DELETED

Second Revision No. 28-NFPA 11-2023 [Detail]

[If this proposed revision passes, it will be added at the end of section H.1.]

Places to find additional information on SFFF testing include, but are not limited to, the following:

(1) SERDP/ESTCP. www.serdp-estcp.org

(2) Fire Protection Research Foundation (FPRF) - Firefighting Foams:Fire Service Roadmap. https://www.nfpa.org/News-and-Research/Resources/Fire-Protection-Research-Foundation/Current-projects/Firefighting-Foams-Fire-Service-Roadmap

(3) LASTFIRE. www.lastfire.org.uk

(4) Federal Aviation Administration. www.faa.gov

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Thu May 25 22:48:19 EDT 2023

Committee Statement

Committee Statement: Based on the other proposed change to Annex H, a list of places where additional testing information can be found is necessary.

Response Message: SR-28-NFPA 11-2023

Second Revision No. 25-NFPA 11-2023 [Section No. 1.3]

1.3 Application.

This standard is not applicable to the following types of systems:

(1) Chemical foams and systems (considered obsolete)

(2) Combined agent systems

(3) Mobile foam apparatus *(See ~~NFPA 1901~~ NFPA 1900)*

(4) Class A foam and systems *(See NFPA 1150)*

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Thu May 25 22:15:43 EDT 2023

Committee Statement

Committee Statement: NFPA 1901 has been consolidated into the new NFPA 1900 standard.

Response Message: SR-25-NFPA 11-2023

Second Revision No. 1-NFPA 11-2023 [Chapter 2]

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 13, *Standard for the Installation of Sprinkler Systems,* 2022 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* ~~2023~~ 2024 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 2022 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* 2022 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection,* 2023 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances,* 2022 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 2023 edition.

NFPA 30, *Flammable and Combustible Liquids Code,* 2024 edition.

NFPA 70®, National Electrical Code®, 2023 edition.

NFPA 72®, National Fire Alarm and Signaling Code®, 2022 edition.

NFPA 220, *Standard on Types of Building Construction,* 2024 edition.

NFPA 409, *Standard on Aircraft Hangars,* 2022 edition.

NFPA 1150, *Standard on Foam Chemicals for Fires in Class A Fuels,* 2022 edition.

NFPA 1900, *Standard for Aircraft Rescue and Firefighting Vehicles, Automotive Fire Apparatus, Wildland Fire Apparatus, and Automotive Ambulances,* 2024 edition.

~~NFPA 1901, *Standard for Automotive Fire Apparatus,* 2016 edition.~~

NFPA 1961, *Standard on Fire Hose,* 2020 edition.

NFPA 1963, *Standard for Fire Hose Connections,* 2019 edition.

2.3 Other Publications.

2.3.1 API Publications.

American Petroleum Institute, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001-5571.

API STD 607, *Fire Test for Quarter-turn Valves and Valves Equipped with Nonmetallic Seats*, ~~2016~~ 2022 .

API STD 650, *Welded Tanks for Oil Storage*, 2020.

2.3.2 ASME Publications.

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

ASME *Boiler and Pressure Vessel Code*, ~~2021~~ 2023 .

ASME B1.20.1, ~~*Standard for*~~ *Pipe Threads, General Purpose (Inch)*, 2018.

ASME B16.1, *Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250*, 2020.

ASME B16.3, *Malleable Iron Threaded Fittings Classes 150 and 300*, 2021.

ASME B16.4, *Gray Iron Threaded Fittings Classes 125 and 250*, 2021.

ASME B16.5, *Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard*, 2020.

ASME B16.9, *Factory-Made Wrought Buttwelding Fittings*, 2018.

ASME B16.11, *Forged Fittings, Socket-Welding and Threaded*, ~~2016, Errata, 2017~~ 2021 .

ASME B16.15, *Cast Copper Alloy Threaded Fittings Classes 125* and 250, 2018.

ASME B16.24, *Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves Classes 150, 300, 600, 900, 1500, and 2500*, ~~2016~~ 2021 .

ASME B16.25, *Buttwelding Ends*, 2017.

ASME B31.1, *Power Piping*, ~~2020~~ 2022 .

2.3.3 ASTM Publications.

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

ASTM A53/A53M *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*, ~~2020~~ 2022 .

ASTM A135/A135M, *Standard Specification for Electric Resistance-Welded Steel Pipe*, 2021.

ASTM A234/A234M, *Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High-Temperature Service*, ~~2019~~ 2023a .

ASTM A312/A312M, *Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes*, ~~2021~~ 2022a .

ASTM A795/A795M, *Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use*, 2021.

ASTM B43, *Standard Specification for Seamless Red Brass Pipe, Standard Sizes*, 2020.

ASTM B315, *Standard Specification for Seamless Copper Alloy Pipe and Tube*, 2019.

ASTM C582, *Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment*, ~~2009, reapproved 2016~~ 2023 .

ASTM D323, *Standard Test Method for Vapor Pressure of Petroleum Products (Reid Method)*, 2020.

ASTM D1331, *Standard Test Methods for Surface and Interfacial Tension of Solutions of Paints, Solvents, Solutions of Surface-Active Agents, and Related Materials*, 2020.

ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, ~~2021~~ 2023 .

IEEE/ASTM SI10, *American National Standard for ~~the Use of the International System of Units: The Modern~~ Metric ~~System~~ Practice* , 2016.

2.3.4 AWS Publications.

American Welding Society, 8669 NW 36 Street, #130, Miami, FL 33166-6672.

AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification*, 2021.

2.3.5 IEEE Publications.

IEEE, ~~Three Park Avenue, 17th Floor, New York, NY 10016-5997~~ Operations Center, 445 Hoes Lane, Piscataway, NJ 08854-4141 .

IEEE 45, *Recommended Practice for Electric Installations on Shipboard*, 2002.

2.3.6 IMO Publications.

International Maritime Organization, 4 Albert Embankment, London, SE1 7SR, United Kingdom.

SOLAS Regulations II-2, *Safety of Life at Sea*, 4.3 and 4.3.5.

2.3.7 ISO Publications.

International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland.

ISO 7–1, *Pipe Threads Where Pressure-Tight Joints Are Made on the Threads — Part 1: Dimensions, Tolerances and Designation*, 1994, technical corrigendum 1, 2007.

2.3.8 UL Publications.

Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 162, *Foam Equipment and Liquid Concentrates*, 2018, revised 2022.

2.3.9 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, ~~2003~~ 2020 .

2.4 References for Extracts in Mandatory Sections.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2022 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 2023 edition.

NFPA 30, *Flammable and Combustible Liquids Code,* ~~2021~~ 2024 edition.

NFPA 820, *Standard for Fire Protection in Wastewater Treatment and Collection Facilities,* ~~2020~~ 2024 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems,* 2022 edition.

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Mon May 15 23:02:41 EDT 2023

Committee Statement

Committee Statement: Revised to align with the latest editions of all referenced publications.

Response Message: SR-1-NFPA 11-2023

Public Comment No. 3-NFPA 11-2022 [Section No. 2.3.3]

Second Revision No. 20-NFPA 11-2023 [Section No. 3.1]

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.~~

3.1.1

The definitions contained in this chapter shall apply to the terms used in this standard.

3.1.2

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.

3.1.3

Merriam-Webster's Collegiate Dictionary, 11th edition, shall be the source for the ordinarily accepted meaning.

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Thu May 25 21:42:14 EDT 2023

Committee Statement

Committee Statement: Revised to comply with the MOS.

Response Message: SR-20-NFPA 11-2023

Second Revision No. 4-NFPA 11-2023 [Section No. 3.3.3.3]

3.3.3.3* Type II Discharge Outlet.

~~An approved discharge device that forcefully applies foam with less submergence into the fuel than a Type III application and without losses from applying the foam from outside the tank~~ A fixed device that delivers foam onto the burning liquid surface, partially submerging the foam and producing restricted agitation of the fuel surface .

A.3.3.3.3 Type II Discharge Outlet.

Examples of Type II discharge outlets include foam chambers and foam makers.

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Tue May 16 12:27:31 EDT 2023

Committee Statement

Committee Statement: Revised the definition to align with how the term is used throughout the industry. The revision aligns with language in UL 162. Type II minimizes submergence, which would not be considered forceful discharge.

Added examples of Type II Discharge Outlets to the annex for clarity.

Response Message: SR-4-NFPA 11-2023

Public Comment No. 5-NFPA 11-2023 [Section No. 3.3.3.3]

Public Comment No. 7-NFPA 11-2023 [New Section after A.3.3.3.2]

Second Revision No. 5-NFPA 11-2023 [Section No. 3.3.3.4]

3.3.3.4* Type III Discharge Outlet.

~~Portable monitors or nozzles that deliver foam forcefully onto the liquid surface with~~ A fixed or portable device that delivers foam onto the surface of the burning liquid and does so in a manner that causes general agitation, submergence of the foam ~~into the fuel~~ , and considerable disturbance of the foam on the surface.

A.3.3.3.4 Type III Discharge Outlet.

~~This application type also involves foam losses outside the tank due to wind and other issues~~ Examples of Type III discharge outlets include hose stream (handline) nozzles, monitor nozzles, and fixed nozzles .

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Tue May 16 12:30:17 EDT 2023

Committee Statement

Committee Statement: Revised the definition to align with how the term is used throughout the industry. The revision aligns with language in UL 162. This definition is applicable to both fixed and portable equipment.

Revised A.3.3.3.4 to align with changes made to the definition of Type III discharge outlets, and added examples for clarity.

Response Message: SR-5-NFPA 11-2023

Public Comment No. 6-NFPA 11-2023 [Section No. 3.3.3.4]

Public Comment No. 8-NFPA 11-2023 [Section No. A.3.3.3.4]

Second Revision No. 10-NFPA 11-2023 [Section No. 3.3.11.8]

3.3.11.8* Synthetic Fluorine-Free Foam (SFFF) Concentrate .

Foam concentrate based on a mixture of hydrocarbon surface active agents that is not formulated to contain per- or polyfluoroalkyl substances (PFAS).

A.3.3.11.8 Synthetic Fluorine-Free Foam (SFFF) Concentrate .

Contamination of per- and polyfluoroalkyl substances (PFAS) from equipment previously used with fluorinated foam concentrates or from environmental sources can potentially be found in synthetic fluorine-free foam concentrates that were not specifically ~~manufactured~~ formulated using these substances.

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Tue May 16 12:41:43 EDT 2023

Committee Statement

Committee Statement: Added the term “concentrate” to remain consistent with the other types of foam concentrates within the standard. Revised “manufactured” to “formulated,” as it clarifies the guidance.

Response Message: SR-10-NFPA 11-2023

Second Revision No. 18-NFPA 11-2023 [Sections 3.3.16.2.1.2, 3.3.16.2.1.3, 3.3.16.2.1.4]

3.3.16.2.1.2* Foam-Water Dry Pipe System.

A foam-water sprinkler system employing automatic sprinklers ~~or nozzles~~ that are attached to a piping system that contains air or nitrogen under pressure, the release of which (as from the opening of a sprinkler) permits the water pressure to open a valve known as a dry pipe valve.

3.3.16.2.1.3* Foam-Water Preaction System.

A foam-water sprinkler system employing automatic sprinklers ~~or nozzles~~ attached to a piping system containing air that might or might not be under pressure, with a supplemental detection system installed in the same area as the sprinklers.

3.3.16.2.1.4* Foam-Water Spray System.

A ~~foam-water sprinkler system designed to use nozzles rather than sprinklers~~ piping network that employs open water spray nozzles or automatic water spray nozzles to discharge a foam solution .

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Thu May 25 09:30:05 EDT 2023

Committee Statement

Committee Statement: Nozzles are not used in Foam-Water Dry Pipe or Foam-Water Preaction systems, and the term is removed to avoid confusion.

The definition of Foam-Water Spray system is revised to more accurately describe these types of systems.

Response Message: SR-18-NFPA 11-2023

Public Comment No. 11-NFPA 11-2023 [Section No. 3.3.16.2.1.2]

Public Comment No. 12-NFPA 11-2023 [Section No. 3.3.16.2.1.3]

Public Comment No. 13-NFPA 11-2023 [Section No. 3.3.16.2.1.4]

Second Revision No. 9-NFPA 11-2023 [Sections 3.3.23.1, 3.3.23.2]

3.3.23.1* Fixed Monitor ~~(Cannon)~~ .

A device that delivers a ~~large~~ foam stream and is mounted on a stationary support that either is elevated or is at grade.

A.3.3.23.1 Fixed Monitor ~~(Cannon)~~ .

The monitor can be fed solution by permanent piping or hose.

3.3.23.2 Portable Monitor ~~(Cannon)~~ .

A device that delivers a foam ~~monitor~~ stream and is mounted on a movable support or wheels so it can be transported to the fire scene.

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Tue May 16 12:37:18 EDT 2023

Committee Statement

Committee Statement: Removal of the word "Cannon" is acceptable and consistent with industry use.
Removed the term “large” from 3.3.23.1, as it adds confusion to the definition.
Removed the term “monitor” from 3.3.23.2 to align with the correct term “foam stream” with 3.3.23.1, which is consistent with how the term is used in the industry.

Response Message: SR-9-NFPA 11-2023

Public Comment No. 14-NFPA 11-2023 [Section No. 3.3.23.1]

Public Comment No. 15-NFPA 11-2023 [Section No. 3.3.23.2]

Public Comment No. 16-NFPA 11-2023 [Section No. A.3.3.23.1]

Second Revision No. 11-NFPA 11-2023 [New Section after 4.3.2.5.2.2]

4.3.2.5.2.3

Other methods of storage, places of storage, or time frames for obtaining the reserve supply shall be permitted with written approval from the AHJ.

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Tue May 16 12:53:18 EDT 2023

Committee Statement

Committee Statement: New text allows options for how the reserve supply is stored, where the reserve supply is stored, and how long it can take to get the reserve supply to the premises. This provides flexibility when considering the need to put the system(s) back in service immediately verses the cost of buying and storing the reserve supply on site, or having it delivered to the site within 24 hours. However, these options must be approved in writing by the authority having jurisdiction (AHJ).

Response Message: SR-11-NFPA 11-2023

Public Comment No. 25-NFPA 11-2023 [New Section after 4.3.2.5.2.2]

Second Revision No. 13-NFPA 11-2023 [Section No. 4.3.2.5.2.2]

4.3.2.5.2.2*

The reserve supply shall be in separate tanks or compartments, in drums or cans on the premises, or shall be able to be obtained from an approved outside source within 24 hours.

A.4.3.2.5.2.2

Reliance on any single external source might not be sufficient to satisfy a 24-hour resupply requirement.

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Tue May 16 14:00:04 EDT 2023

Committee Statement

Committee Statement: The global pandemic and recent catastrophes have highlighted that resupply from a single external source may take more than 24 hours and sufficient planning is necessary to assure timely resupply.

Response Message: SR-13-NFPA 11-2023

Public Comment No. 21-NFPA 11-2023 [New Section after A.4.3.2.4.2]

Second Revision No. 12-NFPA 11-2023 [Section No. 5.2.4.2.1.1]

5.2.4.2.1.1*

~~To determine~~ When determining actual solution flow requirements, the calculations shall include consideration ~~shall be given to~~ for potential foam losses ~~from~~ due to wind~~,~~ and other ~~factors shall be included in the calculations~~ ambient conditions .

A.5.2.4.2.1.1

Examples of ambient conditions include temperature, atmospheric pressure, humidity, and precipitation.

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Tue May 16 13:39:42 EDT 2023

Committee Statement

Committee Statement: Revised the sentence structure of the requirement for clarity. Added ambient conditions because wind might not be the only factor that needs to be accounted for. Added examples of ambient conditions to clarify the requirement.

Response Message: SR-12-NFPA 11-2023

Public Comment No. 19-NFPA 11-2023 [Section No. 5.2.4.2.1.1]

Second Revision No. 19-NFPA 11-2023 [Section No. 5.2.5.1.2]

5.2.5.1.2*

Where two or more discharge outlets are required, the outlets shall be spaced equally around the tank periphery.

A.5.2.5.1.2

Care must be taken to ensure that the foams selected are listed for those applications. See *LASTFIRE Ongoing Testing of New Generation Foams DFW Large Scale Extended Flow Test Report* , and *LASTFIRE Research 2021-2022 Large Test Pit Full Report* , Issue 1, for supporting test data.

5.2.5.1.2.1

Outlets shall be individually piped and separately valved for isolation outside the dike area in accordance with 10.5.1.

5.2.5.1.2.2

Each outlet shall be sized to deliver foam at the minimum application rate or higher.

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Thu May 25 09:45:38 EDT 2023

Committee Statement

Committee Statement: Added A.5.2.5.1.2 for clarification. Relocated LASTFIRE report from A.5.2.6.2.4, as this is the correct location. Added a second LASTFIRE report that gives additional relevant information.

Response Message: SR-19-NFPA 11-2023

Second Revision No. 16-NFPA 11-2023 [Section No. 5.2.6.2.4]

5.2.6.2.4

Where two or more outlets are required, they shall be located so that the foam travel on the surface cannot exceed 100 ft (30 m).

~~**A.5.2.6.2.4**~~

~~Fire tests have proven that most types of firefighting foam applied by monitors, fixed foam appliances, and compressed air foam appliances can and will travel over a burning fuel surface greater than 100 ft (30 m). Test results show that travel of 130 ft (40 m) to as much as 150 ft (46 m) is possible. See *LASTFIRE Ongoing Testing of New Generation Foams DFW Large Scale Extended Flow Test Report* for supporting test data.~~

Submitter Information Verification

Committee: FOM-AAA
Submittal Date: Tue May 16 15:19:29 EDT 2023

Committee Statement

Committee Statement: Relocated material to the correct section, so it is deleted here.
Response Message: SR-16-NFPA 11-2023

Second Revision No. 21-NFPA 11-2023 [Section No. 5.6.5.3.1 [Excluding any Sub-Sections]]

Minimum foam application rates and discharge times for loading racks protected by monitor nozzles shall be as specified in Table 5.6.5.3.1.

Table 5.6.5.3.1 Minimum Application Rates and Discharge Times for Loading Racks Protected by Foam Monitor Nozzle Systems

Foam Type	Minimum Application Rate		Minimum Discharge Time (minutes)	Product Being Loaded
	gpm/ft^2	mm/min*		
Protein, ~~and~~ fluoroprotein, and SFFF ‡	0.16	6.5	15	Hydrocarbons
AFFF, FFFP, and alcohol-resistant AFFF or FFFP	0.10	4.1	15	Hydrocarbons
Alcohol-resistant foams[1]	~~Consult manufacturer for listings on specific products~~		15	Ignitible liquids requiring alcohol-resistant foam

*L/min·m^2 is equivalent to mm/min.

‡ Consult manufacturer for listings on specific products.

Supplemental Information

File Name	Description	Approved
11_FOM_AAA_F2023_SDM_5.6.5.3.1.docx	For staff use only	

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Thu May 25 21:51:40 EDT 2023

Committee Statement

Committee Statement: Added SFFF to the table, as it is used in these situations. Moved the consultation of manufacturer's listing to a subscript, as it applies to multiple items.

Response Message: SR-21-NFPA 11-2023

Public Comment No. 17-NFPA 11-2023 [Section No. 5.6.5.3.1 [Excluding any Sub-Sections]]

Second Revision No. 22-NFPA 11-2023 [Section No. 5.8.1.2 [Excluding any Sub-Sections]]

Once this area has been determined, Table 5.8.1.2 shall be used to calculate requirements to be used as design criteria for portable nozzles or monitors.

Table 5.8.1.2 Minimum Application Rates and Discharge Times for Nondiked Spill Fire Protection Using Portable Foam Nozzles or Monitors

Foam Type	Minimum Application Rate		Minimum Discharge Time (minutes)	Anticipated Product Spill
	gpm/ft^2	mm/min*		
Protein, ~~and~~ fluoroprotein, and SFFF ‡	0.16	6.5	15	Hydrocarbon
AFFF, FFFP, and alcohol-resistant AFFF or FFFP	0.10	4.1	15	Hydrocarbon
Alcohol-resistant foams	~~Consult manufacturer for listings on specific products~~		15	Ignitible liquids requiring alcohol-resistant foam

*L/min·m^2 is equivalent to mm/min.

‡ Consult manufacturer for listings on specific products.

Supplemental Information

File Name	Description	Approved
11_FOM_AAA_F2023_SDM_5.8.1.2.docx	For staff use only	

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Thu May 25 21:54:28 EDT 2023

Committee Statement

Committee Statement: Added SFFF to the table, as it is used in these situations. Moved the consultation of manufacturer's listing to a subscript, as it applies to multiple items.

Response Message: SR-22-NFPA 11-2023

Public Comment No. 18-NFPA 11-2023 [Section No. 5.8.1.2 [Excluding any Sub-Sections]]

Second Revision No. 23-NFPA 11-2023 [Section No. A.1.1]

A.1.1

Firefighting foam is an aggregate of air-filled bubbles formed from aqueous solutions and is lower in density than ignitible liquids. It is used principally to form a cohesive floating blanket on ignitible liquids and prevents or extinguishes fire by excluding air and cooling the fuel. It also prevents reignition by suppressing formation of ignitible vapors. It has the property of adhering to surfaces, which provides a degree of exposure protection from adjacent fires. Foam can be used as a fire prevention, control, or extinguishing agent for ignitible liquid hazards. Foam for these hazards can be supplied by fixed piped systems or portable foam-generating systems. Foam can be applied through foam discharge outlets, which allow it to fall gently on the surface of the burning fuel. Foam can also be applied by portable hose streams using foam nozzles or large-capacity monitor nozzles or subsurface injection systems.

Foam can be supplied by overhead piped systems for protection of hazardous occupancies associated with potential ignitible liquid spills in the proximity of high-value equipment or for protection of large areas. The foam used for ignitible liquid spills is in the form of a spray or dense “snowstorm.” The foam particles coalesce on the surface of the burning fuel after falling from the overhead foam outlets, which are spaced to cover the entire area at a uniform density. *(For systems required to meet both foam and water spray design criteria, see Chapter 6.)*

Large-spill ignitible liquid fires can be fought with mobile equipment, such as an aircraft crash truck or industrial foam truck equipped with agent and equipment capable of generating large volumes of foam at high rates. Foam for this type of hazard can be delivered as a solid stream or in a dispersed pattern. Standards for industrial foam trucks ~~include~~ ~~NFPA 1901~~ , and standards for aircraft crash trucks include ~~NFPA 414~~ NFPA 1900 .

Foam does not break down readily and, when applied at an adequate rate, has the ability to extinguish fire progressively. As application continues, foam flows easily across the burning surface in the form of a tight blanket, preventing reignition on the surfaces already extinguished. Foam is not suitable for three-dimensional flowing liquid fuel fires or for gas fires.

To determine where foam protection is required, see applicable standards such as NFPA 30. Foam can be applied to protect the surface of an ignitible liquid that is not burning. The foam concentrate manufacturer should be consulted to determine the optimum method of application, rate of discharge, application density, and frequency of reapplication required to establish and maintain the integrity of the foam blanket.

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Thu May 25 22:09:45 EDT 2023

Committee Statement

Committee Statement: NFPA 414 and NFPA 1901 have been consolidated into NFPA 1900.

Response Message: SR-23-NFPA 11-2023

Second Revision No. 24-NFPA 11-2023 [Section No. A.3.3.16.3]

A.3.3.16.3 Mobile System.

For mobile systems, see ~~NFPA 1901~~ NFPA 1900 .

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Thu May 25 22:11:03 EDT 2023

Committee Statement

Committee Statement: NFPA 1901 has been consolidated into the new NFPA 1900 standard.

Response Message: SR-24-NFPA 11-2023

Second Revision No. 17-NFPA 11-2023 [Section No. A.5.2.4.3.2]

A.5.2.4.3.2

If application results in foam submergence, the performance of alcohol-resistant foams usually deteriorates significantly, particularly where there is a substantial depth of fuel. The degree of performance deterioration depends on the degree of water solubility of the fuel (i.e., the more soluble, the greater the deterioration). Special alcohol-resistant foams are available for polar solvents in depths greater than 1 in. (25 mm) in both ~~AFFF and SFFF~~ AR-AFFFs and AR-SFFFs. However, higher application rates might be required .

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Tue May 16 15:21:51 EDT 2023

Committee Statement

Committee Statement: Calling attention to the fact that higher application rates might be required per the manufacturers recommendations for AR-AFFFs and AR-SFFFs.

Response Message: SR-17-NFPA 11-2023

Second Revision No. 3-NFPA 11-2023 [Section No. A.6.1.2]

A.6.1.2

The uses of foam (or mechanical foam, as it was first called) for fire protection have increased greatly since it was first used in the 1930s. Original applications of this agent utilized a proteinaceous-type foam-forming liquid concentrate delivered in water solution to a turbulence-producing foam generator or nozzle that then directed the mechanically formed foam to a burning fuel tank or area of burning flammable fuel. (Details of these and similar applications are found in ~~NFPA 402~~ NFPA 440 and ~~NFPA 403~~ NFPA 460 .) As the technology for using this agent developed over the years, new systems and new devices for applying the foam to the hazard being protected and new foam-forming liquid concentrates were proven useful for fire protection purposes. The application of foam from overhead sprinkler-type systems using specially designed foam-making nozzles capable of either forming a foam from protein-type foam concentrate solutions or delivering a satisfactory water discharge pattern where supplied with water only was an early development (circa 1954) in foam fire protection. Protein, fluoroprotein, and aqueous film-forming concentrates or film-forming fluoroprotein foam concentrates are suitable for use with foam-water sprinklers. This latter type of foam concentrate also has been found to be suitable for use with standard sprinklers of the type referred to in NFPA 13 where the system is provided with the necessary foam concentrate proportioning equipment. Care should be exercised to ensure that the choice of concentrate and discharge device are listed for use together.

NFPA 11 is based on available test data and design experience concerning the design information, installation recommendations, operating methods, and maintenance needs for the types of foam-water sprinkler systems previously described and foam-water spray systems utilizing protein, fluoroprotein, or aqueous film-forming foam or film-forming fluoroprotein foam concentrates. These systems possess the common ability to either discharge foam in a spray form or discharge water in a satisfactory pattern for fire protection purposes.

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Tue May 16 08:54:32 EDT 2023

Committee Statement

Committee Statement: NFPA 402 and 403 have been consolidated into newly created NFPA 440 and 460 standards.

Response Message: SR-3-NFPA 11-2023

Second Revision No. 14-NFPA 11-2023 [Section No. D.5.2.3]

D.5.2.3 Water Equivalency Method.

In this approach, water is used as a surrogate liquid in place of foam concentrate. The initial acceptance test(s) are conducted with the actual foam concentrate using equipment similar to that shown in Figure D.5.2.2(b) and Figure D.5.2.2(g): real-time pressure, flow, and conductivity measurements are recorded with the actual foam concentrate to determine that the system is proportioning accurately. Immediately following this test, a water equivalency test at the exact same pressure and flows as in the initial foam discharge test is performed after isolating the foam concentrate tank. Example test setups are shown in Figure D.5.2.3(a) and Figure D.5.2.3(b). This provides a baseline for comparison using water only for follow-on routine inspections and tests. If the foam concentrate in the system is replaced with a different foam concentrate, proportioning system retesting is required using the new foam concentrate and then water to establish new foam concentrate/water equivalency factors.

Figure D.5.2.3(a) Test Setup Schematic for Initial and Follow-on Water Equivalency Tests with Bladder Tank System.

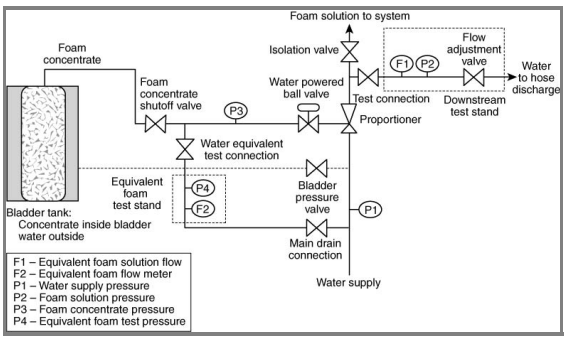
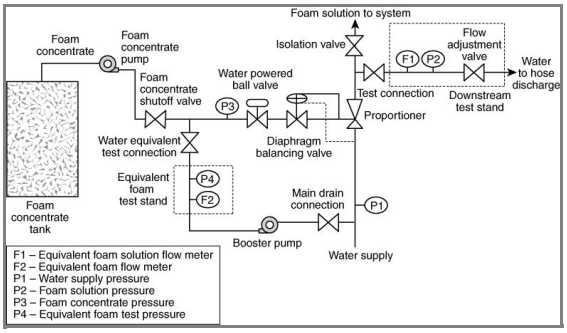


Figure D.5.2.3(b) Test Setup Schematic for Initial and Follow-on Water Equivalency Tests with Balanced Pressure Valve System.



~~This method is appropriate for use with aqueous film-forming foam (AFFF) and high-expansion foam. It should not be used with viscous foam concentrates such as alcohol-resistant aqueous film-forming foam (AR-AFFF).~~

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Tue May 16 14:43:37 EDT 2023

Committee Statement

Committee Statement: This method could also be used with AR-AFFF.

AR-AFFF and many new SFFF foam concentrates have very different viscosity and flow characteristics that will affect the proportioning system performance. A new set of foam concentrate/water correction factors must be developed each time the foam concentrate in the system is changed.

Response Message: SR-14-NFPA 11-2023

Public Comment No. 23-NFPA 11-2023 [Section No. D.5.2.3]

Second Revision No. 26-NFPA 11-2023 [Chapter E]

Annex E Foam Health, Safety, and Environmental Issues

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

E.1 General.

There has been a significant shift in the emphasis on environmental and health concerns associated with legacy foam products. The purpose of this annex is to provide the foam user community with high-level findings and information on the regulatory authorities that are objectively developing suggested solutions for the issues related to firefighting foam health, safety, and environmental issues.

In general, the chemicals contained in legacy fluorinated foams, such as AFFF, AR-AFFF, FFFP, etc. (i.e., fluorinated surfactants that are classified as PFAS), have come under significant health and environmental scrutiny.

Independent of the type of foam, emergency service personnel need to ensure that they are following the proper reporting [e.g., Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)], collection, and disposal requirements as directed by their local environmental protection agencies.

The approach of dilution and release into the environment ~~and/~~ or wastewater treatment systems is obsolete and unacceptable ~~going forward~~ for all fluorinated foams going forward . International, federal, state, and local jurisdictions are limiting the use and disposal of legacy ~~AFFF~~ fluorinated foams as a result of these concerns. Several states have implemented take-back programs for PFAS-containing foams. The local state environmental protection agency should be consulted to obtain more details on available take-back programs. Effective programs may be completely free of charge for pickup, transport, and safe disposal of all forms of legacy fluorinated foams.

The fire protection industry is working with environmental and health groups to develop an approach for assessing environmental and health concerns associated with the new synthetic fluorine-free foam (SFFF). Unfortunately, the development of a standardized approach is still in its infancy. Most assessments and approaches developed to date consist of comparing the list of chemicals in the foam concentrate to standard databases of chemicals that are known to be health hazards (e.g., persistent, bio-accumulative, toxic, carcinogen) or are known to have ecotoxicity issues. These assessments are typically based on composition data provided by the manufacturer, which is seldom ever empirically or analytically verified. Two such assessments are GreenScreen (https://www.greenscreenchemicals.org/) and the US EPA's Safer Choice (https://www.epa.gov/saferchoice). The new military specification for fluorine-free foam (MIL-PRF-32725) requires a health hazard assessment to be performed by the Navy and Marine Corp Public Health Center.

Since there are no widely enforced specific requirements on the health and environmental hazards of SFFF, other than possibly PFAS or fluorine content, it is typically left to the foam manufacturer to have the product assessed. In the future, this may change, and a list of the various certified products may become available. Until then, the end user will need to ask the manufacturer(s) for these types of certifications.

U~~.~~ S~~.~~ Department of Defense (DoD) and civil aviation authorities are also researching and implementing new restrictions on the use of these legacy products.

Most NFPA standards that cover foam fire suppression agents and systems are being revised to address these new trends and allow for flexibility going forward.

The criteria for defining an environmentally/toxicologically acceptable alternative ~~is~~ are still changing. Once an alternative is found, the industry will need to define the testing and metrics needed to validate it. With that said, there has been a significant shift to the use of ~~synthetic fluorine-free foam (~~ SFFF~~)~~ .

The following are key issues that should be evaluated when using existing legacy fluorinated foams~~, switching to AFFF C6 foams,~~ or switching to SFFF ~~foams~~ :

Firefighter Health and Safety. First responder exposure should be minimized using safer work practices and personal protective equipment (PPE~~).~~), independent of the type of foam used. In addition, rinsing procedures should be developed in case foam comes into contact with a person's eyes or skin. AFFF foams are believed to be primarily an ingestion hazard, with lower risks related to inhalation and only eye/skin irritation risk from dermal/skin contact. The following information is from the Interstate Technology Regulatory Council (ITRC) *PFAS Technical and Regulatory Guidance Document.*

Personal Protective Equipment. The use of PPE is highly recommended when exposure to

AFFF or other firefighting foams is possible. A critical aspect of PPE is ensuring the proper use of the equipment. The equipment should be used correctly and maintained and decontaminated routinely.

During the application or immediate cleanup of ~~AFFF~~ foam, the use of a self-contained breathing apparatus or positive pressure-supplied air respirator is recommended to avoid respiratory exposure. Dermal exposure should also be avoided, as skin contact can result in irritation and dryness. When responding to fires, first responders should wear appropriate turnout gear or proximity gear per their specific department requirements.

Respiratory Equipment . During the application of foam during an emergency, the use of a self-contained breathing apparatus is recommended to avoid respiratory exposure. This will protect the responder from respiratory hazards from the product on fire, as well as potential exposure to the foam.

PPE cleanup after using AFFF and other foams is discussed in the ~~Decontamination~~ decontamination section.

Decontamination. Although ~~PPE~~ firefighting bunker gear will prevent initial exposure to ~~AFFF,~~ foam, the possible PFAS contamination of the ~~PPE~~ bunker gear itself can present health risks. Decontamination of PPE and personal hygiene are crucial preventative measures in reducing or avoiding exposure ~~to AFFF and avoiding cross-contamination~~ .

When handling ~~AFFF~~ foam concentrate or foam solution , it is imperative to avoid hand-to-mouth contact. After the use or cleanup of ~~AFFF~~ foam , responders should wash their hands and use other decontamination procedures to remove any residual ~~AFFF~~ foam from their skin. Responders should also remove contaminated clothing and launder it before reuse.

PPE should be placed in a bag and container after exposure to AFFF and other foams. In 2020, NFPA released its latest edition of NFPA 1851, which provides guidance for the proper care of firefighting protective gear as well as the health hazards associated with improper maintenance or contamination of protective equipment. The standard outlines different decontamination measures for turnout gear and proximity gear.

Turnout gear is the general PPE for firefighting. It should be machine washed in warm water in the normal cycle. Turnout gear should be spot treated with warm water, a soft brush, and mild detergent prior to being machine washed. When hand washing and spot treating PPE, wear protective gloves—either latex or PVC—to avoid skin contact with any residual AFFF. No fabric softener or bleach should be used. Turnout gear should never be washed in home washing machines, as this practice has the potential to contaminate personal clothing. Advanced cleaning is suggested on at least a yearly basis ~~(Avsec, 2015)~~ .

Although PPE decontamination prior to reuse is important, it is equally important to recognize when decontamination is not possible. In that case, gear should be considered hazardous and be discarded in accordance with local, state, and federal regulations.

When decontaminating or laundering PPE, the disposition of the waste stream should be considered. The potential for environmental impacts due to laundering in washing machines is not well-defined, but the potential does exist. Regulatory agencies should consider implementing decontamination procedures when working with firefighters, refinery safety personnel, and other potential first responders to develop best management practices.

The following health information summary was developed after reviewing several safety data sheets for widely used AFFF and SFFF ~~foams~~ .

The following outlines the recommendations for PPE when handling firefighting foam. This applies to both foam concentrate and foam solutions.

General Precautions. Handle ~~PPE~~ foam in accordance with good industrial hygiene and safety practices for harmful chemicals. Avoid contact with skin~~;~~ . ~~if~~ If the foam concentrate or solution gets on the skin, wash it off as soon as possible. Do not ingest the foam solution or concentrate. Take off contaminated clothing and wash it before reuse.

~~All foam types, when used in the foam concentrate state such as loading and uploading, concentrated foam, during cleanup of foam spills or after use, during decontamination of personnel, PPE, or equipment after exposure (direct contact with foam concentrate or foam solution).~~

Respiratory Protection. ~~Do not inhale vapors/fumes. Respiratory protection is not needed under typical~~ During handling ~~conditions of firefighting foam concentrate. If vapors reach irritating levels, wear a NIOSH-approved respirator equipped~~ , such as filling containers or cleanup of foam, use air-purifying negative respirators or powered air-purifying respirators with organic vapor and amine cartridges for acute short-term exposures. Long-term exposures may require the use of positive pressure supplied air respirators or self-contained breathing apparatus .

Eye Protection. Wear eye protection (e.g., safety glasses, a full-face shield ~~with safety glasses~~ , or a full-face respirator~~.~~).

Skin Protection. To protect skin from exposure to foam, use the following:

~~Protective gloves and footwear~~

(1) Rubber, butyl rubber, or PVC gloves or equivalent impervious gloves

(2) Impervious boots

(3) Disposable Class C protective clothing ~~(e.g., Tyvek)~~ over normal work clothing (where large quantities or heavy contamination is likely)

~~Note: Fluorine-free foam chemicals have not been listed as carcinogenic by the U.S. National Toxicology Program, the International Agency for Research on Cancer (IARC), or the Occupational Safety and Health Administration (OSHA).~~

Review the firefighting foam manufacturer's SDS and hazard information for the specific foam being used and its applicable precautions. Follow the instructions on the SDS provided by the firefighting foam concentrate manufacturer if they are more protective than these minimum requirements. Such considerations should include the following:

(1) *Collection of firefighting foam after use*. Industry best practice is for all foams and fire water/foam runoff to be contained, collected, and disposed of based on federal, state, and local requirements, as well as the most current technical information as suggested in the references listed in the next two paragraphs. Foam discharge is easier to handle when there is an in-place collection capability (i.e., primary and secondary containment). This setup might be found in warehouses, tank farms, and firefighting training facilities. Where these facilities are not available, temporary diking is an alternative where time and resources permit.

The overall environmental impact of foam discharge requires additional evaluation and development of generally recognized guidance. Until recognized guidance is promulgated, users should rely on the manufacturer data and guidance from policy makers such as the ITRC and LASTFIRE. In all situations, discussions with environmental regulatory authorities are important.

~~Work is continuing to identify the appropriate policy and criteria to protect facilities that have typically been protected by foam suppression systems. These efforts are focusing on identifying the applicable codes and standards, analyzing the environmental impact, evaluating the alternatives, and revisiting the containment options.~~

(2) *Disposal of firefighting foams*. Legacy AFFF must be disposed of according to federal, state, and local regulations. As a general practice, AFFF waste (i.e., foam discharge, rinsate water, wastewater) should be contained and stored prior to disposal. ~~AFFF and PFAS waste can be either destroyed through a high-energy process or safely stored in a highly contained long-term waste facility.~~

In December 2020, the EPA released interim guidance on the destruction and disposal of PFAS and AFFF. This guidance included the following disposal recommendations based on current data:

(a) Interim storage (2–5 years) while alternative thermal destruction methods are developed

(b) Permitted deep well injection (Class I)

(c) Storage in permitted hazardous waste landfills (RCRA Subtitle C)

(d) Storage in solid waste landfills (RCRA Subtitle D) that have composite liners and leachate collection and treatment systems

The EPA plans to release revised recommendations for destruction technologies as early as 2023 via an updated guidance document. The EPA ~~does not recommend~~ is reviewing incineration as a form of destruction. Multiple states established regulations restricting incineration of AFFF as a disposal method and more restrictions are being proposed.

Several states have implemented take-back programs for PFAS-containing foams. Consult with your state environmental protection agency to obtain more details on available take-back programs. Some programs offer free pickup, transport, and safe disposal of all forms of legacy AFFF.

(3) *Documentation*. Due to the increasing restrictions and regulations related to AFFF, documentation is often required for any foam discharge, both accidental and intentional. Check ~~your~~ local and statewide regulations to determine the reporting required for any release of AFFF. This usually includes reporting details specific to the release of any AFFF ~~(intentional or accidental)~~ to state environmental agencies. The EPA regulations, such as the CERCLA or the Toxic Release Inventory (TRI), should be reviewed for potential additional requirements. The information required might include the type of foam, amount of foam released, fuel type, location, and containment measures used. It is recommended that release of SFFF be documented as well.

(4) *Procedures for decontaminating legacy equipment and acceptable levels of cleanliness*. ~~Trying to determine the level of cleanliness required continues to be an issue~~ Cleanliness requirements are not well defined and might need to be determined based on the regulators' direction or manufacturers' information. The EPA has proposed a 4 ppt maximum contaminant level (MCL) for six PFAS chemicals, including PFOA and PFOS, in drinking water. Unless equipment is properly cleaned, it could allow a new foam to continue to contaminate the environment. Clean levels might be in the parts per billion to trillion range. Testing and metrics will need to be defined to validate the level of cleanliness.

Equipment containing legacy AFFF needs to be cleaned prior to transitioning to a new foam or when it is being decommissioned. This might include storage tanks, fixed installation piping, fire trucks, or other aircraft rescue and firefighting equipment. The most common method of cleaning AFFF from firefighting equipment is rinsing with water. This method requires the draining and collection of the AFFF solution followed by a ~~triple-rinse~~ multiple rinses with PFAS-free water to ensure no foam concentrate remains. New chemical cleaners are being researched and developed to aid in this process. All rinsate should be stored and disposed of per all required local, state, and federal regulations.

As of ~~the end of 2021~~ early 2023 , there was no clear guidance for how clean final rinsate water needs to be to satisfy local regulators. ~~All rinsate should be stored and disposed of per all required local, state, and federal regulations.~~ The European Chemicals Agency (ECHA) proposed a limit on PFAS ~~concentration of 1 ppm. This can be achieved using a relatively simple~~ contamination for equipment cleaning ~~process and would prevent the majority of emissions~~ . Additional guidance for U~~.~~ S~~.~~ -based agencies is still being developed.

~~The environmental/health concerns associated with these chemicals are challenging for both toxicologists and regulators, as they require continued research and updated regulatory requirements are still changing.~~ Any users of firefighting foam should research the latest procedures and precautions for their use and disposal prior to placing it into service. The following are three organizations that have developed technically up-to-date and accurate information on this subject:

(1) The ITRC is a state-led coalition working to reduce barriers to the use of innovative air, water, waste, and remediation environmental technologies and processes. The ITRC produces documents and training that can help broaden and deepen technical knowledge and expedite quality regulatory decision making while protecting human health and the environment. With public and private sector members from all 50 states and the District of Columbia, the ITRC provides a national perspective. The issues associated with AFFF and the changes in the environmental/use landscape are well documented on the ITRC website. https://pfas-1.itrcweb.org/.

(2) The Office of the Secretary of Defense Strategic Environmental Research and Development Program and the Environmental Security Technology Certification Program (SERDP/ESTCP) are funding research for PFAS-free AFFF; detection, fate, and transport of PFAS; ecotoxicity; and PFAS treatment technologies~~, including~~ for equipment clean out and environmental remediation . More information is available at https://www.serdp-estcp.org/Featured-Initiatives/Per-and-Polyfluoroalkyl-Substances-PFASs.

(3) The LASTFIRE Project provided an independent and comprehensive assessment of fire-related risk in large, open-top, floating roof storage tanks, which resulted in a methodology by which site-specific fire hazard management policies can be developed and implemented. It, therefore, represents a major advancement in the knowledge about this risk. The LASTFIRE Foam Position Paper is available at http://lastfire.org.uk.

E.2 Discharge Scenarios.

The following are examples of scenarios that might include the use of foam, which are presented here to provide the user with ideas on how to handle these situations. The examples are not intended to be complete, as the science on how to handle these situations is changing very rapidly. Look at the information provided by the ITRC, DoD, and LASTFIRE and sources of current discharge handling approaches. The discharge of a foam-water solution is most likely to be the result of one of the four following scenarios:

(1) Manual firefighting or fuel-blanketing operations

(2) Training

(3) Foam equipment system and foam fire apparatus tests

(4) Fixed system releases

These four scenarios include events at such places as aircraft facilities, firefighter training facilities, and special hazards facilities (such as flammable/hazardous warehouses, bulk ignitible liquid storage facilities, and hazardous waste storage facilities). Each scenario is considered separately in E.2.1 through E.2.4.

E.2.1 Firefighting Operations.

Fires occur in many locations and under many different circumstances. In some cases, it is possible to collect the foam solution used to douse a fire after it has been put out~~;~~ . ~~in~~ In others, such as in marine firefighting, it is not. These incidents include aircraft rescue and firefighting operations, vehicular fires (i.e., cars, boats, train cars), structural fires involving hazardous materials, and ignitible liquid fires. A foam-water solution that has been used in firefighting operations will probably be heavily contaminated with the ~~fuel or~~ fuels involved in the fire. It is also likely to have been diluted with water discharged for cooling purposes.

In some cases, the foam solution used during fire department operations can be collected. However, it is not always possible to control or contain the foam. In situations in which it is not possible to control or contain foam due to the location, size, or circumstances of the incident, a non-persistent foam, such as SFFF, should be considered.

Event-initiated manual containment measures are usually executed by the responding fire department to contain the flow of a foam-water solution when conditions and manpower permit. Those operations include the following measures:

(1) *Blocking sewer drains*. This is a common practice used to prevent a contaminated foam-water solution from entering the sewer system unchecked. It is then diverted to an area suitable for containment.

(2) *Portable dikes*. These are generally used for land-based operations. They can be set up by fire department personnel during or after extinguishment to collect runoff.

(3) *Portable booms*. These are used for marine-based operations in the absence of better techniques and are set up to contain foam in a defined area. These operations generally involve the use of floating booms within a natural body of water. The boom contains the foam bubbles, but as the bubbles drain, the foam solution might not be contained and could spread into the rest of the body of water.

E.2.2 Training.

Legacy training facilities that have previously used AFFF are under significant environmental scrutiny due to potential groundwater contamination. Consequently, the use of fluorinated foams for training has been banned in a number of states and other areas of the world, with additional states likely to follow.

Going forward, and independent of the local, state, and federal requirements, using AFFF for training is strongly discouraged for several reasons, including the following:

(1) Repeated personal exposure to AFFF can increase a firefighter's risk of health impacts, including cancer

(2) Repeated application of AFFF to a training site can contaminate soil and groundwater

(3) Use of AFFF near wells or surface water bodies could contaminate drinking water

It is also recommended that fire departments make their firefighters aware of the dangers detailed above and track any exposure during training or at emergency scenes.

Over the past decade or so, training has transitioned away from using foam fire extinguishing products on large liquid fuel fires to using water hose lines to extinguish propane burner fires. This trade-off minimizes environmental exposure/contamination but is less effective for training, so it might need to be revisited.

Although the efficacy of the new SFFFs has been demonstrated in numerous research and development programs, the results also suggest that these new foams are not as forgiving as AFFF and could require more finesse when used manually. However, this performance gap can be reduced with the proper equipment, tactics, and training.

If the consensus is to revisit training with liquid fuels and foam products, the training should be conducted under circumstances conducive to the collection of effluent (i.e., fuel and spent foam). Only environmentally acceptable foam products should be used for training (i.e., no AFFF of any kind).

Some fire training facilities have elaborate systems designed and constructed to contain and collect effluent, separate fuel from the foam/water solution, treat it, and, in some cases, reuse the treated water. These types of capabilities will be required going forward if liquid fuels and foam solutions are used during training .

After the fuel and training foam solution ~~has~~ have been separated, the foam solution must be analyzed to determine if it can be diluted and discharged into a wastewater treatment facility for disposal. This requires the training facility to consult and work with the public works ~~and~~ , wastewater management organizations, and, potentially, regulators . If the effluent foam solution cannot be disposed of in the local wastewater treatment facility, it must be handled as hazardous waste and collected by a credible hazardous waste collection and disposal company, which can be very expensive.

The new SFFFs do not present a PFAS contamination risk; however, their chemical compositions need to be assessed on a case-by-case basis.

There are specially designed training foams available from most foam manufacturers that simulate firefighting foam during live training but have some level of environmental acceptance. These foams are biodegradable, have minimal environmental impact, and can be safely treated at a local wastewater treatment plant. These training foams have reasonable firefighting capabilities but typically provide reduced burnback protection. Firefighters and other foam users should work with the authority having jurisdiction (AHJ) to ensure that the use of training foams meets all the local and application-specific live training requirements. In some cases, training foams can also be used as substitutes for legacy fluorinated foams in vehicle and equipment testing.

E.2.3 System Tests.

Testing primarily involves engineered, fixed foam fire-extinguishing systems. Two types of tests are generally conducted on foam systems: acceptance tests, which are conducted pursuant to the installation of the system, and maintenance tests, which are usually conducted annually to ensure the operability of the system.

In the execution of both acceptance and maintenance tests, only a small amount of foam concentrate should be discharged to ensure the correct concentration of foam in the foam-water solution. Designated foam-water test ports can be included in the piping system so that the discharge of the foam-water solution can be directed to a controlled location. The controlled location might consist of a portable tank that is transported to an approved disposal site by a licensed contractor. The remainder of the acceptance test and maintenance test should be conducted using only water.

NFPA 11 explicitly recognizes proportioning test methods that limit or eliminate the need to discharge foam concentrate. These methods are permitted in 12.6.4.

E.2.4 Fixed System Releases.

This type of release is generally uncontrolled, whether it is the result of a fire incident or ~~a malfunction in~~ another issue with the system. The foam solution discharge in this scenario can be dealt with via event-initiated operations or engineered containment systems.

Event-initiated operations encompass the same temporary measures that are taken during fire department operations: portable dikes, floating booms, and so forth. Engineered containment is based mainly on the location and type of facility and consists of holding tanks or areas where the contaminated foam-water solution can be collected, treated, and disposed of properly.

E.3 Fixed Systems.

Facilities can be divided into those without an engineered containment system and those with an engineered containment system.

The choices for containment of foam-water solutions at such facilities fall into two categories: event-initiated manual containment measures and the installation of engineered containment systems. Selecting the appropriate option depends on the location of the facility, the risk to the environment, the risk of an automatic system discharge, the frequency of automatic system discharges, and any applicable rules or regulations.

E.3.1 Facilities Without Engineered Containment.

~~Given the absence of any past requirements for containment, many existing facilities allow foam-water solutions to flow out of the facilities and evaporate into the atmosphere or percolate into the ground. Steps should be taken to avoid this as part of future foam management planning.~~ Existing facilities without engineered containment need to develop foam management plans to prevent improper release of both AFFF and SFFF firefighting foam into the environment.

~~The choices for containment of foam-water solutions at such facilities fall into two categories: event-initiated manual containment measures and the installation of engineered containment systems. Selecting the appropriate option depends on the location of the facility, the risk to the environment, the risk of an automatic system discharge, the frequency of automatic system discharges, and any applicable rules or regulations.~~

Event-initiated manual containment measures ~~are the most likely option~~ will be required for existing facilities without engineered containment systems. This can fall under the responsibility of the responding fire department and include such measures as blocking storm sewers, constructing temporary dikes, and deploying temporary floating booms. The degree of such measures should be dictated by the facility's location, as well as the available resources and manpower.

The installation of engineered containment systems ~~is an option~~ should be considered and may be required for existing facilities~~, and there are cases that might warrant the design and installation of such systems~~ .

E.3.2 Facilities with Engineered Containment.

~~Any engineered~~ Engineered containment systems usually includes an oil/water separator. During normal drainage conditions (i.e., no foam solution runoff), the separator functions to remove any fuel particles from drainage water. However, when a foam-water solution is flowing, the oil/water separator should be bypassed so that the solution is diverted directly to storage tanks.

The size of the containment system should be dependent on the duration of the foam-water flow, the flow rate, and the maximum anticipated rainfall in the area. Most new containment systems only accommodate individual facilities. However, some containment systems can accommodate multiple facilities depending on the topography of the land and early identification during the overall site planning process.

The specific type of containment system selected should also depend on the location, desired capacity, and function of the facilities in question. The available systems include ~~earthen~~ engineered, lined containment retention systems, belowground tanks, open-top inground tanks, and sump and pump designs (i.e., lift stations) piped to aboveground or in-ground tanks. Storing spent foam below ground is not advisable due to the potential for leaks. Regular checks can reduce the risk of leaks, but even a small leak over time could result in contaminated soil.

~~Earthen retention designs consist of open-top earthen berms that usually rely on gravity-fed drainage piping from a protected facility. They allow the foam-water solution to be collected in an impermeable liner. Legacy foams should not be contained using earthen retention, as the soil can become contaminated.~~

Closed-top, belowground storage tanks usually consist of a gravity-fed piping arrangement that can also be used to suction pump contents out.

Open-top, belowground storage tanks are usually lined concrete tanks that rely on gravity-fed drainage piping or a sump and pump arrangement. These can accommodate individual or multiple facilities. They must also accommodate the maximum anticipated rainfall.

Aboveground tanks incorporate a sump and pump arrangement to closed, aboveground tanks. Such designs usually incorporate the use of one or more submersible or vertical shaft large-capacity pumps. These can accommodate individual or multiple facilities.

E.3.3 New Facilities.

~~The~~ Foam-water containment systems may be required by local, state, and federal regulations. In the absence of a requirement, the decision to design and install a fixed foam-water solution containment system should be dependent on the location of the facility, the risk to the environment, the possible impairment of facility operations, the design of the fixed foam system (i.e., automatically or manually activated), the ability of the responding fire department to execute event-initiated containment measures, and any pertinent regulations.

Where conditions warrant the installation of engineered containment systems, there are a number of considerations to take into account, including the size of the containment system, the design and type of containment system, and the capability of the containment system to handle individual or multiple facilities. Engineered containment systems can be used in facilities where foam extinguishing systems are installed immediately adjacent to a natural body of water. These systems might also be prudent at new facilities, where site conditions permit, to avoid impairment of facility operations.

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Thu May 25 22:18:38 EDT 2023

Committee Statement

Committee Statement: Revise Annex E to be consistent with the most current information available.

Response Message: SR-26-NFPA 11-2023

Second Revision No. 27-NFPA 11-2023 [Chapter H]

Annex H Synthetic Fluorine-Free Foam (SFFF) Research Testing ~~Summary~~

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

Detail SR-28

H.1 Overview.

Extensive testing has been done and additional testing is expected as different manufacturers and research organizations develop the next generation of fluorine-free firefighting foam for hydrocarbon/polar solvent fires. Testing has been conducted by the following three types of organizations:

(1) Foam manufacturers and research organizations

(2) User organizations or research organizations for those users such as LASTFIRE and US Naval Research Laboratory (NRL)

(3) Research or standard writing organizations such as the Fire Protection Research Foundation (FPRF), FM Approvals, and Underwriters Laboratories, Inc.

Places to find additional information on SFFF testing include, but are not limited to, the following:

(1) SERDP/ESTCP. www.serdp-estcp.org

(2) Fire Protection Research Foundation (FPRF) - Firefighting Foams:Fire Service Roadmap. https://www.nfpa.org/News-and-Research/Resources/Fire-Protection-Research-Foundation/Current-projects/Firefighting-Foams-Fire-Service-Roadmap

(3) LASTFIRE. www.lastfire.org.uk

(4) Federal Aviation Administration. www.faa.gov

~~**H.1.1**~~

~~Annex H covers testing conducted by two independent research organizations — LASTFIRE and the FPRF — to better understand the use of fluorine-free foams (FFFs) in extinguishing Class B ignitible liquid fires.~~

~~Many of the application characteristics of synthetic fluorine free foam (SFFF) are the same or similar to the application characteristics of protein foam, the major firefighting foam prior to the introduction of aqueous film forming foams (AFFF). Both work by applying bubbles of foam on the fire.~~

~~H.1.2~~

Following is a summary of researchers' findings so far and the key differences between AFFF and SFFF. More research is needed, not only about the properties of the existing FFFs, but also for the still-to-be-introduced alternative foam agents and their properties.

Drop-in replacements for AFFF and the common properties of each type of foam:

AFFF: Generally, listed AFFFs today have common properties and can be used interchangeably in proportioning and application systems with only minor change-out requirements (most manufacturers do not recommend mixing different AFFF, but this is done during emergency situations). Because their foam quality properties are common, one listed AFFF is a drop-in replacement for another listed AFFF.

SFFF: Generally, listed SFFFs today do not have common properties and cannot be used interchangeably in proportioning and application systems without first ensuring they will operate in AFFF equipment. Presently, there is no drop-in replacement SFFF for AFFF. The equipment would require reassessment to ensure that the proportioning and application nozzles operate correctly with the new foam. As in the early days of AFFFs, each SFFF is unique and cannot be used interchangeably with other SFFFs — they might not have the same density or viscosity properties. Users must work with foam suppliers to ensure the SFFFs and proportioning and application equipment work together.

Foam blanket versus foam blanket and foam film:

AFFF: As the name implies, AFFFs, when properly applied, provide both a blanket of foam solution and air bubbles that flows across the fuel and a film that flows from the bubbles to quickly cover the fuel surface. This characteristic makes AFFF especially useful in aircraft fire and rescue situations.

SFFF: SFFF, when properly applied, provides a blanket of foam solution and air bubbles that flows across the fuel. This foam does not produce a film agent.

Foam drain time:

AFFF: Drain time is relatively short — 10 to 15 minutes. This allows the foam bubbles to refresh the film, but the foam blanket/bubbles must be reapplied often. If the AFFF is being used for vapor suppression over a long period of time, a significant amount of foam concentrate is needed for AFFF reapplication.

SFFF: When properly applied, SFFF produces a blanket of foam that is robust and stays in the mixture longer — 30 minutes to several hours depending on how it is applied. This allows for less frequent reapplication than AFFF and results in lower foam concentrate use when SFFF is employed for vapor suppression.

Aspiration rate of the foam:

AFFF: Presently, most AFFFs are applied using non-air-aspirating nozzles, whether by fixed equipment, handline, or master stream application. This results in an air-aspiration ratio of between 3 to 5 times foam solution to air aspiration. For many reasons, this has worked successfully for AFFFs, but the addition of the film to assist the foam in extinguishing the fire is the most important one.

SFFF: SFFFs presently available appear to work much better on extinguishing Class B fires when applied using an air-aspirated nozzle, whether fixed equipment, handline, or master stream. This results in an air-aspiration ratio of at least 7 to 10 times foam solution to air aspiration. The SFFFs being tested at this time also appear to work much better when applied using compressed air foam technology with its more uniform bubble configuration.

Based on previous experience with protein foam, higher air-aspiration ratios in the 10 to 20 range could produce even more robust SFFFs.

Foam application range:

AFFF: Most AFFFs are applied using a nozzle that is not specifically designed to air-aspirate the foam. These AFFFs have a more concentrated liquid finished foam and, when applied, tend to have an application footprint similar to a water-only application. Chapter 5 requires the application rate to be increased by 50 percent to compensate for

the impact of wind and foam drop-out. Large master stream non-air-aspirated appliances are available that can deliver non-air-aspirated foam up to 400 ft to 500 ft (120 m to 150 m) effectively.

SFFF: When properly applied using handline and master stream nozzles, SFFFs should have a higher air-aspiration ratio and will not travel as far as a similar water stream application. Chapter 5 requires the application rate to be increased by 50 percent to compensate for the impact of wind and foam drop-out — a concept originally developed for protein-based foam. Large master stream air-aspirated appliances are available that can deliver air-aspirated foam up to 350 ft to 400 ft (105 m to 120 m) effectively.

H.2 Testing Conducted by the Fire Protection Research Foundation (FPRF).

H.2.1 General.

To provide data and guidance for foam system application standards, the FPRF contracted Jensen Hughes and the Naval Research Laboratory (NRL) to conduct an experimental program to assess the firefighting capabilities of fluorine-free, Class B firefighting foams on fires involving hydrocarbon and alcohol-based fuels. The objectives of this study were to determine the fire extinguishment and burnback times for five FFFs and one short-chain C6 AFFF formulation (for baseline) as a function of application rate (gpm/ft ^{2}) and foam discharge density (gal/ft ^{2}) for a range of test parameters, including foam quality and aspiration, fuel type, water type, and fuel temperature. The complete report is available at the FPRF website.

~~**H.2.2** Report Summary.~~

The assessment was conducted as a blind study. The foams were given generic names, and the manufacturers were not identified. The experimental approach consisted of conducting a parametric assessment of the critical variables that could affect the fire protection performance of new foam formulations using UL 162, *Foam Equipment and Liquid Concentrates* , as the basis for the investigation. Under UL 162, FFFs fall under the broad category of "synthetic (S)" foams and are defined as foams that have a chemical base other than a fluorinated surfactant or hydrolyzed protein. Because UL 162 was used as the basis of this assessment, the test parameters for synthetic foams were used.

The variables assessed during this program included the following:

- Two discharge types: UL Type II with polar solvents and UL Type III with other fuels
- Six foam types (all UL Listed): one alcohol-resistant C6 AFFF (AR-AFFF); three alcohol resistant FFFs (AR-FFF1, AR-FFF2, and AR-FFF3); and two hydrocarbon listed FFFs (H-FFF1 and H-FFF2)
- Four fuel types: heptane, gasoline (MIL SPEC and E10), and isopropyl alcohol (IPA)
- Fuel temperature: ambient temperature: 60°F (15°C); and high temperature: 85°F (30°C)
- Discharge densities: up to three discharge densities
- Two water types: freshwater and saltwater
- Two foam qualities: lower aspiration (3 to 4 expansion) and higher aspiration (7 to 8 expansion)

The tests were conducted in two series. Series I focused on assessing the capabilities of these foams at a lower foam quality and aspiration, representative of a nonaspirating discharge device. Series II reassessed the foams at a higher foam quality and aspiration, representative of an aspirating discharge device.

The assessment was conducted on approval scale size fires. A 50 ft^2 (4.65 m^2) square stainless-steel pan with sides 12 in. (30 cm) high was constructed. The pan was placed on concrete cinder blocks and skirted on three sides during each test. The pan was filled with the appropriate amount of fuel, typically 8 in. to 10 in. (20 cm to 25 cm) below the top of the pan.

During Type II tests, the nozzle was fixed, positioned, and aimed so that the spray impacted a backboard located on the opposite side of the pan. The nozzle remained fixed for the duration of the test. Most of the Type II tests were conducted using IPA as the test fuel with no water substrate.

During Type III tests, the foam nozzle was initially fixed and held still so that the spray impacted the fuel near the center of the fire pan until the intensity of the fire was reduced by approximately 90 percent (defined as control). Once the fire had been knocked down and controlled, the firefighter then manually directed the spray at the remaining fire in the pan while simultaneously cooling the sides. The firefighter was limited to two sides of the pan, and the nozzle was never allowed to extend over the edge of the pan as required by UL 162. The two types of tests are illustrated in Figure H.2.2(a) .

Figure H.2.2(a) Test Configurations.

During this assessment, 165 tests were conducted. To summarize the results, the baseline C6 AR-AFFF demonstrated consistent, superior firefighting capabilities through the entire test program under all test conditions. For the FFFs in general, the firefighting capabilities of the foams varied from manufacturer to manufacturer making it difficult to develop generic

design requirements. This might also be the case with AFFFs, but only one was tested during this program, yielding no data to assess variability.

During the series II tests, all three AR-FFFs successfully extinguished the fires at rates 10 percent to -20 percent below the UL-listed parameters. The successful tests are summarized in Table H.2.2(a) and shown graphically in Figure H.2.2(b) . All the Type II tests were conducted with the higher foam quality and aspiration rate.

Table H.2.2(a) Successful Type II Test Results (IPA)

Foam	Type of Discharge	Fuel Type	Water Type	Flow Rate	Exp. Ratio	Cont. sec	Cont. gal/ft ^{2}	Ext. sec	Ext. gal/ft ^{2}
AR-AFFF	Type II	IPA	Fresh	2.25 gpm	7-8	160	0.12	270	0.203
AR-AFFF	Type II	IPA	Salt	2.25 gpm	7-8	140	0.105	270	0.203
AR-FFF1	Type II	IPA	Fresh	8.0 gpm	7-8	135	0.36	275	0.733
AR-FFF1	Type II	IPA	Salt	8.0 gpm	7-8	96	0.256	215	0.573
AR-FFF2	Type II	IPA	Fresh	8.0 gpm	7-8	120	0.32	295	0.787
AR-FFF2	Type II	IPA	Salt	8.0 gpm	7-8	115	0.307	255	0.68
AR-FFF3	Type II	IPA	Fresh	5.0 gpm	7-8	100	0.167	270	0.45

For SI units, 1 gpm = 3.8 L/min; 1 gal/ft ^{2} = 40 L/m ^{2} .

Figure H.2.2(b) Type II IPA Foam Comparison.

The Type III tests were conducted with both higher and lower foam qualities and aspiration rates, using heptane, MILSPEC gasoline, and E10 gasoline.

Throughout this test program, heptane was shown to be the easiest of the test fuels to control and extinguish. The original five foams all met the UL 162 requirements at the design

and recommended flow rates with the higher aspirated foam (higher foam quality) using heptane as the fuel. Gasoline was shown to be more difficult to control and extinguish than heptane, with some FFFs requiring as much as a 50 percent increase in flow rate to extinguish the fire. The E10 gasoline was even harder to extinguish that the MILSPEC gasoline. The three AR-FFFs required a 50 percent increase in flow and application rate to extinguish the E10 fires. The two H-FFFs required a 25 percent increase in flow and application rate to extinguish the E10 fires. Surprisingly, the H-FFFs were able to extinguish the E10 fires at a lower rate than the AR-FFFs. Independent of the flow and application rate, the FFFs typically required about twice as much agent to extinguish the E10 fires as compared to the MILSPEC fires. In general terms and based on the extinguishment densities, it appears that MILSPEC gasoline is twice as hard to extinguish as heptane, and E10 gasoline is twice as hard as MILSPEC gasoline (four times as hard as heptane) for the FFFs. The results are summarized in Table H.2.2(b) and plotted in Figure H.2.2(c) .

Table H.2.2(b) Summary of Findings: Fuel Type and Agent Comparison — Higher Aspirated Foam with Freshwater

				Heptane		MILSPEC		E(10)	
Foam	Type of Discharge	Water Type	Exp. Ratio	Flow Rate	Ext. gal/ft^2	Flow Rate	Ext. gal/ft^2	Flow Rate	Ext. gal/ft^2
AR-AFFF	Type III	Fresh	7-8	3.0 gpm	0.051	3.0 gpm	0.065	3.0 gpm	0.06
AR-FFF1	Type III	Fresh	7-8	3.0 gpm	0.105	3.0 gpm	0.22	4.5 gpm	0.413
AR-FFF2	Type III	Fresh	7-8	3.0 gpm	0.107	3.0 gpm	0.21	4.5 gpm	0.383
AR-FFF3	Type III	Fresh	7-8	3.0 gpm	-	3.0 gpm	0.23	4.5 gpm	0.353
FFF1	Type III	Fresh	7-8	3.0 gpm	0.092	3.0 gpm	0.185	3.75 gpm	0.356
FFF2	Type III	Fresh	7-8	3.0 gpm	0.055	3.0 gpm	0.17	3.75 gpm	0.363

Figure H.2.2(c) Fuel Type and Agent Comparison — Higher Aspirated Foam with Freshwater.

~~One of the major findings of the study was the effect that foam quality and aspiration had on the capabilities of the FFFs. In general, lower foam quality and aspiration rates caused a 20 percent to 50 percent increase in extinguishment densities as compared to higher foam quality and aspiration rates and had a greater impact on the alcohol-resistant foams than the FFFs approved only for hydrocarbon fuels. In some instances, the reduced aspiration and foam quality required higher application rates to extinguish the fires. These findings are summarized in Table H.2.2(c) and illustrated in Figure H.2.2(d). Figure H.2.2(d) only illustrates data for the tests conducted using freshwater for the foam solution.~~

~~Table H.2.2(c) Foam Quality and Aspiration Comparison (MILSPEC Gasoline — Densities)~~

~~Foam~~	~~Type of Discharge~~	~~Fuel Type~~	~~Water Type~~	~~3 to 4 Expansion Ratio~~		~~7 to 8 Expansion Ratio~~	
				~~Flow Rate~~	~~Ext gal/ft^2~~	~~Flow Rate~~	~~Ext gal/ft^2~~
~~AR-FFF1~~	~~Type III~~	~~MILSPEC~~	~~Fresh~~	~~4.5 gpm~~	~~0.45~~	~~3.0 gpm~~	~~0.25~~
~~AR-FFF1~~	~~Type III~~	~~MILSPEC~~	~~Salt~~	~~4.5 gpm~~	~~0.375~~	~~3.0 gpm~~	~~0.26~~
~~AR-FFF2~~	~~Type III~~	~~MILSPEC~~	~~Fresh~~	~~4.5 gpm~~	~~0.39~~	~~3.0 gpm~~	~~0.255~~
~~AR-FFF2~~	~~Type III~~	~~MILSPEC~~	~~Salt~~	~~4.5 gpm~~	~~0.375~~	~~3.0 gpm~~	~~0.27~~
~~FFF1~~	~~Type III~~	~~MILSPEC~~	~~Fresh~~	~~3.0 gpm~~	~~0.165~~	~~3.0 gpm~~	~~0.15~~
~~FFF1~~	~~Type III~~	~~MILSPEC~~	~~Salt~~	~~3.0 gpm~~	~~0.29~~	~~3.0 gpm~~	~~0.21~~
~~FFF2~~	~~Type III~~	~~MILSPEC~~	~~Fresh~~	~~3.0 gpm~~	~~0.187~~	~~3.0 gpm~~	~~0.16~~

~~Figure H.2.2(d) Foam Quality and Aspiration Comparison — MILSPEC Gasoline and Freshwater.~~

~~During a study conducted for the FAA in the mid-90s, the firefighting capabilities (control and extinguishment times) of foam extinguishing agents were typically shown to follow an "L curve." An example L curve is shown in Figure H.2.2(e) .~~

~~Figure H.2.2(e) Firefighting Control and Extinguishment Times — L Curve.~~

~~From a performance standpoint, this curve makes perfect sense. When the foam is applied at a high rate, the fire is quickly controlled and extinguished, as illustrated by the right side of the plot where the performance levels off even though the foam is being applied at higher rates. As the application rate is reduced, the times tend to increase as the rate approaches a critical value. Specifically, the times asymptotically approach the rate where the foam is being consumed by the fire as fast as it is being applied. In Figure H.2.2(e) , this asymptotic value is just below 0.03 gpm/ft~~ $\stackrel{2}{=}$ ~~(1.2 L/min/m~~ $\stackrel{2}{=}$ ~~). These tendencies are used to describe the capabilities of the FFFs in the following paragraphs. The L curves for the foams included in this assessment — AR-AFFF, AR-FFFs, and H-FFFs — are shown in Figure H.2.2(f) for the hydrocarbon-based fuels — heptane, E10 gasoline, and MILSPEC gasoline.~~

~~Figure H.2.2(f) L Curves Illustrating Extinguishment Capabilities (Agent-Type Comparison).~~

~~When comparing the capabilities of the FFFs to the baseline AFFF at the same foam quality and aspiration, the FFFs typically required between 1.5 to 3 times the application rates to produce comparable performance for the fuels included in this assessment [heptane, gasoline (E10 and MILSPEC), and IPA]. When comparing the capabilities of the AR-FFFs to the H-FFFs, the H-FFFs were similar to the AR-FFFs at a 40-percent reduced flow rate for the lower expanded foam and a 30-percent reduced rate for the higher expanded foam. Consequently, the use of higher aspirated foam reduced the differences in capabilities between the two FFF types (i.e., alcohol-resistant and hydrocarbon FFFs). These capabilities are plotted in Figure H.2.2(f) as a function of foam type.~~

~~With respect to elevated fuel temperatures, the results were consistent over the range in ambient and fuel temperatures included in this assessment. With that said, it is understood that fires involving boiling ignitible liquids are much harder to extinguish than fires that are combatted prior to the transition into boiling. The type of water (i.e., freshwater versus saltwater) was also shown to have a minimal effect on the firefighting capabilities of the FFFs and varied between foams.~~

H.2.3 Key Points and Conclusions.

In summary, the results demonstrated that, while FFFs have come a long way, there is more to learn about their capabilities and limitations. As of today, FFFs are not a drop-in replacement for AFFFs. However, some can be made to perform effectively as an AFFF alternative with proper testing and design (i.e., with higher application rates and densities).

The baseline C6 AR-AFFF performed well against all test fuels included in this assessment — IPA, heptane, and gasoline (MILSPEC and E10). The FFFs did well against heptane but struggled against some of the scenarios conducted with IPA and gasoline (both MILSPEC and E10), especially when the foam was discharged with a lower foam quality and aspiration. The FFFs typically required between 1.5 to 3 times the application rates to produce comparable performance as the baseline AR-AFFF for the range of parameters included in this assessment. The extinguishment densities for the FFFs were typically 2 to 4 times greater than the baseline AR-AFFF for the IPA fires conducted with the Type II test configuration, 3 to 4 times greater than the baseline AR-AFFF for the tests conducted with MILSPEC gasoline, and between 6 to 7 times greater than the baseline AR-AFFF for the tests conducted with E10 gasoline.

With respect to the types of FFFs (i.e., alcohol-resistant versus hydrocarbon), the H-FFFs typically demonstrated better capabilities than the AR-FFFs. In general, for the tests conducted with the lower aspiration, the extinguishment densities for the AR-FFFs were about twice that of the H-FFFs. This difference was reduced with the use of the higher aspirated foams. For the tests conducted with the higher aspirated foams, the extinguishment densities for the AR-FFFs were, on average, about 1.5 times that of the H-FFFs. However, the AR-FFFs required a higher flow and application rate of 1.5 times that of the H-FFFs against the E10 fires to achieve those results.

The results also showed that the legacy fuel — heptane — used to list and approve foams might not be a good surrogate for all hydrocarbon-based fuels. Some foams struggled against other fuels, like gasoline, compared to heptane. Going forward, it was recommended that FFFs be tested and listed for a variety of hydrocarbon fuels, the approach currently used for polar solvent listings and approvals.

Due to its oleophobic properties, AFFF has two separate mechanisms that combine to aid in the extinguishment of an ignitible liquid fire: a water and surfactant film that forms on the fuel surface and a foam blanket of bubbles, both of which serve to seal in the flammable vapors resulting in extinguishment (i.e., shutting off the fuel vapors that are burning above the fuel surface). FFFs have only the foam blanket to seal in the vapors. As a result, the capabilities of FFFs will be highly dependent on the characteristics of the foam blanket, which depend on the associated discharge devices as well as the foam type itself. The film produced by AFFF has provided an additional level of protection for systems and discharge devices that do not produce aspirated foam. Additional attention will need to be given to the discharge devices identified as part of the UL listing when using these foams.

Ultimately, end users will need to design and install within the listed parameters to ensure a high probability of success during an actual event. This applies not only to the discharge devices but also to the proportioning systems, due to the highly viscous nature of some of the FFF concentrates.

H.3 Testing Conducted by LASTFIRE.

H.3.1 General.

Increasing environmental concerns related to fluorosurfactant-containing foams (PFAs) and the potential for regulatory controls have prompted a number of organizations to carry out extensive testing of new generation fluorine-free foams. In particular, the FPRF and LASTFIRE (the international Joint Industry Project developing best practice guidance for storage tank fire hazard management) conducted extensive complementary, independently managed testing. Key conclusions from LASTFIRE are summarized in this section but full reports are available from the respective organizations.

Because there are ongoing developments in this field, it is worthwhile to check for any updates in knowledge that might be relevant and assist in optimizing effectiveness prior to finalizing any foam application system design.

It should be noted that, while emphasis was placed on fluorine-free foams, testing was also carried out on new generation post-EPA stewardship program C6-based fluorosurfactant-containing foams. Such foams were developed to reduce the use of C8-based materials and minimize contamination levels of C8 fluorosurfactants in C6-based formulations. While such foams are film forming and generally work on the same principles as older formulations, they have not been subjected to the same levels of large-scale testing or actual incident application.

~~**H.3.2** Report Summary.~~

LASTFIRE carried out a range of testing, normally totally funded by the organization, but also as independent witnesses of work carried out by others, including foam and equipment suppliers. The objective was to provide a firm basis for future cost-effective, long-term, sustainable policies regarding the selection and use of firefighting foam based on rational, relevant, and independent end-user-driven test programs.

Following are the series of tests conducted, including logical progression from small-scale in accordance with recognized test standards through to large-scale, real-life scenarios using this standard's design guidelines for test protocol development. Full reports for most of the tests are available from LASTFIRE.

A series of small-scale tests of five different FFFs and both C6 and C8 (as a proven reference) fluorosurfactant-containing foams. This included testing to EN1568 (European norm) and LASTFIRE (a specific protocol designed by LASTFIRE to simulate storage tank fires) test protocols. Such tests were carried out at approximately 50 percent of the application rate used in practice based on recognized standards such as this standard.

Small-scale [50 ft^2 (5 m^2) and 200 ft^2 (20 m^2)] spill fires using the same foam concentrates with a number of application techniques, including plunging (Type 3) semi-aspirating "monitor," aspirating "monitor," medium expansion and compressed air foam nozzles, and system pourer nozzles (Type 2). These tests included obstructions in the pan to simulate pipework, and so forth, that might disrupt foam movement and cause additional hot surfaces to seal against.

Proportioning tests for the same foam concentrates using both venturi-based standard in-line proportioners and positive displacement pumped proportioning systems.

Large-scale tank [1080 ft^2 (100 m^2) surface area, 36 ft (11 m) diameter, 30 ft (9m) high] application using the same foams but at this standard's system design rates using aspirating monitors, nonaspirating monitors, system pourer, and CAF monitor application. Note: The CAF application rate was approximately 75 percent of the conventional foam application rate. These tests were intended to validate the smaller scale testing and demonstrate the effectiveness of new generation foams when used at typical application rates using proprietary equipment. FFFs successfully extinguished fires in these tests. *[See Figure H.3.2(a) .]*

Long-flow [100 ft (30 m) and 130 ft (40 m)] application on Jet A fuel using conventional pourer and CAF pourer applications at typical design application rates. Only one FFF was taken through to this test. The application rate for CAF pourer was 0.7 gpm/ft^2 (2 L/min/m^2), for conventional pourer 1.4 gpm/ft^2 (4 L/min/m^2). These tests successfully extinguished fires. *[See Figure H.3.2(b) .]* Some of the results are as follows:

Conventional foam pourer application at 1.4 gpm/ft^2 (4 L/min/m^2), extinguishment at 100 ft (30 m) flow – 2'32"

CAF based foam pourer application at 0.7 gpm/ft^2 (2 L/min/m^2), extinguishment at 100 ft (30 m) flow – 2'23"

Subsurface application of one FFF on Jet A fuel using a test procedure based on UL 162. Successful extinguishment was accomplished with both conventional and CAF-based applications. *[See Figure H.3.2(c) .]*

Vapor suppression tests with both FFF and C6 fluorosurfactant-containing foams in fire and nonfire situations, using an array of vapor detectors over the LASTFIRE test.

Hybrid monitor application using low expansion FFF to carry medium expansion foam further (claiming to lead to less forceful plunging into the fuel) than one FFF on 5650 ft^2 (525 m^2) diesel fire at typical application rates used in practice.

Bund length 65 ft (20 m) flow testing of one FFF in system pourer application using

approximately 75 percent of typical application rates — with extensive obstructions in the path of foam. Fire was successfully extinguished.

Testing of one additional FFF in a 36 ft diameter (11 m diameter), 6.6 ft (2 m) high tank at approximately 75 percent of normal design application rates. Fire was successfully extinguished.

Small-scale testing of a self-expanding foam (SEF) application system using FFF and the LASTFIRE test protocol adapted for SEF application. (SEF uses a premix foam solution held under CO_2 pressure. On actuation, the CO_2 comes out of solution and forms foam bubbles.)

Figure H.3.2(a) From LASTFIRE: FFF — 36 ft (11 m) Tank Fire Testing.

Figure H.3.2(b) A 98 ft (30 m) Flow Test Approaching Full Extinguishment.

Figure H.3.2(c) Extinguishing Sequence, FFF, Subsurface Injection.

Throughout the tests a variety of fuels were used, including heptane, gasoline, diesel, crude, Jet A-1, and ethanol. In addition, some tests included both saltwater and freshwater applications. At times compatibility with dry chemical was also assessed.

~~**H.3.3** Key Points and Conclusions.~~

~~LASTFIRE concluded that some FFFs are suitable for some applications, including hydrocarbon spill fires and smaller storage tanks subject to validated testing of the specific foam and application device. The LASTFIRE Group is confident that other applications can be proven with additional test work.~~

~~Further phases of testing are planned, including small-scale testing to optimize foam properties through equipment design, thereby maximizing extinguishing performance. In addition, further large-scale testing [165 ft (50 m) flow length] trials are to be carried out with a range of FFFs using both monitor and pourer applications.~~

~~These extensive testing programs have resulted in the following critical findings relevant to application of new generation foams. Although the focus is on FFFs, some apply to both "post-EPA stewardship" C6-based formulations.~~

~~With the current stage of development of FFFs and the wide range of products being developed, it is not possible to be generic in terms of the performance of this type of foam concentrate on any specific fuel. Thus, it is important to base any system design on recognized and scenario-relevant approval tests, including the appropriate fuel, ideally also validated by larger scale testing.~~

~~Foam performance is dependent on application equipment as well as foam concentrate and application rate. This is true with all foam types but appears to be particularly the case with FFF types. Undoubtedly, they all work more effectively with aspirating equipment, although LASTFIRE testing showed that some can work also with typical nonaspirating equipment.~~

~~Physical properties as well as firefighting performance are critical to ensuring appropriate performance. Some FFFs, particularly those having high viscosity, might require modifications to the proportioning system to ensure a pick-up rate within acceptable tolerances. No foam of any type should be regarded as a drop-in replacement without fully evaluating extinguishing performance and system and equipment suitability and compatibility.~~

~~Compressed air foam can provide effective extinguishing performance with FFF at lower application rates than conventionally generated foam — again, subject to validation through testing for a specific set of circumstances.~~

~~It is recognized that further work should be carried out on other fuel types, especially water soluble polar solvent fuels, including alcohols such as IPA. Note: The ETANKFIRE Project of the SP Technical Research Institute of Sweden carried out some small-scale testing of FFFs on ethanol, but larger scale work is required to develop and validate application design rules.~~

~~It is important that a validated test method specifically relevant to the application is used to determine system design characteristics wherever possible. Ideally a performance-based method should be used so that the end user can adjust parameters such as application rate, run time, or proportioning rate to suit the performance of the foam if necessary.~~

~~It is recognized that a major gap in knowledge still exists in the application of any new generation foam, but particularly FFF types to large diameter tank fires using large throughput monitors, especially nonaspirating types. While the comparative tests on smaller tank fires [36 ft (11 m) diameter] have shown effective performance can be achieved with some foam and equipment combinations, this has not been validated in larger scale testing.~~

Submitter Information Verification

Committee: FOM-AAA

Submittal Date: Thu May 25 22:45:39 EDT 2023

Committee Statement

Committee Statement: All of the information in Annex H is a summary of research reports on Synthetic Fluorine-Free Foam (SFFF) testing. The information can be located within the individual reports. Previous research that was deleted is outdated, and more research testing is now available. Rather than continually updating Annex H, it is easier to reference the relevant organizations and places to find the reports and information.

Response Message: SR-27-NFPA 11-2023

Public Comment No. 24-NFPA 11-2023 [Section No. H.3]

Second Revision No. 2-NFPA 11-2023 [Chapter J]

Annex J Informational References

J.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.

J.1.1 NFPA Publications.

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

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2022 edition.

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Submitter Information Verification

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Committee Statement

Committee Statement: Revised to align with the latest editions of all referenced publications. Added newly referenced publications from other proposed revisions.

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