily installed flame effects shall specify the date(s) and time(s) of use and the expiration date of the permit.

5.1.3.2.2 Use permits for permanently installed flame effects shall specify the duration and expiration date of the permit.

5.1.3.3 Any activity authorized by the use permit shall be conducted by the permittee or the permittee's agents or employees in compliance with all requirements of this standard applicable thereto and in accordance with the approved plans and conditions.

5.2 Approval Requirements.

5.2.1 Prior Approval Required. Other than during the flame effect demonstration, as described in Section 5.4, the use of all flame effects shall be first approved by the authority having jurisdiction.

5.2.2 Approval of Flame Effect Plan. A plan for the use of flame effects shall be submitted to the authority having jurisdiction for approval.

5.2.2.1 After a flame effect plan has been approved, the plan shall be maintained to be readily accessible at the venue and shall be subject to inspection as specified by the authority having jurisdiction.

5.2.2.2* If any addition or modification of flame effects to that described in the approved plan is made, that addition or modification shall be approved by the authority having jurisdiction prior to use of the modified flame effects.

5.3* Content of Flame Effect Plans.

5.3.1 Flame Effect Plan Requirements.

5.3.1.1 The plan for the use of flame effects shall be submitted in writing or other form acceptable to the authority having jurisdiction.

5.3.1.2 The plan shall include the following:

(1) The name of the person, group, or organization responsible for the production
(2) The dates and times of the production
(3) The location of the production
(4) The criteria in Annex B
(5) The flame effect classification
(6) A site plan showing the following:
  (a) A narrative description of the flame effect
  (b) The location of flame effect devices to be fired and their controls and control sequence
  (c) The area affected by the flame effect device
  (d) The location of the audience
  (e) The fuels used and their estimated consumption
  (f) Air for combustion and ventilation for indoor effects
  (g) Flammable materials piping
  (h) Storage and holding areas and their capacities
  (i) Supplemental fire protection features
  (j) Emergency response procedures
  (k) Means of egress
(7) A current material safety data sheet (MSDS) for the materials (fuels) consumed in the flame effect
(8) Documentation that the combustible materials used for construction of the flame effects have been rendered flame retardant
(9) The name of the effect operator

5.3.2 The operator shall make operating instructions for flame effects available to the authority having jurisdiction.

5.4 Flame Effect Demonstration.

5.4.1 When required, a walk-through and a representative demonstration of the flame effects shall be provided to the authority having jurisdiction before flame effects are approved.

5.4.2 The demonstration shall be scheduled with sufficient time to allow resetting of the flame effects prior to the arrival of the audience.

5.5 Interruption of Fire Protection and Life Safety Systems During Flame Effect Demonstrations and Operations. Fire protection and life safety systems shall not be permitted to be interrupted during the operation of flame effects.

5.5.1 Portions of fire protection and life safety systems shall be permitted to be interrupted during the operation of temporary indoor flame effects when the following conditions are met:

(1) Approval of the authority having jurisdiction is received.
(2) Approval of the owner or owner's agent is received.
(3)*An approved fire watch capable of directing the operation of all fire protection and life safety systems installed in the building is present.

5.5.2 Fire protection and life safety systems shall be permitted to be interrupted during the operation of permanently installed indoor flame effects only for initial acceptance of the system.

Chapter 6 Documentation of Flame Effects

6.1 General.

6.1.1 All flame effect devices and materials shall have drawings, manuals, or written descriptions to describe the type of item and performance specifications of the flame effect created.

6.1.2 This documentation shall be on site and available to the authority having jurisdiction.

6.2 Operating Procedures.

6.2.1 All flame effects shall have written operating instructions including start-up, show operations, normal shutdown procedures, and emergency shutdown procedures.

6.2.2 Operating instructions shall be available to the operator.

Chapter 7 Use of Flame Effects

7.1* Testing and Evaluation.

7.1.1 Flame effects shall be inspected on an interval acceptable to the authority having jurisdiction.

7.1.2 Flame effects shall be tested to verify that they operate in accordance with their designs.

7.1.3 Flame effects shall be evaluated to verify that operators, performers, and the audience are not exposed to a hazardous situation when the flame effects are activated as designed or anticipated.

7.2 Housekeeping. The premises where flame effect devices are installed or fired shall be maintained in a neat and orderly condition.

7.3 Site Inspection. The flame effect operator shall inspect all areas of the site where flame effect materials and devices are ignited before start-up and after shutdown.

7.4 Smoking.

7.4.1 Smoking shall be prohibited in the area where fuels used in flame effects are present.

7.4.2 Smoking by performers as part of the performance shall be permitted where approved by the authority having jurisdiction.

7.5 Rehearsal and Pre-Show Operations.

7.5.1 The flame effect operator shall advise all performers and support personnel that they are exposed to a potentially hazardous situation when performing or otherwise carrying out their responsibilities in the vicinity of a flame effect.

7.5.2 Performers and support personnel familiar and experienced with the flame effects being used shall be permitted to be in the area of a flame effect, but only voluntarily and in the performance of their duties.

7.6 Show Operations. Show operations shall be in accordance with the plan approved by the authority having jurisdiction.

7.7 Post-Show Operations. Post-show operations shall be in accordance with the plan approved by the authority having jurisdiction.

7.7.1 Fire and life safety systems that have been interrupted shall be restored immediately after completion of the flame effect.

7.7.2 When restoration of fire and life safety systems is necessary, it shall be conducted by a person trained in the operation of all aspects of the systems.

7.8 Maintenance. Flame effect systems shall be maintained to design specifications.

7.9 Emergency Operations. Emergency operations shall be in accordance with the plan approved by the authority having jurisdiction.

7.10 Protective Clothing.

7.10.1 The flame effect performers, operators, and assistants shall be protected by clothing or other means suitable for their exposure to flame effects.

7.10.2 Protective clothing requiring fire resistance shall be tested and demonstrated to be flame retardant, and documentation shall be furnished to the authority having jurisdiction upon request.

7.10.3 Bare skin (naked) shall be permitted when the illusion of danger is implicit in the visual effect desired by the performer.

7.11 Security.

7.11.1 A means shall be provided to render installed flame effect systems inoperative when not in use.

7.11.2 Portable flame effects shall be stored and secured when not in use.

Chapter 8 Flame Effect Operator

8.1* Operator Qualifications.

8.1.1 The operator of any flame effect shall understand and be familiar with the operating manual or instructions.

8.1.2 The operator shall demonstrate competency by experience and training or by holding a license acceptable to the authority having jurisdiction.

8.2 Operator Responsibilities. The flame effect operator shall be responsible for storage, setup, operations, and teardown of all flame effect materials, devices, equipment, systems, and supervision of assistants.

8.3 Substance Abuse and Safety. No person shall use or handle flame effect materials or devices under the influence of the following:

(1) Intoxicating beverages
(2) Narcotics or controlled substances
(3) Prescription drugs and/or nonprescription drugs that can impair judgment

8.4* Minimum Age. All flame effect operators shall be at least 21 years of age.

Chapter 9 System Components, Flame Effect Control Systems, and Design

9.1 General Requirements for Flame Effect Control System Design.

9.1.1 All flame effect control systems shall be designed and installed to prevent accidental firing and unintentional release of fuel.

9.1.2 All Group II through Group VII control systems shall be designed to ensure against accidental firing by providing at least a removable activator, keyswitch, or coded arming system in which no control power can be applied to any control system unless the operator intentionally does both of the following:

(1) Deliberately applies control power
(2) Enables or arms the control system

9.1.3 Control System Attendance Requirements.

9.1.3.1 Any Group III, Group VI, or Group VII flame effects control systems shall not be left unattended while connected to a fuel source.

9.1.3.2 Control systems that are disconnected from their power source or de-energized by means of a removable activator,

keyswitch, or coded arming system shall be permitted to be left unattended while connected to a fuel source.

9.1.4 Control System Operation.

9.1.4.1 All flame effect control systems shall be designed to implement the following functions:

(1) Emergency stop capability
(2) Fuel management
(3) Controlled enabling of flame effect
(4) Controlled arming of flame effect
(5) Controlled and repeatable firing of flame effect

9.1.4.2 The flame effect plan submitted for approval to the authority having jurisdiction shall indicate the means of providing for these requirements.

9.1.5 Flame effect control system components shall be listed.

9.1.5.1 Where listed devices are not available, approved devices shall be permitted.

9.1.6 Control system components and protective devices, including sensors, valves, and switches, shall be located so that they are protected against physical damage and tampering, and so they can be serviced and maintained.

9.2* Specific Requirements for Flame Effect Control System Design and Operation, by Group. Control systems for each flame effect group shall be in accordance with Table 9.2.

9.3 Implementation of the Required Control Functions.

9.3.1* Emergency Stop.

9.3.1.1 Flame effects shall not be used prior to one of the following conditions being met:

(1) Approval of a plan to extinguish the flame effect as required in 9.3.1.4
(2) Approval of a supervisory control system for the emergency stop and complete shutdown of the flame effect and any interrelated safety-critical system as required in 9.3.1.5

9.3.1.2 Interrelated safety-critical system and flame effect control system safety considerations shall extend to safety-critical effects, allied equipment, and other proximate equipment to avoid additional or contributory hazards.

9.3.1.3 Where the hazards described in 9.3.1.2 exist, the effects safety controller shall have a direct validated means of confirming the status or other information from the other systems before the safety-critical effect is enabled or triggered.

Table 9.2 Group Control Functions Required

Flame Effect Group	Control Type	Minimum Control Requirements
I	Manual controls	1. No automatic controls shall be required.
II	Automatic controls	1. Ignition supervision shall be provided. 2. Automatic shutoff shall follow failure.
III	Automatic controls	1. Manual operation of the effect valve shall be permitted. 2. If the operator cannot confirm the pilot or direct ignition source for the flame special effect, a primary safety control shall be installed. 3. Two fuel shutoff valves shall be provided, installed in series, one of which will be a safety shutoff valve.
IV	Automatic controls	1. Primary limit device(s) shall be installed as required. 2. A fuel supervisory station shall be installed with fuel pressure limit switches to control the supervisory station valves. 3. Each flame effect burner shall be equipped with a primary safety control and an effect valve. 4. A flame effect safety control system that is capable of safely operating the entire flame effect consistently for repeated cycles shall be used.
V	Automatic controls	1. The requirements for Group IV shall apply. 2. A flame effect safety control system that is capable of safely operating the entire flame effect consistently that is sequenced by the main control system shall be used. The flame effect safety control system shall maintain all of its internal safety features, with the interface between the flame effect control system and the main show control system limited to those commands and status indicators that cannot alter or override the flame supervisory system control logic.
VI	Automatic controls	1. The requirements for Group V shall apply. 2. Where cast members are in close proximity to the flame effect, the flame effect shall be under the active control of a main show control system and a fail-safe positive manual enable (PME).
VII	Manual or automatic controls	1. Controls shall be as recommended by the designer and acceptable to the authority having jurisdiction.

9.3.1.4 Manually controlled flame effects (Group I and manually controlled Group VII) shall have a plan for the emergency stop and complete shutdown of the operation of the effects through one or more of the following:

(1) Manual fuel shutoff valve(s)
(2) Manual turn-off of control power
(3) Fire containment devices
(4) Other devices acceptable to the authority having jurisdiction

9.3.1.5 Automatically controlled flame effects (Group II through Group VI and automatically controlled Group VII) shall have provisions for the emergency stop and complete shutdown of the operation of the effects installed according to the following criteria:

(1) The flame effect control system shall not be capable of operation unless the emergency stop is reset.
(2) The actuation of the emergency stop shall bring the flame effect control system to a safe state.
(3) The emergency stop shall require manual reset.
(4) The emergency stop shall actuate both manually and automatically upon the detection of an unsafe condition, including power failure.
(5) The emergency stop shall be fail-safe.
(6)*The emergency stop shall be automatically actuated when a monitored condition exceeds a preset limit of operation.

9.3.1.6 Manual Emergency Stop Control Stations.

9.3.1.6.1 Manually operated emergency stop control stations shall be clearly identified and placed in accessible locations and shall maintain the actuated state until manually reset.

9.3.1.6.2 Operation of a manual emergency stop station shall actuate the emergency stop.

9.3.2 Fuel Management.

9.3.2.1 The fuel supply for the operation of the flame effect shall be only available during operation.

9.3.2.2 Fuels not provided through a central distribution system and that are supplied to the flame effect shall be limited to that amount necessary for operation.

9.3.2.3 Minimum tank size for liquefied flammable gas flame effects shall be determined by the surface area required to prevent reduced fuel delivery to the burner during the effect.

9.3.2.4 Fuel Delivery.

9.3.2.4.1 Fuels delivered through a central distribution system shall be in accordance with the following:

(1) A manual fuel shutoff valve shall be installed as follows:
   (a) It shall be installed in an accessible location at the point of delivery and upstream of any other flame effect control system components that, when closed, will shut off all fuel supplied to the flame effect control system.
   (b) Where the point of delivery is outside a building containing the flame effect control system, the valve shall be located outside of the building.
(2) The following shall apply to fuel pressure:
   (a) Where low fuel pressure could cause the flame effect control system to malfunction, devices to provide low-pressure supervision shall be installed.
   (b) Where high fuel pressure could cause the flame system to malfunction, devices to provide high-fuel-pressure supervision shall be installed.
(3)*A supervisor station shall be installed and shall meet the following criteria:
   (a) It shall be installed downstream of the manual fuel shutoff valve.
   (b) It shall shut off all fuel supplied to the flame effect control system when closed.
   (c) When opened during the enable process, it shall be held open by a maintained signal from the flame effect control system.

9.3.2.4.2 The supervisor station shall be provided with a means to test the seat-tightness of the shutoff valve at the operating pressure.

9.3.2.5 Effect Valve.

9.3.2.5.1 Each flame effect shall be provided with an automatic fuel shutoff valve (the effect valve), installed upstream of the burner.

9.3.2.5.2 The effect valve shall shut off all fuel to the burner when closed.

9.3.2.5.3 The effect valve shall be opened only at the time of firing the flame effect and shall be held open by a maintained signal from the flame effect control system.

9.3.2.5.4 The effect valve shall close on loss of the hold-open signal.

9.3.2.6* Systems Using Fuel Accumulators. Fuel accumulators used in flame effect control systems shall meet the following requirements:

(1) Accumulator tanks shall be designed, manufactured, and certified as unfired pressure vessels.
   (a)*Accumulators for use with flammable or liquefied gas shall be designed, manufactured, and tested in accordance with ASME *Boiler Pressure Vessel Code* or the Department of Transportation for the pressure of the gas in use.
(2)*The volume of fuel stored in an accumulator tank shall be no more than what is required to produce the desired flame effect.
(3) Each accumulator shall have a manual fuel shutoff valve at the connection to the inlet of the tank, and when closed, this valve shall shut off all fuel supplied to the accumulator tank.
(4) An accumulator charge valve that charges the accumulator when opened shall be installed at the connection to the inlet of the tank.
(5) The accumulator shall be charged as close to the time of the actual arming and firing of the effect as is practical.
(6) Each accumulator shall be designed and installed so that the fuel can be safely removed, as follows:
   (a) Accumulators fixed in location shall be provided with a permanently installed means of conveying the fuel to a safe point of discharge.
   (b) Portable accumulators shall be allowed to be moved to a safe location for discharge.
(7) The mixing of air or any other oxidizing media with fuel that creates a flammable mixture within an accumulator tank shall be prohibited.

9.3.3* Controlled Enabling of Flame Effect Control System. All flame effect control systems shall be manually or automatically enabled according to a prescribed sequence of operations outlined in the plan, which prepares the flame effect for subsequent arming and firing.

9.3.3.1 Flame Effect Safety Controller Function.

9.3.3.1.1 A flame effect safety controller shall be used to automatically sequence the enable process, monitor areas of restricted access, and allow, trigger, and request safety-critical action.

9.3.3.1.2 Flame effect control system safety considerations shall extend to other safety-critical effects, allied equipment, and other proximate equipment to avoid additional or contributory hazards.

9.3.3.1.3 In circumstances described in 9.3.3.1.2, the flame effect safety controller shall have a direct validated means of confirming the status or other information from the other systems before the flame effect is enabled.

9.3.3.2* The enable process shall begin with the activation of the control power to the flame effect control system.

9.3.3.3 Fuel Supply and Auxiliary Services.

9.3.3.3.1 Following the activation of the control power, the fuel supply and auxiliary services necessary to the operation of the flame effect control system (compressed air supply, oxidizers, additives, etc.) shall be permitted to be turned on.

9.3.3.3.2 Positive confirmation through the use of an interlock or other device of the fuel supply and each auxiliary service shall be made prior to the continuation of the enable process.

9.3.3.4* Interlocks.

9.3.3.4.1 Interlocks shall be provided in the control system to monitor changes of condition and to automatically implement control system responses to the change of condition.

9.3.3.4.2 Safety interlocks shall be fail-safe.

9.3.4 Controlled Arming of Effect.

9.3.4.1 All flame effects shall be manually or automatically armed prior to any attempt to fire.

9.3.4.2 The arming of the effect shall be manually or automatically monitored and confirmed until the effect is fired.

9.3.4.3 Manual Confirmation of Arming (Group I and Manually Controlled Group VII).

9.3.4.3.1 The flame effect shall be confirmed as armed when the means of ignition can be clearly and directly seen by the operator or assistant(s) firing the flame effect for the entire time that the effect is enabled.

9.3.4.3.2 When the means of ignition cannot be clearly and directly seen by the operator or assistant(s) firing the flame effect for the entire time that the effect is enabled, the confirmation of the arming of that effect shall be done automatically.

9.3.4.4* Automatic Confirmation of Arming (Group II through Group VI and Automatically Controlled Group VII). The flame effect shall be confirmed as armed when a sensor(s) has detected the presence of the means of ignition necessary for the correct operation of the effect through the monitoring of a characteristic unique to the means of ignition.

9.3.4.5 Control sensors and devices used to automatically confirm arming shall operate in the environment where installed.

9.3.4.6 Where cast members or moving set pieces are present in the hazard area immediately before or after the arming and firing of the flame effect, a positive manual enable (PME) shall be required during arming and firing.

9.3.4.7 Ignition Detection Device Function.

9.3.4.7.1 It shall not be possible for an ignition detection device to report the presence of an ignition device or pilot, due to false sensing of ignition devices, pilots, or flame effects other than that ignition device or pilot intended to be sensed by the ignition detection device.

9.3.4.7.2 It also shall not be possible for an ignition detection device to report the presence of an ignition device or pilot due to false sensing of other non-fire-related devices normally present in the local environment including, but not limited to, spark effects, ultraviolet light sources, or effects that generate heat without flame.

9.3.5* Firing of Flame Effects.

9.3.5.1 Flame effects shall only be fired after they have been confirmed as armed following the completion of the enable and arming process and confirmation that the hazard area is clear.

9.3.5.2 If the arming confirmation is lost during the firing process or the hazard area becomes unsafe, the firing of the effect shall be immediately terminated and the effect secured until the problem has been corrected.

9.3.5.3* Monitoring of the Hazard Area Surrounding the Flame Effect.

9.3.5.3.1 That area surrounding each flame effect that is made hazardous by the operation of the effect shall be monitored and confirmed clear and ready for firing, or access to the area shall be supervised by automatic means, or the area shall be made inaccessible, prior to any attempt to fire the effect.

9.3.5.3.2 Other parameters critical to the safety of the flame effect shall also be monitored or supervised.

9.3.5.4* Supervision of the Hazard Area Surrounding the Flame Effect.

9.3.5.4.1 The accessible hazard area shall be under the direct observation of the operator or assistant(s) firing the flame effect for the entire time that the effect is enabled and fired.

9.3.5.4.2 Where the hazard area cannot be seen by the operator or assistant(s) firing the flame effect for the entire time that the effect is enabled, an alternative means of monitoring the area shall be permitted to be used, with the approval of the authority having jurisdiction.

9.3.5.4.3 Use of Enable Buttons.

9.3.5.4.3.1 If all areas of safety concern cannot be seen by a single human operator, as many enable buttons shall be used as are necessary to ensure safety.

9.3.5.4.3.2 Such buttons shall be monitored separately and verified for proper operation by the flame effect control system.

9.3.5.5 Firing. The design of the flame effect control system shall prevent the firing of any flame effect except on the deliberate positive action of an operator or on the verification by the automatic control system of correct enabling and arming of the effect.

9.3.5.5.1 Manual Firing of Flame Effects. It shall be the responsibility of the operator to verify the correct enabling and arming and the safety of the hazard area prior to the manual firing of the effect.

9.3.5.5.2 Automatic Firing of Flame Effects.

9.3.5.5.2.1 The operating power for firing any flame effect shall originate from the flame effect control system and only be supplied under the supervision of all limits, interlocks, and ignition-monitoring devices present for the safe and reliable operation of the flame effect.

9.3.5.5.2.2 All effect valves shall be permitted to be opened only by a maintained firing signal from the flame effect control system and shall automatically close on loss of signal.

9.3.6 Post-Operation Securing. Immediately following the firing of any flame effect, the enable and arming signals shall be removed, all fuel and auxiliary services shall be secured without going through the sequence of operation specified in 9.3.5.5, and a visual inspection of all effect hazard areas shall be completed prior to confirmation that the flame effect control system is secure.

Chapter 10 System Installation and Testing

10.1 General.

10.1.1 Flame effects shall be tested to verify that they operate in accordance with the flame effect control system design.

10.1.2 Documentation of the testing shall be provided by the manufacturer or fabricator.

10.2 Pressure Testing and Inspection of Piping. Where flame effect systems use piping, such piping shall be pressure tested in accordance with the requirements of the authority having jurisdiction.

10.2.1 The complete piping system with all accessories in place shall be pressure tested at no less than the system operating pressure.

10.2.2 Pressure Test Procedures.

10.2.2.1 System pressures shall be recorded together with the temperature and the atmospheric pressure.

10.2.2.2 Pressure testing of reassembled flame effect piping systems designed to be separated into subassemblies shall be permitted to be tested at system operating pressure, with leak detection using a noncorrosive leak detecting solution, or other means acceptable to the authority having jurisdiction, at the reconnected joints.

10.3 Temperatures of Components.

10.3.1 Temperatures of components that are used in the fabrication of a flame effect control system shall not exceed the rated temperature limits of the component during sustained operation of the flame effect.

10.3.2 Temperatures of components subject to the heat of the flame effect shall be determined while the flame effect is being operated at its maximum design cycle rate during the acceptance test required by Section 10.1.

10.3.2.1 The temperatures shall be observed until a maximum or stable reading has been attained.

10.3.2.2 The temperatures attained shall not exceed the rated temperatures for the components.

10.3.3 Temperatures of Surroundings.

10.3.3.1 Temperatures of combustible materials subject to the heat of the flame effect shall not exceed 117°F (47.2°C) above the ambient temperature after equilibrium temperatures are attained.

10.3.3.2 The temperatures shall be observed until a maximum or stable reading has been attained.

Chapter 11 Fire Protection Provisions

11.1 General. The wide range in size, arrangement, and location of flame effects covered by this standard shall preclude the inclusion of detailed fire protection provisions that are applicable to all flame effects.

11.2 Evaluation for Permanently Installed Flame Effects.

11.2.1* Where required by the authority having jurisdiction, a fire hazards evaluation shall be conducted for permanently installed flame effects to be used at a venue for a performance.

11.2.2 The evaluation in 11.2.1 shall be coordinated with the building owner, the flame effect operator, and the authority having jurisdiction.

11.3* Additional Fire Safety Provisions for Temporary Installations.

11.3.1 Where determined by the authority having jurisdiction that a need for fixed or additional fire protection equipment or standby fire safety personnel exists, such equipment or personnel shall be provided.

11.3.2 Four or more fire extinguishers of the proper classification and size as approved by the authority having jurisdiction shall be readily accessible while the flame effects performance is being conducted.

11.3.2.1 In all cases, at least two pressurized water, Class 2-A, extinguishers and two Class 10-BC extinguishers shall be provided, in addition to those required by NFPA 10, *Standard for Portable Fire Extinguishers*, for the building.

11.3.2.2 The extinguishers shall be placed so that at least one each is located on opposing sides of the performance where flame effects are used.

11.4 Standby Fire Safety Personnel Requirements.

11.4.1 Where required by the fire hazards evaluation or the authority having jurisdiction, standby fire safety personnel shall be present along with operational supplemental equipment.

11.4.2 Standby fire safety personnel shall have a working knowledge of the supplemental fixed or portable fire-fighting equipment used in the area of the flame effects.

11.4.3 Standby fire safety personnel shall have a means of communication or of transmitting an alarm during the operation of flame effects.

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.1.1 This document details how to control the use of flame effects. The issue of permitting or prohibiting the use of open flames before an audience is in the scope of a code such as NFPA *101*, *Life Safety Code*. The *Life Safety Code* has traditionally prohibited open flames within assembly occupancies.

A.1.3.1 The circumstances of each show or attraction can be unique and can require individual evaluation when determining the need for protective systems. Factors such as the experience and qualifications of the operations and maintenance personnel, clearance distance between show elements and nonparticipants, visual conditions, and magnitude of the potential hazards are to be weighed in the development and presentation of the production.

A.1.3.3(2) For information on the use of pyrotechnic special effects before an audience, see NFPA 1126, *Standard for the Use of Pyrotechnics before a Proximate Audience*.

A.1.3.3(3) For information on the storage of flammable and combustible liquids, see NFPA 30, *Flammable and Combustible Liquids Code*. For information on the storage of flammable gases, see NFPA 55, *Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks*, and NFPA 58, *Liquefied Petroleum Gas Code*.

A.1.3.3(6) For information on the manufacture, transportation, or storage of model or high-power rocket motors, see NFPA 1125, *Code for the Manufacture of Model Rocket and High Power Rocket Motors*. For information on the sale or use of model or high-power rocket motors, see NFPA 1122, *Code for Model Rocketry*, and NFPA 1127, *Code for High Power Rocketry*.

A.1.3.4 This standard contains user requirements for the performance, use, or installation of flame effects. User requirements are those that apply to users of the product and specify when/where/how a product is used.

Unlike this standard, a product standard contains performance, testing, and third-party certification requirements, and can contain design requirements, for a specific product, such as a flame effect appliance. Third-party certification includes the requirements for the testing, labeling, listing, follow-up, and quality assurance programs by which a product is certified as being compliant with a specific standard from a certification organization. Product standards should be written, to the extent possible, such that the product is evaluated and tested for compliance with minimal or no judgmental decisions and with specific pass/fail requirements and a designated test method to evaluate the performance. NFPA 160 does not meet these requirements, nor is it intended for use as a product standard.

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.

A.3.3.3 Arm. In a manually operated system, the enabling, arming, and firing functions are provided directly through the actions of the flame effect operator or assistant. *Arm* means supplying a source of ignition and verifying its presence; such as manual ignition of a pilot, flammable liquid, or flammable solid.

A.3.3.7 Enable. In a manually operated system, the enabling, arming, and firing functions are provided directly through the actions of the flame effects operator or assistant. *Enable* means bringing to the site all the equipment, setting it up, and readying it for arming; such as bringing a campfire effect to the stage, verifying that no hazards are present in the area, and connecting all components.

A.3.3.10 Fire. In a manually operated system, the enabling, arming, and firing functions are provided directly through the actions of the flame effect operator or assistant. *Fire* means supplying fuel to the source of ignition, such as by manually opening a valve and verifying that the fuel ignites.

A.3.3.18 Flame Effect System. Manually controlled systems might not have interconnected components, devices, and/or appliances that provide all of the functions necessary to fuel, monitor, supervise, generate, and control flame effects, including the emergency shutdown of the flame effects and, where necessary, the monitoring of external conditions that affect operation. The flame effects operator or assistant carries out all the functions described in the definition.

A.3.3.19 Flame Effect Systems, Classifications. Examples of flame effects are as follows:

(1) *Group I.* Hand-held burning torches, cigarette lighters, candles, matches, and lighting paper in an ashtray, jugglers burning batons, fire rings that are jumped through, and other fire effects that have the illusion of danger to a performer.
(2) *Group II.* Unattended torches, burning urns, and small fires.
(3) *Group III.* Effects used by traveling shows and concerts and effects used for limited-duration special events, such as the Olympics. This group also includes a traveling entertainment event that plays various venues, such as (but not limited to) circus, opera, musicals, stage plays, trade shows, or corporate events. This group effect also includes a nontraveling entertainment event that plays a single venue.
(4) *Group IV.* A burning cabin or bonfire and large single or multiple flaming brazier entrance features used to create a "theme" atmosphere. A stand-alone-type flame effect control system without any significant control supervision by a main show control system is used.
(5) *Group V.* A simulated building or vehicle explosion that is part of a larger theme-type attraction. The flame effect control system is totally dedicated to the operation of the flame effect elements. The flame effect control system maintains all its internal safety features, with the interface between the flame effect control system and the main show control system limited to those commands and status indicators that cannot alter or override the flame supervisory system control logic.
(6) *Group VI.* A live-action stunt show that is part of a larger theme-type attraction. The flame effect control system is totally dedicated to the operation of the flame effect elements. The flame effect control system maintains all its internal safety features, with the interface between the flame effect control system and the main show control system limited to those commands and status indicators that cannot alter or override the flame supervisory system control logic.
(7) *Group VII.* A fire created as part of an illusion used to make an item or individual disappear.

See Table A.3.3.19 for a list of features included in each flame effect group.

A.3.3.23 Primary Safety Control. In the event of ignition failure or loss of flame, the control causes a safety shutdown.

A.3.3.26 Safety Shutdown (Lockout). The flame effect can be restarted only after a manual reset following correction of the abnormal condition.

A.3.3.29 Supervisory Control System. In the case of a manual system, this function might be performed by the flame effect operator or assistant.

A.3.3.31 Venue. The term *venue* is one that is widely used in the entertainment industry. For the purposes of this standard, the term is to be used to specify the exact area of the property, building, or the room within a building where the use of flame effects is to be allowed. For example, the use of flame effects can be allowable in one specific meeting room of a hotel, but not in another; or in the case of reconfigurable (flexible plan) buildings or rooms, some configurations can be safe for the use of flame effects, but not others.

Table A.3.3.19 Features Included in Flame Effect Groups

	Flame Effect Groups						
Features	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**
Outside	X	X	X	X	X	X	X
Inside	X		X	X	X	X	X
Temporary installation	X	X	X		X	X	X
Permanent installation		X		X	X	X	X
Attended	X		X			X	X
Unattended		X		X	X		X
Visual flame verification	X		X				X
Automatic flame supervision		X		X	X	X	X
Manual fuel controls	X						X
Automatic fuel controls		X	X	X	X	X	X
Main show control					X	X	
Proximate cast			X			X	X

Note: A blank space means that the feature cannot be in the group. An X means that it is a feature of the group.

A.4.1 The following NFPA standards cover storage of flame effect materials:

NFPA 30, *Flammable and Combustible Liquids Code*

NFPA 54, *National Fuel Gas Code*

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

NFPA 58, *Liquefied Petroleum Gas Code*

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

NFPA *101*, *Life Safety Code*

NFPA 430, *Code for the Storage of Liquid and Solid Oxidizers*

NFPA 1126, *Standard for the Use of Pyrotechnics before a Proximate Audience*

A.5.1.1 Because permit and approval requirements vary with each jurisdiction, this standard is intended to provide requirements that can be used by the authority having jurisdiction in making sound judgment regarding the safety of the proposed use of flame effects and the qualifications of the flame effect operator.

A.5.1.2 The use of flame effects is governed by a permit, which specifies the date(s) and time(s) or the expiration date of the permit, which, in turn, define the period during which the effects can be used. The length of this period determines the term of installation — that is, whether the flame effect installation is to be considered permanent or temporary. The term of installation is used in this standard as a criterion to classify the flame effects into one of seven groups.

A.5.2.2.2 There is an inherent danger in the modification of flame effects once the initial commissioning activities are complete. A protective control system could provide protection against events and safety concerns that are not recognized or fully understood by other than the original designers of the system. For others to attempt modifications to a protective system invites the inadvertent elimination of subtle but important safety features of a system.

A.5.3 Measures for control of inadvertent liquefied or gaseous fuel releases, additive system releases, portable component releases, or fire should be coordinated with local emergency-handling agencies, such as fire and police departments.

Information on those hazards not commonly covered in the training programs of emergency-handling agencies should be provided upon request to emergency responders.

The safety of emergency personnel should be considered in the plan.

A.5.5.1(3) A fire watch is a qualified person or persons in attendance during all times when fixed fire protection systems are intentionally taken out of operation and should be acceptable to the authority having jurisdiction. The fire watch should be familiar with the operation of all fire and life safety systems in the building and be able to notify emergency responders.

A.7.1 An audience should be located so that the incident thermal radiation received does not exceed that calculated by the following equation:

$$t = \left(\frac{35}{q} \right)^{1.33}$$

where:
t = time in seconds
q = incident thermal flux in kW/m^2

The value of q can also be taken from Figure A.7.1.

When applying the preceding equation to an effect with a duration of 4 seconds or less, the time used in calculating the maximum acceptable level of incident thermal flux should correspond to the root mean square (RMS) value of the peak incident thermal flux.

The incident radiation should not cause the surface temperature of the exposed skin of a member of the audience to exceed 111°F (44°C). Incident radiation can be measured with a radiometer. Skin temperature can be measured with an infrared surface thermometer or other equivalent means.

Calibrated tinder techniques can be used for measurement of continuous effects.

A.8.1 There is no substitute for a diligent, capable, well-trained operations and maintenance staff; therefore, operators of equipment involved in safety-critical processes or effects are the primary safety and control element and should have a full understanding of the system including the possible dangers and the required responses.

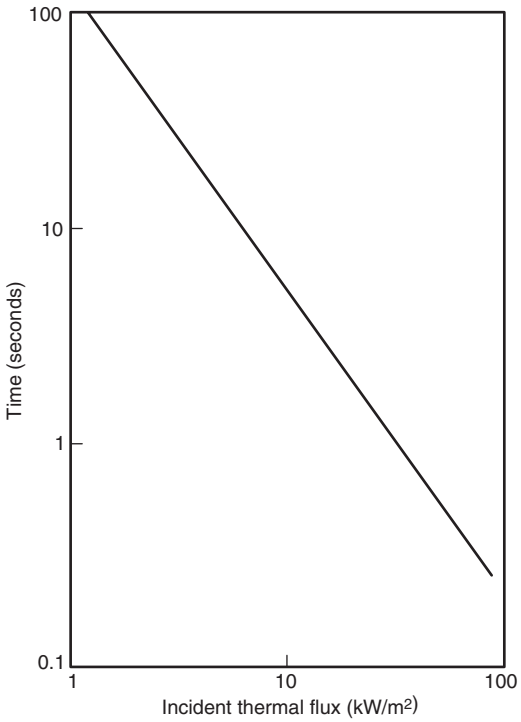


FIGURE A.7.1 Time Required for Pain Due to Exposure to Thermal Radiation.

A.8.4 The flame effect operator is defined as the person who has overall responsibility for the flame effect. Attendants and assistants can be less than 21 years of age.

A.9.2 In Table 9.2, Group VI, positive manual enable (PME) is sometimes known as "Man in the Loop."

A.9.3.1 Enabling the safety-critical effect could require coordination of the emergency stop systems of independent subsystems developed by separate vendors or contractors. This requirement applies only when an emergency stop button is pressed. Generally, conditions internal or local to a single subsystem (other than pressing an emergency stop button) that cause an automatic safety shutdown of one subsystem need not cause a shutdown of other subsystems. After a safety shutdown resulting from a pressed emergency stop button, and after the offending button has been reset, individual subsystems can be brought out of the shutdown condition, as long as no emergency stop button remains pressed.

A.9.3.1.5(6) Examples of monitored conditions are as follows:

(1) Loss of purge airflow to electrical enclosures in classified areas
(2) Loss or impairment of required ventilation systems
(3) Detection of flammable gas
(4) Loss of "proof of vacancy" in areas that present a serious hazard to personnel
(5) Loss of proof of the safe state of any valve or other protective device that is required to maintain the protective nature of the system
(6) Detection of a person in an unsafe area
(7) Detection of unsafe environmental conditions
(8) Detection of equipment in an unsafe state, condition, or position

(9) Wind or other weather conditions that create unsafe conditions
(10) System errors that should be addressed or acknowledged prior to a restart of the system

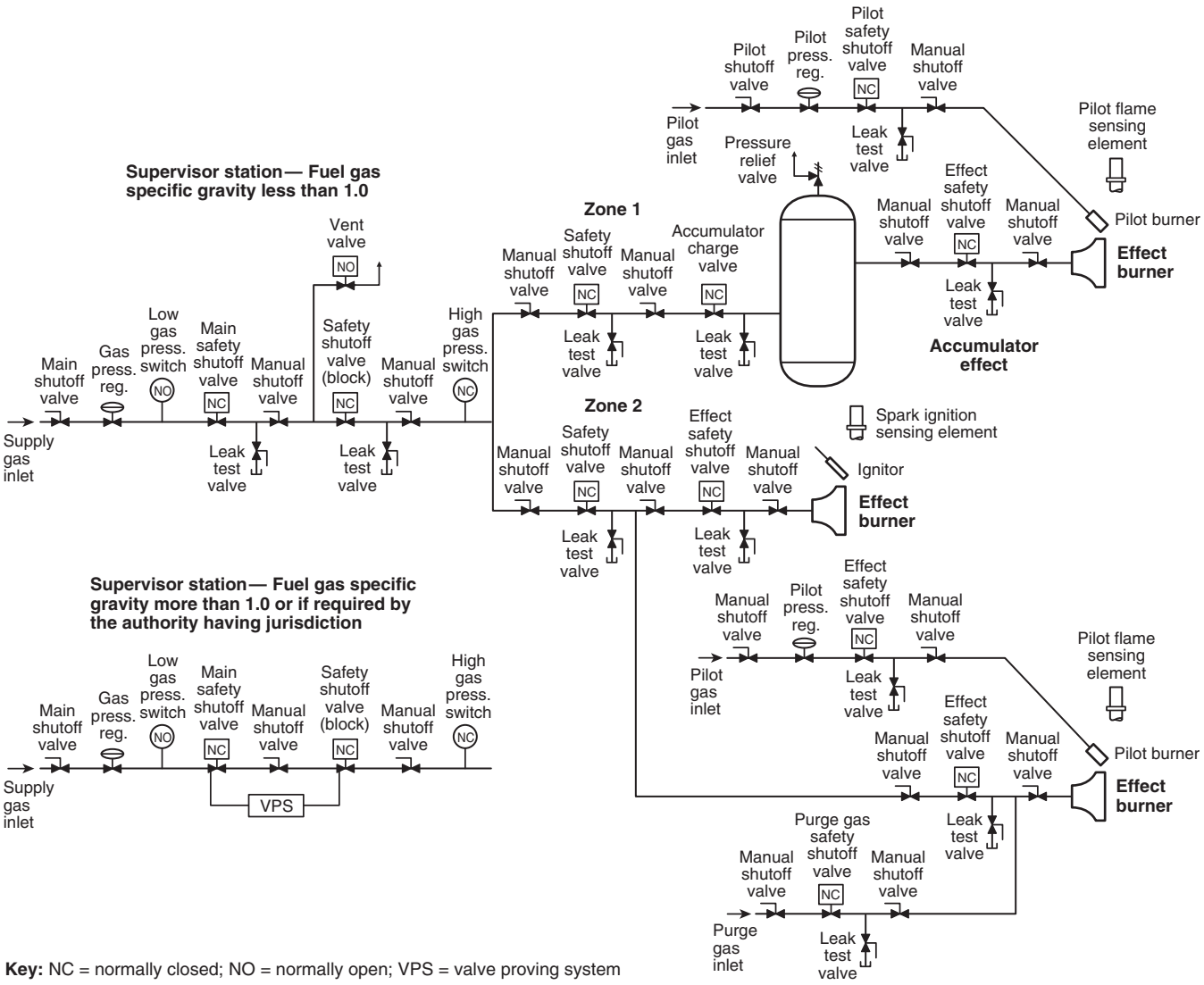
A.9.3.2.4.1(3) As shown in Figure A.9.3.2.4.1(3), an example of a supervisor station can include the following:

(1) Two safety valves in series, each with proof of closure, should be provided in the gas line to the main burners. An automatic vent valve should be provided between the two valves.
(2) Where the automatic vent valve is prohibited by the authority having jurisdiction, two safety shutoff valves in series, each with an interlock switch, supervised by a listed automatic valve proving system should be provided in the gas line to the burners. Valve proving should be performed either after every burner shutdown or prior to every burner light-off.
(3) Where flame effect fuel piping systems are subdivided into zones, each zone should be separated from other zones by a zone station. A zone station should consist of a manual fuel shutoff valve at the point of connection to the fuel supply piping and upstream of any other station components, and an automatic zone valve. The zone station shuts all fuel to or from the flame effect zone when closed. When opened during the enable process, this station should be held open by a maintained signal from the flame effect control system.

The zone valve should automatically close in the event of the loss of the hold-open signal. The zone valve should only be opened as close to the time of the actual arming and firing of the flame effects as is practical. The zone valve should be provided with a means to test the seat-tightness of the valve at operating pressure.

A.9.3.2.6 The operating characteristics of some flame effects require that fuel be released at a rate greater than can be delivered by the fuel supply. To do so requires that quantities of fuel be temporarily accumulated at the location of the effect.

A.9.3.2.6(1)(a) For applications outside of the United States, equivalent national standards can be used.



Key: NC = normally closed; NO = normally open; VPS = valve proving system

FIGURE A.9.3.2.4.1(3) Example of Various Flame Effect Control and Piping Components.

A.9.3.2.6(2) The standard requires that the amount of fuel in an accumulator tank never be more than what is required to produce the effect. However, that amount deserves some consideration, as producing the desired effect can sometimes require that more fuel be stored in the accumulator than is actually discharged during the effect. Three examples of situations where it is necessary to store more fuel in the accumulator than is actually consumed are as follows:

(1) The creation of perfectly round fireballs — those without a tail — often requires that the effect valve be shut while the gas is still exiting the burner nozzle at relatively high velocity. This means that significant residual pressure is left in the accumulator after the effect is complete; in other words, to produce round fireballs it is required to have an amount of fuel in the accumulator in excess of that consumed.
(2) Bursts of multiple fireballs or jet flames are often required to be produced rapidly, sometimes without sufficient interval between each discharge to allow the accumulator to recharge. This situation occurs often in temporarily installed or portable flame effect appliances, particularly when the fuel supply is not capable of supporting high flow rates during the charge cycle. In this case, the accumulator must store more fuel than is consumed in a single discharge, although it is expected that the bulk of the fuel will be consumed over the course of a full burst.
(3) It is considered good practice to maintain a fuel-rich atmosphere inside the accumulator at all times, one that is well above the upper flammable limit. In order to do so it is necessary to shut the effect valve before all of the pressure in the accumulator is exhausted, trapping some fuel in the accumulator in excess of the amount consumed.

It is important to realize that even when an accumulator is sized exactly to the amount of fuel to be consumed, there are some situations where the accumulator will be left with an excess of fuel. Take, for example, an accumulator that has been charged, but for any number of reasons — performer off the mark, detected failure of the igniter, and so forth — the flame effect is not discharged. The result is a fully charged accumulator that can or cannot be consumed during the subsequent course of the performance. This scenario points out the necessity of providing each accumulator with a means of venting the fuel to a safe point of discharge, as required in 9.3.2.6(6).

A.9.3.3 Some of the operating parameters that can be enabled or monitored during the enabling of the flame effect control system include the following:

(1) Control power
(2) Main fuel supply
(3) Safety interlocks
(4) Ventilation airflow interlock (where used)
(5) Support services (compressed air, hydraulic pressure, etc.)
(6) Other parameters as required by the authority having jurisdiction

A.9.3.3.2 Where required for operation and maintenance, control systems can have separate sources of control power to allow operation in distinct modes; for example, they can have one source for automatic (normal) operation and a second for limited operation of the flame effects for the purpose of maintenance and testing. Where multiple sources of control power are available, the design of the flame effect control system should meet the following minimum criteria:

(1) One mode of operation should be "off," which should remove all control power from the flame effect control system.
(2) System operation should be such that the selection of one mode of operation disables all other modes of operation. It should not be possible to change from one mode of operation to another without turning all control power off. The flame effect control system should operate safely during the transition from one mode to any other mode of operation.
(3) All control power, regardless of source and mode of operation, should be interrupted by actuation of the emergency stop system. Loss of control power should bring the flame effect system to a safe state.
(4) When a main show control system is used, the status of the control power (mode of operation) should be automatically sent to the show control system at all times. Where a main show control system is used, and the mode of operation is in any mode other than that of normal automatic operation, or "off," the sending of any command from the show control system to the flame effect control system should automatically actuate the emergency stop system and bring the flame effect system to a safe state.

Circumstances for consideration include the following:

(1) Particular position, mode, or state for the proper operation of a safety-critical system.
Example: A fire-breathing dragon that needs to be in a particular position before fire is initiated.
Similarly, other set pieces might have to be out of the area of the fire before fire is initiated.
Example: A fire on a set that is on a lift that is not to be initiated until the lift is confirmed to be in the fully raised position.
(2) Effects on vision or hearing that could prevent the safe operation of systems or the related procedures or operations.
Example: A fog or other atmospheric effects system that could obscure egress routes or interfere with monitoring an effect fire or with taking corrective action in case of an incident.
(3) Conditions that can be confused with conditions or events of the safety-critical system.
Example: Other effect systems that create the appearance of fire, smoke, or heat.

Personal computers, single-board controllers, and other systems that have control capability but that are not routinely used in protective applications should not be used as life safety controllers. Only effect safety controllers should be used to prevent any safety-critical action. Non-effect safety controllers should not be used to allow, trigger, or request safety-critical action unless the signals of these non-effect safety controllers are intercepted and qualified by an effect safety controller that has responsibility for allowing safety-critical actions. Personal computers and single-board controllers can be used in related applications such as the display, logging, and trending of process variables, environmental conditions, status, faults, and other information.

Show controllers, including stage, lighting, pyrotechnics, animation, automation, and audio controllers that are used to control overall show timing relationships or that provide synchronization with audio, lighting, and unrelated effects, should be permitted to provide timing information to a flame effect safety controller but should not directly control safety-critical processes. The flame effect safety protective controller then should use this information, and other safety-related information, to control safety-critical effects.

The flame effect control system that is responsible for control of safety-critical effects should not provide control of general show timing or of non-safety-critical effects, except as follows:

(1) Timing internal to a single effect, such as to create phases or sub-effects, should be permitted to be programmed into the flame effect control system.
(2) The protective flame effect control system should be permitted to provide control of a limited number of small non-safety-critical effects with limited and simple timing needs. In such cases, there should be a division of the safety-critical and non-safety-critical functions of the system.

The purpose of the requirement in 9.3.3.2 is to prevent equipment that is being used for protective control purposes from being utilized for general show control purposes when doing so would partially obscure the protective control purpose of the system, distracting the designers and operators from devoting attention to the safety-critical aspects of the system, which are of primary concern.

A.9.3.3.4 Examples of interlocks that can be included in the flame effect control systems are as follows:

(1) Wind speed and direction
(2) Critical temperatures
(3) Opacity instrumentation
(4) Purge airflow and/or damper positions
(5) Combustion airflow
(6) Position indicator switches for animated figures and sets
(7) Cast position confirmation switches
(8) Audience position/ride vehicle position indicators
(9) Others as required by the operation of the show

A.9.3.4.4 Some of the sensors that are currently in use for monitoring these characteristics are as follows:

(1) Ultraviolet flame detector in combination with a listed primary safety control
(2) Infrared flame detector in combination with a listed primary safety control
(3) Flame rod in combination with a listed primary safety control
(4) Thermocouple temperature sensor in combination with a listed primary safety control or as part of a listed automatic valve assembly
(5) Other devices directly sensitive to the characteristics of the means of ignition and acceptable to the authority having jurisdiction

A.9.3.5 The firing of the flame effect is normally achieved through the release of the fuel into ambient air where the mixture is ignited by an ignition device. Normally, this is achieved by the opening of a manual or electrically actuated fuel release valve. Other methods of fuel release are acceptable on the approval of the local authority. Examples of firing methods for flame effects are as follows:

(1) Manual firing by cast member or technician
(2) Firing by a timer and/or programmable logic controller (PLC)
(3) Firing by a PLC with PME

A.9.3.5.3 Certain venues can have areas, both visible to and out of sight of the technical director, in which a person who is present in the area during the firing of the effects might be exposed to the possibility of injury. These areas should be supervised by an intrusion monitor and alarm system during all times when the effects are enabled.

A.9.3.5.4 Certain venues can have areas, both visible to and out of sight of the technical director, where during the enable process one of the following can occur:

(1) Cast members can be present immediately before or after the firing of the effect.
(2) Members of the audience might enter the area during the firing of the effect.
(3) Moving set pieces can affect the safe operation of the effect.

A PME of the flame effect control system should be maintained by a qualified operator with a clear view of the operating area of the effect during the entire process of the enabling, arming, and firing of the effect.

Where the technical director does not have a clear view of the hazard area, additional PME devices should be installed and operated by qualified operators who are in such a position that they have a clear view of the area. Cast members who can be present immediately before the arming and firing of the effect should have additional PME devices that have to be actuated before the flame effect can be fired.

These PME devices should have the following characteristics:

(1) The PME device should consist of a momentary contact push button switch that will close a normally open isolated contact when depressed, thereby sending a confirming signal to show control.
(2) These enable operators should be located in positions such that the technician or cast member can view the effects area and/or confirm that they are safely out of harm's way.
(3) Manual enable operators should be clearly identified as to function. Indicator lights can be provided in the push button or adjacent to the push button to confirm to the operator that the enable signal has been sent to show control.
(4) In the event that any PME signal is not sent or is removed during the arming and firing sequence of an effect, a non-recycling shutdown of that effect or group of effects should occur. The effects can be returned to service only following the removal of the effect enable input and restarting the process. Other flame effects and show elements can continue to operate normally for the remainder of the show.

Repetitive protective operations by human operators are of limited value due to the acclimatization of the operator. When repetitive enabling of an effect is required, appropriate steps should be taken to assure that the operator remains alert for every action.

Although each situation is different and multiple remedies could be required in some situations, steps that can be used to address this concern include the following:

(1) Use two individually monitored buttons, each serving the same enabling function, separated by a distance such that the operator has to be facing the area of safety concern when the buttons are pressed.
(2) Activate the buttons upon an indication in the vicinity of the area of safety concern. For example, rather than illuminating the enable buttons, illuminate an indicator near the flame so that the operator will be encouraged to look in the direction of the flame to determine when to press the enable button.
(3) Vary the timing of the effect to the extent possible within the creative constraints of the show.

A.11.2.1 The following steps are recommended as part of the fire hazards evaluation procedure:

(1) List and describe the following:
   (a) Sources of ignition
   (b) Spread of fire
   (c) Potential duration of fire
   (d) Smoke generation
   (e) Potential collection or drift of flammable vapors and gases
   (f) Exposure of personnel to decomposition products
   (g) The time required for emergency evacuation of the audience
   (h) Extinguishment potential of supplemental standby fire equipment
   (i) The additional fire load from the flame effect
   (j) Existing building fire protection systems
   (k) Other factors specific to the flame effect
(2) Prepare a general description of the fire prevention and fire protection systems that exist and that will be provided. Define the fire hazards that can exist and state the loss-limiting criteria to be used in the design of the flame effect.
(3) Conduct an exposure analysis to determine safe distances of the flame effect from adjacent facilities. Consider the use and effect of noncombustible fire-retardant and heat-resistant materials.
(4) Review and describe the control and operating room areas, if applicable, and the detection and extinguishing systems that will be provided for these areas.

A.11.3 Supplemental fire protection equipment can consist of charged handlines, hand portable extinguishers, wheeled extinguishers, pre-engineered or engineered systems capable of properly extinguishing the flame effect, and any combustible materials within the immediate area. The manufacturer of the equipment should be consulted for assistance on fire extinguishing equipment and agents.

Annex B Design of Flame Effects

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

B.1 Design Plan. The design plan for flame effects should be based on the criteria outlined in B.1.1 through B.1.2.

B.1.1 Location.

B.1.1.1 The design plan for outdoor flame effects should include the following:

(1) Weather (e.g., wind), with safety provisions provided to halt the effect where safe operation of a flame effect can be influenced by hazardous weather conditions
(2) Intrusion (security)
(3) Egress
(4) Clearance to combustibles
(5) Fire protection

B.1.1.2 The design plan for indoor flame effects should include the following:

(1) Ventilation (where used to exhaust the products of combustion of a flame effect), with means provided to prevent fuel flow in the event that the source of ventilation air is interrupted
(2) Clearance to combustibles
(3) Egress
(4) Environment
(5) Fire protection
(6) Life safety provisions
(7) Intrusion (security)

B.1.2 Flame Effect Operator Participation.

B.1.2.1 The design plan for attended effects should include the following:

(1) Control by the operator or performer during start-up, operation, and shutdown
(2) Operator in attendance during effect
(3) Training of operators

B.1.2.2 The design plan for unattended effects should include the following:

(1) Design for unattended operation
(2) Supervision by automatic systems
(3) Audience proximity/audience intrusion prevention
(4) Control type — automatic
   (a) Show events cued by a control system (mechanical or electrical)
   (b) Different levels of automatic operation
   (c) Requirements to be developed for flame effect control systems
(5) Manual control type — supervision of the performance of the device by the operator or technician with the flame effect in open view
(6) Control location
   (a) Local control — a flame effect controlled by an operator who has a clear view of the flame effect area
   (b) Remote control
(7) Fuel supply and fuel additives
   (a) Portable
   (b) Fixed

Annex C Inspection Guidelines

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

C.1 The following guidelines are provided as a possible inspection routine that can be used as a model.

C.2 Inspection and Re-verification of Flame Effects Function. Following issuance of the use permit by the local authority having jurisdiction *(see 5.3.1)* and completing the Approval Requirements *(see Section 5.2),* the flame effect(s) show action equipment should be subjected to a periodic functional verification and calibration of critical components according to the requirements of a written test plan/procedure as created by the designer of the effects or other responsible individual. A written report and/or completed checklist in a format acceptable to the local jurisdiction should be made a permanent part of the effects documentation.

C.2.1 Temporary Flame Effects Installations. Temporary flame effects installations should be evaluated on a periodic basis by a qualified technician/operator according to the following guidelines.

C.2.1.1 Daily Inspection and Testing. Any critical deficiencies and/or malfunctions are to be corrected and noted in the show documentation prior to the operation of the effects in the show. Inspection should include the following:

(1) Visual inspection of fuel storage area, which includes verifying that the fuel supply is properly secured, that general housekeeping is according to proper standards, whether there is accumulation of flammable materials, convenient access to critical areas, and the absence of any items not directly related to the storage or management of the fuel supply.
(2) Visual inspection of performance area, which includes general housekeeping, accumulation of incidental flammable materials, condition of sets and props, convenience of access, and any other condition relating to the proper operation of the effects.
(3) Visual inspection of fire effects equipment to verify that the components are functional. Significant degradation or damage should be noted and repaired or replaced as necessary.
(4) As part of the daily preset for the show, the effect(s) should be operated according to the procedure established by the designer of the effect to verify the proper operation of the enable and arming as designed. Any discrepancies in the normal operation of the effect should be noted and corrected prior to the operation of the effect during the show.
(5) Verification that all provisions for the emergency shutdown of the effect, including fuel management and fire suppression measures, are present and/or operating normally.
(6) Observation of the operation of the effect during the show to verify that it is functioning according to the expected operating profile.

C.2.1.2 Weekly and Monthly Inspection and Testing. Weekly and monthly inspection and testing should be conducted and noted as dictated by the design and operation of the effects and the duration of the temporary installation.

C.2.2 Permanent Flame Effects Installations. Permanent flame effects installations should be evaluated on a periodic basis by a qualified operator according to the following guidelines.

C.2.2.1 Daily Inspection and Testing. Any critical deficiencies and/or malfunctions are to be corrected and noted in the show documentation prior to the operation of the effects during the show. Inspection should include the following:

(1) Visual inspection of fuel storage area, which includes verifying that the fuel supply is properly secured, that general housekeeping is according to proper standards, whether there is accumulation of flammable materials, convenient access to critical areas, and the absence of any items not directly related to the storage or management of the fuel supply.
(2) Visual inspection of performance area(s), which includes general housekeeping, accumulation of incidental flammable materials, condition of sets and props, convenience of access and any other condition relating to the proper operation of the effects.
(3) Visual inspection of fire effects equipment to verify that the components are functional. Significant degradation or damage should be noted and repaired or replaced as necessary.
(4) Verification that all primary limits [lower explosive limit (LEL) sensors, airflow switches, fuel pressure switches, etc.] are conditioned in the proper control profile and that they indicate a proper operating level of the parameter being monitored.
(5) As part of the daily preset for the show, the effect(s) should be operated according to the procedure established by the designer of the effect to verify the proper operation of the enable and arming as designed. Any discrepancies in the normal operation of the effect should be noted and corrected prior to the operation of the effect during the show.
(6) Verification that all provisions for the emergency shutdown of the effect, including fuel management and fire suppression measures, are present and/or operating normally.
(7) Observation of the operation of the effect during the show to verify it is functioning according to the expected operating profile.

C.2.2.2 Monthly Inspection and Testing. In addition to the recommended tests as stated in C.2.2.1, the following tests and inspections should be performed as required:

(1) Test and calibrate any limit or interlock control device that could be subject to a change in the measured value as a normal part of the operation of the device over a period of time according to the recommendations of the manufacturer.
(2) Perform a leak test of any primary fuel supply shutoff valves according to the recommendations of the manufacturer.
(3) Verify that any intrusion and/or position interlocks are operating properly and the actuation of any such device results in the desired control system response.
(4) Other test sequences as recommended by the effects designer or other cognizant individual.

C.2.2.3 Quarterly Inspection and Testing. In addition to the recommended tests as stated in C.2.2.1 and C.2.2.2, the following tests and inspections should be performed as required:

(1) Calibrate all primary limit or interlock control devices, which could be subject to a change in the measured value as a normal part of the operation of the device over a period of time.
(2) Actuate all primary limit or interlock control devices to confirm proper function, control response, and confirmation of actuation.
(3) Actuate any central fire alarm system to verify that the actuation will result in the emergency stop of the effects control system.
(4) Actuate all show emergency stop operators to confirm their proper function and confirmation of actuation. Furthermore, selected emergency stop operators should be actuated during the operation of the effects to verify the proper emergency shutdown of the effects.
(5) Operate the fuel supply enable control circuit to verify the proper function of the fuel limits and valves.
(6) Enable and arm randomly selected effects to verify the proper operation of the ignition management control circuit, including safe start check, trial for ignition, flame failure response time and non-recycling operation as necessary. The number of effects to be tested should be a minimum of 3 or 20 percent of the total number of flame effects in the control system. Where the design of the controls included multiple zones, at least one effect in each zone should be tested.
(7) Test the PME operator during the operation of the effects to verify that the effects will not enable, arm, and fire without the presence of the positive manual enable PME and

that the removal of the positive manual enable PME during the enabling, arming, and firing sequence of the effects will shut down the effects operation as designed.

(8) Operate the effects in the normal show mode to verify that they are enabling, arming, and firing in the expected sequence according to the normal show profile.

(9) Other test sequences as recommended by the effects designer or other cognizant individual.

C.2.2.4 Annual Inspection. The annual inspection of the flame effects will verify the proper function of all effects control components and serve as a certification of the condition and operation of the effects control system for the renewal of the operating permit as issued by the local jurisdiction. The test sequence should include those sequences as stated in C.2.2.1, C.2.2.2, and C.2.2.3, to such an extent that all control systems and components are tested, verified, and functioning properly, and that any other tests as recommended by the effects designer or other cognizant individual are performed.

Annex D Informational References

D.1 Referenced Publications. The following documents or portions thereof 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.

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

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

NFPA 54, *National Fuel Gas Code*, 2006 edition.

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

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

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

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

NFPA 430, *Code for the Storage of Liquid and Solid Oxidizers*, 2004 edition.

NFPA 1122, *Code for Model Rocketry*, 2002 edition.

NFPA 1125, *Code for the Manufacture of Model Rocket and High Power Rocket Motors*, 2001 edition.

NFPA 1126, *Standard for the Use of Pyrotechnics Before a Proximate Audience*, 2006 edition.

NFPA 1127, *Code for High Power Rocketry*, 2002 edition.

D.1.2 Other Publications. (Reserved)

D.2 Informational References. (Reserved)

D.3 References for Extracts in Informational Sections. (Reserved)