

NFPA[®]

160

Standard for the
Use of Flame Effects
Before an Audience

2021



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NFPA® 160

Standard for the

Use of Flame Effects Before an Audience

2021 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. It was issued by the Standards Council on March 15, 2020, with an effective date of April 4, 2020, and supersedes all previous editions.

This edition of NFPA 160 was approved as an American National Standard on April 4, 2020.

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. The first edition of the standard was 1998.

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 included a complete revision of the standard by the Committee. Key changes found in the 2006 edition included 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.

The 2006 edition of the standard also incorporated editorial changes according to the *Manual of Style for NFPA Technical Committee Documents*.

The 2011 edition of the standard incorporated amendments to the application section to clarify that NFPA 140, *Standard on Motion Picture and Television Production Studio Soundstages, Approved Production Facilities, and Production Locations*, applies to flame effect use when no audience is present. The Committee added definitions for the terms *performer* and *support personnel* extracted from NFPA 1126, *Standard for the Use of Pyrotechnics Before a Proximate Audience*, for consistency between the special effects documents. Requirements for development and approval of the flame effects plan were included. The Committee revised the separation distance requirements to eliminate the thermal flux provision and retain the skin surface temperature requirements. The skin surface temperature is based on a test method that can be more easily performed in the field.

The 2016 edition of NFPA 160 defined *hybrid flame effect* and added requirements for its use. The 2016 edition also indicated which portions of hybrid flame effects are covered by NFPA 160 and which are covered by NFPA 1126, since both documents apply, and added explanatory annex material to provide further guidance on the simultaneous application of NFPA 160 and NFPA 1126. In addition, the 2016 edition clarified that the use of ground-based effects utilizing explosives, liquid fuels, or other combustibles in air show environments is not covered by NFPA 160 and provided a reference for the use of such effects.

The 2021 edition of NFPA 160 significantly reorganizes the document to cover new advances in flame effect technology. Previously, NFPA 160 only contained requirements for flame effect technology using flammable gases, and it has now been revised to separate each flame effect technology by fuel source, which will now include solid, liquid, prepackaged single-use containers, and gels. Requirements that are common for all flame effect systems are now in Chapter 9, with the requirements specific to the fuel of the device located in Chapters 11 through 13. Fire performers now have requirements in Chapter 14 as well.

Dedication

The Technical Committee dedicates the 2021 edition of NFPA 160 to the memory of Tedward LeCouteur, a Committee member who worked tirelessly and passionately for the fire-performing community. It was his work that laid the foundation for Chapter 14 for fire performers.

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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.

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NFPA 160

Standard for the

Use of Flame Effects Before an Audience

2021 Edition

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

A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced and extracted 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 3.3.13, 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
- (6) That portion or component of any hybrid flame effect that utilizes fuels, materials, devices, and methodologies governed by this standard

▲ 1.3.3 This standard shall not apply to the following:

- (1)* Flame effects produced solely by pyrotechnic special effects devices or pyrotechnic material
- (2)* Use of pyrotechnic special effects
- (3)* Storage of flammable solids, liquids, and gases not to be used to create flame effects
- (4) Nitrocellulose-based flame projectors
- (5) Manufacture, off-site storage, and transportation of materials and equipment used to produce flame effects
- (6) Use of flame effects in fire training, except where there is an audience that is not part of the training
- (7)* Manufacture, transportation, storage, sale, or use of model or high-power rocket motors
- (8) 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
- (9) Use of consumer fireworks by the public
- (10) Use of motor vehicles in races or sanctioned competitive sporting events
- (11)* Use of ground-based effects utilizing explosives, liquid fuels, or other combustibles in air show environments
- (12) Use of pyrotechnic effect simulation equipment as defined in NFPA 1126

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

▲ 1.3.5 When there is no audience present, NFPA 140 shall be used to regulate any flame effect use.

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.

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

NFPA 1, *Fire Code*, 2021 edition.

NFPA 10, *Standard for Portable Fire Extinguishers*, 2018 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2021 edition.

NFPA 140, *Standard on Motion Picture and Television Production Studio Soundstages, Approved Production Facilities, and Production Locations*, 2018 edition.

NFPA 1126, *Standard for the Use of Pyrotechnics Before a Proximate Audience*, 2021 edition.

2.3 Other Publications.

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

Boiler Pressure Vessel Code, 2013.

N 2.3.2 European Commission Publications. European Commission, Rue de la Loi 130, 1049 Brussels, Belgium.

Pressure Equipment Directive, 2014.

2.3.3 Other Publications.

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

2.4 References for Extracts in Mandatory Sections.

NFPA 1, *Fire Code*, 2018 edition.

NFPA 1126, *Standard for the Use of Pyrotechnics Before a Proximate Audience*, 2016 edition.

Chapter 3 Definitions

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

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

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

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

3.2.5 Shall. Indicates a mandatory requirement.

N 3.2.6 Standard. An NFPA Standard, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase “standards development process” or “standards development activities,” the term “standards” includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

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

3.3.5 Cast Members. Performers involved in a production involving the use of flame effects.

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

3.3.7 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.

3.3.8* 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 **can** be implemented.

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

3.3.10 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.

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

N 3.3.12 Fire Watch. The assignment of a person or persons to an area for the express purpose of notifying the fire department, the building occupants, or both of an emergency; preventing a fire from occurring; extinguishing small fires; protecting the public from fire and life safety dangers. [1, 2018]

3.3.13 Flame Effect. The combustion of solids, liquids, or gases utilizing atmospheric oxygen to produce thermal, physical, visual, or audible phenomena before an audience.

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

3.3.13.2* Hybrid Flame Effect. A flame effect that is used in combination with a pyrotechnic material or device.

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

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

3.3.14* Flame Effect Appliance. The complete assembly of components and devices that controls and generates a flame effect, which are further defined by the type of fuel used for the primary flame.

N 3.3.14.1 Gaseous-Fuel Flame Effect Appliance. An appliance that uses gaseous fuel as the primary fuel.

N 3.3.14.2 Liquid-Fuel Flame Effect Appliance. An appliance that uses liquid fuel as the primary fuel.

N 3.3.14.3 Prepackaged Single-Use Container Fuel Flame Effect Appliance. An appliance that uses fuel from a prepackaged single-use container.

N 3.3.14.4 Solid-Fuel Flame Effect Appliance. An appliance that uses solid fuel as the primary fuel.

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

3.3.16* Flame Effect Materials. Flammable or combustible materials used as fuel for flame effects and identified by their state of matter at standard temperature and pressure (STP).

N 3.3.16.1 Gaseous Fuel. A fuel that is a gas or vapor, or a liquefied flammable gas that has been vaporized.

N 3.3.16.2* Liquid Fuel. A fuel that is a liquid.

N 3.3.16.3* Solid Fuel. A fuel that is a solid.

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

3.3.18 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").

3.3.19* 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.

3.3.20* Flame Effect Systems, Classifications.

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

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

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

3.3.20.4 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.

3.3.20.5 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.

3.3.20.6 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.

3.3.20.7 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.

3.3.21 Hybrid Flame Effect. See 3.3.13.2.

3.3.22 Installation, Term of.

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

3.3.22.2 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.

N 3.3.23* Oxidizer. The source providing oxygen to a combustion reaction.

Δ 3.3.24* Performer. Any person active in a performance during which flame effects are used and who is not part of the audience or support personnel.

3.3.25 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.

3.3.25.1 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.

3.3.26 Plan.

3.3.26.1 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.

3.3.26.2 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.

N 3.3.27 Prepackaged Single-Use Container. A container intended for single use and not to be refilled, approved for transportation, which has been factory filled with a pressurized fuel and is equipped with a prepackaged single-use container valve that allows connection to the container receiver of a prepackaged single-use container flame effect appliance.

N 3.3.27.1 Prepackaged Single-Use Container Receiver. A receiver installed on a prepackaged single-use container flame effect appliance with the receiver mating with the prepackaged single-use container, which when fully mated, allows for the operation of the prepackaged single-use container valve contained within the prepackaged single-use container and admits fuel to the appliance.

N 3.3.27.2 Prepackaged Single-Use Container Valve. A self-closing device internal to a prepackaged single-use container to allow dispensing of the fuel.

3.3.28* 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.

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

3.3.30 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.

3.3.31* 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.

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

3.3.33* Support Personnel. Any individual who is not a performer or member of the audience. [1126, 2016]

3.3.34 Valve.

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

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

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

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

3.3.35* 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 AHJ.

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 AHJ.

4.2.2 Supervision. 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 AHJ, 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 AHJ.

5.2.1.1* Hybrid flame effects shall meet the requirements of 5.2.1.1.1 and 5.2.1.1.2.

5.2.1.1.1 That portion of the hybrid flame effect that is governed by NFPA 160 shall meet all of the requirements of NFPA 160.

▲ **5.2.1.1.2** That portion of the hybrid flame effect that is governed by NFPA 1126 shall meet all of the requirements of NFPA 1126.

5.2.2 Approval of Flame Effect Plan. A plan for the use of flame effects shall be submitted to the AHJ 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 AHJ.

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 AHJ prior to use of the modified flame effects.

5.2.2.3 In the case of a hybrid flame effect, the plan shall identify those portions of the flame effect that require compliance with NFPA 160 and those portions that require compliance with NFPA 1126.

5.3* Content of Flame Effect Plans.

▲ **5.3.1** The plan for the use of flame effects shall be submitted in writing or other form acceptable to the AHJ.

• **5.3.2*** 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 flame effect classification
- (5) 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
- (6) A current Safety Data Sheet (SDS) for the materials (fuels) consumed in the flame effect
- (7) Documentation that the combustible materials used for construction of the flame effects have been rendered flame retardant
- (8) The name of the effect operator

5.3.3 The operator shall make operating instructions for flame effects available to the AHJ.

5.3.4 The plan shall be reviewed with the AHJ, flame effects operator, and building owner/representative prior to the production, to ensure coordinated response in the event of an emergency.

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 AHJ 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 AHJ 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 AHJ.

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 tested to verify that they operate in accordance with their designs.

7.1.2* Flame effects shall be evaluated to verify that spectators, performers, support personnel, and the operator are not exposed to a hazardous situation when the flame effects are activated as designed or anticipated.

7.1.3 On an interval acceptable to the AHJ, flame effects shall be inspected for normal and safe operating condition and retested for operation as designed and anticipated.

7.1.4 Documentation of the testing and evaluation shall be permitted to be prepared by a third party acceptable to the AHJ.

7.1.5 The documentation shall be made available to the AHJ as a part of the application for approval of the flame effect.

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 AHJ.

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 AHJ.

N 7.6.1 Operating Temperature Requirements.

N 7.6.1.1* Manufacturers of flame effect appliances shall specify a minimum and maximum ambient temperature rating if it is critical to proper operation of the appliance.

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

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.

N 7.7.3 Portable flame effect appliances shall be depressurized and fuel sources disconnected prior to removal from one venue and transportation to another and in accordance with venue, local policies, or regulations.

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 AHJ.

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 effect, fuels, or the heat of the effect.

7.10.2 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 AHJ.

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 while under the influence of the following:

- (1) Intoxicating beverages
- (2) Narcotics or controlled substances

- (3) Prescription drugs and/or nonprescription drugs that impair judgment

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

Chapter 9 Flame Effect System Classification and General Requirements

9.1 General Requirements for Flame Effect Control System Design. The requirements of this chapter shall not apply to Chapter 14.

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 AHJ 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 that 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 One of the following conditions shall be met prior to the use of flame effects:

- (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.

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 AHJ

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 available only during operation.

Table 9.2 Group Control Functions Required

Flame Effect Group	Control Type	Minimum Control Requirements
I	Manual controls	1. No automatic controls are required.
II	Automatic controls	1. Ignition supervision is provided.
III	Automatic controls	2. Automatic shutoff follows in the event of failure.
		1. Manual operation of the effect valve is permitted.
		2. If the operator cannot confirm the pilot or direct ignition source for the flame special effect, a primary safety control will be installed.
		3. Two fuel shutoff valves, one of which will be a safety shutoff valve, are provided and installed in series.
IV	Automatic controls	1. Primary limit device(s) will be installed as required.
		2. A fuel supervisory station is installed with fuel pressure limit switches to control the supervisory station valves.
		3. Each flame effect burner is 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 is used.
V	Automatic controls	1. The requirements for Group IV 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 is used. The flame effect safety control system maintains 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 apply.
		2. Where cast members are in close proximity to the flame effect, the flame effect is 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 are as recommended by the designer and acceptable to the AHJ.

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 Fuel Delivery.

9.3.2.3.1 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-fuel-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.

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

9.3.2.4 Effect Valve.

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

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

9.3.2.4.3 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.

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

Δ 9.3.2.5* Systems Using Fuel Accumulators. Where fuel accumulators are used in a flame effect appliance, they shall meet the following requirements:

- (1) Accumulator tanks shall be designed, manufactured, and certified as unfired pressure vessels.
 - (a)* Accumulators shall be designed, manufactured, and tested in accordance with the ASME *Boiler Pressure Vessel Code*, Department of Transportation regulations, or the European Commission *Pressure Equipment Directive* 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 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.

9.3.3.1.2 In circumstances described in 9.3.3.1.1, 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 **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 AHJ.

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.

N Chapter 10 Gaseous Flame Effect Appliance Components, Control Systems, and Design

N 10.1 Design Criteria.

N 10.1.1 All applicable design criteria and components from Chapter 9 shall apply to gaseous flame effects appliances in addition to the specific requirements in this chapter.

N 10.1.2 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.

N Chapter 11 Flame Effect Appliances Using Fuel in Prepackaged Single-Use Containers and Appliance System Components, Control Systems, and Design

N 11.1 Design Criteria.

N 11.1.1 All applicable design criteria and components from Chapter 9 shall apply to prepackaged single-use containers for flame effect appliances in addition to the specific requirements in this chapter.

N 11.1.2* Only fuels expressly manufactured for burner or combustion applications and specified by the manufacturer of a flame effect appliance shall be used as flame effect fuels for that appliance.

N 11.1.3 The quantity of prepackaged single-use containers supplying the appliance shall be limited to the manufacturer's design specification.

N 11.1.4 Each individual prepackaged single-use container receiver shall have a means to prevent backflow from the appliance.

N 11.1.5 Prepackaged single-use containers used in prepackaged single-use container appliances shall be protected from exposure to the direct heat of the flame effect.

N 11.1.6 Prepackaged single-use containers shall be inspected for damage or leakage prior to installation.

N 11.1.6.1 Damaged or leaking cylinders shall not be used.

N 11.1.7 Prepackaged single-use containers with expiration dates shall not be used after the expiration date.

N 11.1.8 Prepackaged single-use containers shall be handled and used according to the appliance manufacturer's instructions.

N 11.1.9 Prepackaged single-use containers shall not be refilled.

N 11.1.10 Used prepackaged single-use containers shall be disposed of in accordance with the manufacturer's instructions as well as in compliance with venue and local regulations.

N Chapter 12 Liquid-Fuel Flame Effect Appliance Components, Control Systems, and Design

N 12.1 Design Criteria.

N 12.1.1 All applicable design criteria and components from Chapter 9 shall apply to liquid-fuel flame effect appliances in addition to the specific requirements in this chapter.

N 12.1.2 Liquid-fuel flame effect appliances shall have a source of ignition appropriate for the types of fuels and pressures used.

N 12.1.3 All components of the appliance shall be compatible with the fuel and operating pressures specified in the design.

N 12.1.4 Liquid-fuel flame effect appliance containers storing or using a fuel under pressure shall comply with the following:

- (1) All containers used for fuels shall be designed, manufactured, and tested under the ASME *Boiler Pressure Vessel Code*, Department of Transportation (DOT) regulations, or the European Commission *Pressure Equipment Directive*.
- (2) All materials shall be compatible for the liquid fuel.
- (3) All containers shall be designed for rated working pressure.
- (4) All containers shall have overpressure protection capable of handling a maximum possible overpressure event.
- (5) All containers shall have a manual shutoff valve at the fill connection, charging connection, and output to the burner.
- (6) All valves shall be closed at time of transport.

N 12.1.5 Where fuel pressure is outside normal operating parameters, a pressure supervisory control system shall be provided to prevent operation of the appliance.

N 12.1.6 Spill containment shall be used during refilling of containers as approved by the AHJ.

N 12.1.7 Refillable containers shall be refilled and pressurized in a location approved by the AHJ.

N 12.1.8 Where flame effect appliances use external pressure sources, a method of isolating the pressure source from the system shall be provided.

N 12.1.8.1 A manual method shall be provided for the controlled depressurization of containers.

N 12.1.9 A method to remove any unused liquid fuel from the system shall be provided.

N Chapter 13 Gel- and Solid-Fuel Flame Effect Appliance System Components, Control Systems, and Design

N 13.1* Design Criteria.

N 13.1.1 The surface, holder, or device the fuel is applied to shall be constructed from noncombustible material and shall prevent unintended migration of the fuels to undesired locations.

N 13.1.2* A means of extinguishing these effects shall be provided.

N Chapter 14 Fire Performers

N 14.1 Performers. All performers shall act in accordance with 8.1.2.

N 14.1.1 Capability.

N 14.1.1.1* Performers shall comply with Section 8.3.

N 14.1.1.2 Each performer shall be physically capable of executing their performance.

N 14.1.1.3 At least one cast member shall be designated as the flame effect operator and comply with the requirements of Chapter 8.

N 14.1.2 Rehearsal.

N 14.1.2.1 Each routine shall be rehearsed in costume with fire prior to the initial performance before an audience or after any change to the performance is made.

N 14.1.2.2 The flame effects operator shall confirm the cast members and the routine are ready for performance before an audience.

N 14.1.3* Clothing. Fire performers shall comply with the requirements of Section 7.10.

N 14.2 Safety Personnel.

N 14.2.1 Each performance and rehearsal with fire shall have at least one spotter.

N 14.2.1.1 Spotters shall be in charge of onstage and backstage fire safety, including emergent and intentional wick extinguishing.

N 14.2.1.2 Spotters shall be aware of the aspects of fire performance and familiar with the routine to be performed.

N 14.2.1.3* Spotters shall be trained in flame extinguishing, reaction time, equipment control, and audience control.

N 14.2.1.4 Spotters shall be attentive and have a clear view and unobstructed access to the hazard they are responsible for.

N 14.2.1.5 Spotters shall comply with the requirements of Section 7.10.

N 14.2.1.6 Spotters shall carry a safety towel at all times.

N 14.2.1.7 Spotters shall have unobstructed access to the fire extinguishers required in 16.3.2.

N 14.3 Fire Props.

N 14.3.1 Testing.

N 14.3.1.1 Fire props shall be tested prior to each use to verify they operate in accordance with their intended use.

N 14.3.1.2 Any defect found in the fire prop shall be repaired or replaced.

N 14.3.2 Wicks.

N 14.3.2.1 A wick shall be fire-resistant, absorbent material intended to temporarily store and convey fuel to the flame effect during the performance.

N 14.3.2.2 Wicks shall be attached to the fire prop such that they cannot be forcibly removed from the prop.

N 14.3.2.3* Wick material shall be made in such a way as to prevent loss of any part of the wick during use.

N 14.3.3 Handles.

N 14.3.3.1* Shafted fire props shall either be made of fire-resistant materials or have a fire-resistant covering that extends at least 4 in. (100 mm) beyond the anticipated flame contact zones.

N 14.3.3.2 Handles shall be attached to the fire prop such that they cannot be forcibly removed from the prop.

N 14.3.3.3 Chain grips shall be made of noncombustible materials.

N 14.3.4* Connectors. Connectors shall be constructed to prevent inadvertent separation from the wick and handle.

N 14.3.5 Fueling.

N 14.3.5.1* Fueling shall take place in an approved area.

N 14.3.5.2 Excess fuel that has been removed shall be stored in accordance with NFPA 1 or NFPA 30.

N 14.3.5.2.1 Fuel residue shall be removed immediately following the performance.

N 14.3.5.2.2 Fuel-soaked waste shall be stored and disposed of in accordance with the manufacturer's instructions as well as in compliance with venue and local regulations.

N 14.3.5.3 Fire props shall be cooled to ambient temperature before fueling.

N 14.3.6* Fire Prop Extinguishment. In addition to the requirements of Section 16.3, flames shall be permitted to be extinguished using suitable materials or methods.

N 14.4 Fuels. Safety data sheets (SDS) shall be available for all fuels and hazardous chemicals used.

N 14.4.1 Storage. Fuel shall be stored in accordance with NFPA 1 or NFPA 30.

N 14.4.2 Fueling Area.

N 14.4.2.1 All fueling shall take place in an approved fueling area.

N 14.4.2.2 Designated fuel stations shall be attended by the flame effect operator or spotter until the hazard is removed.

N 14.4.2.3 Fuel containers and dip buckets shall be sealed when not in use.

N 14.4.2.4 The fueling area shall be located outside or in an approved area.

N 14.4.2.4.1 There shall be an unobstructed path from the fueling area to the performance area.

N 14.4.2.4.2 Fuel-soaked wicks shall not be permitted to be moved through the audience without at least one spotter.

N 14.4.2.4.3 The audience shall be prohibited within 25 ft (7.6 m) of the fueling area.

N 14.4.2.4.4 Smoking and other sources of ignition shall be prohibited within 25 ft (7.6 m) of the fueling area.

N 14.5 Performance.

N 14.5.1 Separation. Separation between the performer and the audience shall be maintained to prevent fuel or flame contact with audience members as approved by the AHJ.

N 14.5.2* Performance Area. The performance area shall be free of flammable or combustible materials, or materials shall be treated with approved fire-retarding chemicals and tested for combustibility in an approved manner.

N 14.6 Post-Performance Procedures.

N 14.6.1 In addition to the post-performance procedures required in Sections 14.1 through 14.5, Section 14.6 shall be followed for post-performance procedures.

N 14.6.2 Fire props shall be cooled to ambient temperature before storage or transportation post performance.

Chapter 15 System Installation and Testing

15.1 General.

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

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

15.2 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 AHJ.

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

Δ 15.2.2 Test Procedures.

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

Δ 15.2.2.2 Reassembled flame effect piping systems designed to be separated into subassemblies shall be permitted to be leak tested at system operating pressure at the reconnected joints, using a noncorrosive leak-detecting solution or other means acceptable to the AHJ.

15.3 Temperatures of Components and Surroundings.

15.3.1 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.

Δ 15.3.2 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.

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

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

• **15.3.2.3** 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.

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

Chapter 16 Fire Protection Provisions

16.1 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.

16.2 Evaluation for Permanently Installed Flame Effects.

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

16.2.2 The evaluation in 16.2.1 shall be coordinated with the building owner, the flame effect operator, and the AHJ.

16.3* Additional Fire Safety Provisions for Temporary Installations.

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

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

Δ **16.3.2.1** The following shall be provided in addition to those required by NFPA 10 for the building:

- (1) Two pressurized water extinguishers, each with a minimum rating of 2-A
- (2) Two extinguishers, each with a minimum rating of 10-B:C, or two extinguishers appropriate to the fuel source being used

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

16.4 Standby Fire Safety Personnel Requirements.

16.4.1 Where required by the fire hazards evaluation or the AHJ, standby fire safety personnel shall be present along with operational supplemental equipment.

16.4.2 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.

16.4.3 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. 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(1) As covered in NFPA 1126.

A.1.3.3(2) For information on the use of pyrotechnic special effects before an audience, see NFPA 1126.

Δ **A.1.3.3(3)** For information on the storage of flammable and combustible liquids, see NFPA 30. For information on the storage of flammable gases, see NFPA 55 and NFPA 58.

A.1.3.3(7) For information on the manufacture, transportation, or storage of model or high power rocket motors, see NFPA 1125. For information on the sale or use of model or high power rocket motors, see NFPA 1122 and NFPA 1127.

A.1.3.3(11) For information and guidance on ground-based effects in air shows, refer to International Council on Air Shows (ICAS) *Guidelines for the Use of Pyrotechnics and Special Effects at Air Shows* and NFPA 495.

Δ **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, and 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 indi-

vidual 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 with manual ignition of a pilot, flammable liquid, or flammable solid.

A.3.3.8 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.3.3.11 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.3.3.13.2 Hybrid Flame Effect. Flame effects that use any of the fuels allowed by this standard but are initiated or directly ignited by means of a pyrotechnic device are common examples of a hybrid flame effect. One example of a hybrid flame effect is one that uses a pyrotechnic device or igniter to provide the initial flame to light a supervised pilot burner, which, when ignited, can be then proven by a conventional flame safeguard or other means. Often this hybrid configuration is used where the pilot burner is in and/or around water or spray, and conventional ignition means have been determined to be unreliable or to utilize voltages or currents that provide a risk of hazard to persons in and around the water. In other instances, this configuration might be used for added reliability, operational integration, or simply for convenience. In any of these instances, the pyrotechnic igniter is used under the requirements of NFPA 1126 and is installed, maintained, and operated to meet the requirements of both NFPA 1126 and the AHJ. The flame effect itself, regardless of the fuel it uses, is designed, installed, maintained, and operated to meet the requirements of both NFPA 160 and the AHJ.

A second example of a hybrid flame effect is one that utilizes a combustible dust, initially aerosolized and propelled out the end of the burner nozzle by a charge of compressed air and ignited as it passes through a field of burning metal sparks generated by yet another pyrotechnic device. Dust or powder fuel is an acceptable flame effect material under this standard. What causes this effect to be classified as a hybrid flame effect is

that the pyrotechnic ignition device(s) falls under the purview of NFPA 1126. (Note that if a gas pilot burner or even a burning brand were used to ignite an aerosolized powder, this flame effect would not be considered hybrid and would fall entirely under the scope of NFPA 160.)

A third example is an often-used flame effect that is typically limited to outdoor use and utilizes flammable or combustible liquid as a fuel. This would be an acceptable flame effect material under this standard. The fuel is contained in a nonporous bag and placed inside a suitable open-topped container that serves as a “mortar” or burner nozzle. Upon firing, the liquid is freed from the bag, lifted from the barrel, and aerosolized by means of a substantial black powder lifting charge. A second pyrotechnic device might or might not be used to ensure ignition of the fuel at the mouth of the container. What causes this effect to be classified as a hybrid flame effect is that the aerosolizing and igniting charges fall under the purview of NFPA 1126, or, depending upon the particular composition and quantity of the charge in use, possibly NFPA 1123 or NFPA 495. Additionally, the storage and/or handling of the liquid fuel would be governed by the requirements of NFPA 30. (Note that if a compressed air charge was used to aerosolize the liquid and a gas-fired pilot burner or even a burning brand was used to ignite the aerosol, this flame effect would not be considered hybrid and would fall entirely under the scope of NFPA 160.)

A.3.3.14 Flame Effect Appliance. Secondary fuels, or other sources, are sometimes used to provide the energy required to ignite the primary flame.

A.3.3.16 Flame Effect Materials. Oxygen, necessary to sustain combustion, is provided from the atmosphere and could be supplemented by additional sources in some circumstances.

A.3.3.16.2 Liquid Fuel. Commonly used liquid fuels include fuels based on methyl, ethyl, and isopropyl alcohols that could contain salt or acids, as well as commercially available compounds, such as isoparaffinic and n-paraffinic solvents that are regularly used in many liquid-fueled flame effects.

A.3.3.16.3 Solid Fuel. Solid fuels that might be used as a flame effect fuel include wood, coal, and other similar organic materials, as well as selected household and industrial compounds, and in particular, the finely ground dust or powder of these same materials.

A.3.3.19 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.3.3.20 Flame Effect Systems, Classifications. Examples of flame effects are as follows:

- (1) *Group I.* Where used to give the illusion of danger to a performer, the use of hand-held burning torches, cigarette lighters, candles, matches, lighting paper in an ashtray, jugglers burning batons, fire rings that are jumped through, and other flame effects that are not included in another flame effect group.
- (2) *Group II.* Unattended torches, burning urns, and small fires.

- (3) *Group III.* An attended, temporarily installed flame effect 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) circuses, operas, musicals, stage plays, trade shows, or corporate events. This group effect also includes a non-traveling 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 standalone-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.3.3.20 for a list of features included in each flame effect group.

A.3.3.23 Oxidizer. The atmosphere is typically the source of the oxygen required to allow combustion of the fuel.

When a combustion rate, faster than would be allowed by the use of atmospheric oxygen alone, is required, such as the percussive detonation of a crackle barrel flame effect, a supplementary source of oxygen can be provided.

When ignition is particularly difficult, such as in, around, and under water, a source of supplementary oxygen might be provided to ensure successful ignition of the pilot flame and the primary fuel.

A.3.3.24 Performer. Performers can include, but are not limited to, fire performers, stunt people, actors, singers, musicians, and acrobats.

A.3.3.28 Primary Safety Control. In the event of ignition failure or loss of flame, the control causes a safety shutdown.

A.3.3.30 Safety Shutdown (Lockout). The flame effect can be restarted only after a manual reset following correction of the abnormal condition.

A.3.3.32 Supervisory Control System. In the case of a manual system, this function might be performed by the flame effect operator or assistant.

A.3.3.33 Support Personnel. Among others, support personnel include the road crew of any production, stage hands,

Table A.3.3.20 Features Included in Flame Effect Groups

Features	Flame Effect Groups						
	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.

property masters, security guards, fire watch officers, janitors, or any other employee. [1126, 2016]

A.3.3.35 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.

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

NFPA 30
 NFPA 54
 NFPA 55
 NFPA 58
 NFPA 59A
 NFPA 101
 NFPA 400
 NFPA 1126

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 AHJ 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.5.2.1.1 Where the standards impose different requirements, the most stringent requirement should be the one used, unless otherwise approved by the AHJ.

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.5.3.2 See Annex B for guidelines on design of flame effects.

A.5.4.1 The AHJ should invite the local responding fire companies to witness the demonstration to familiarize them with the potential hazards involved.

A.7.1.2 As a guide, the incident radiation from the flame effect should not cause the surface temperature of the exposed skin of a member of the audience to exceed 111°F (44°C), as measured using an infrared surface thermometer or other equivalent means. The operator should have, on site, the instrumentation necessary to verify skin temperature, if requested by the AHJ.

A.7.6.1.1 When operated outside of specified temperature ranges, fuels might not properly ignite, resulting in improper device performance.

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.

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

Δ A.9.3.2.3.1(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 AHJ, 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 off 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.9.3.2.5 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.9.3.2.5(1)(a) For applications outside of the United States, equivalent national standards can be used.

A.9.3.2.5(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 9.3.2.5(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 **AHJ**

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 and 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 **AHJ**

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.

N A.11.1.2 Fuels should be prepackaged in UN-approved shipping containers with a purpose built internal prepackaged single-use container flame valve. Paint, starting fluid, air fresheners, lubricants, hairsprays, and insecticides are prohibited for use as flame effect fuels. All materials in contact with the fuel should be compatible with the fuels used in the system.

N A.13.1 Most gel- and solid-fuel-based flame effects fall into Group I effects and involve a fuel gel, paste, or pelletized or compressed solid that is placed in or on a flameproof substrate or container and ignited manually. Examples of gel and solid fuel include gelled alcohol, colored flame gels and pastes, handheld fuel-pellet-based torches, and lycopodium powder.

N A.13.1.2 Appropriate means of extinguishment might be a fire extinguisher, snuff box, fire blanket, or other method approved by the AHJ.

N A.14.1.1.1 Fire breathers who use ethanol should be aware that alcohols might be absorbed through the mouth during the performance leading to possible intoxication. Multiple performances should be spaced appropriately to ensure sobriety.

N A.14.1.3 Cotton, wool, leather, or similar natural fiber clothing is appropriate for fire performers.

N A.14.2.1.3 Reaction time in relation to 14.2.1.3 is the time it takes the spotter to react to fires and related hazards.

N A.14.3.2.3 Typically, preventing loss of any part during use is achieved by using fireproof materials in construction.

N A.14.3.3.1 Shafted props can include clubs or staffs.

N A.14.3.4 Connectors that could be exposed to heat should be made of materials that are resistant to the heat of the effect. Examples of materials that should not be used are plastics, drop forged metal, or spring metal.

N A.14.3.5.1 An approved area is an area that is away from unauthorized personnel, well ventilated, and free of ignition sources. Where practicable, attachments should be used to catch fuel before it hits the ground.

N A.14.3.6 Suitable materials or methods can be a safety towel or damp cloth, flame-treated cloth, or high-heat material.

N A.14.5.2 An approved testing method might be in accordance with NFPA 705.

A.16.2.1 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.16.3 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 General. 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 **AHJ** (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 guidelines outlined in C.2.1.1 and C.2.1.2.

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(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) 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 guidelines outlined in C.2.2.1 through C.2.2.4.

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.

- ience 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 that 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 includes 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 PME and that the removal of the 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

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

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

NFPA 30, *Flammable and Combustible Liquids Code*, 2021 edition.

NFPA 54, *National Fuel Gas Code*, 2021 edition.

NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, 2020 edition.

NFPA 58, *Liquefied Petroleum Gas Code*, 2020 edition.

NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)*, 2019 edition.

NFPA 101®, *Life Safety Code®*, 2021 edition.

NFPA 400, *Hazardous Materials Code*, 2019 edition.

NFPA 495, *Explosive Materials Code*, 2018 edition.

NFPA 705, *Recommended Practice for a Field Flame Test for Textiles and Films*, 2018 edition.

NFPA 1122, *Code for Model Rocketry*, 2018 edition.

NFPA 1123, *Code for Fireworks Display*, 2018 edition.

NFPA 1125, *Code for the Manufacture of Model Rocket and High-Power Rocket Motors*, 2017 edition.