

**NFPA®**

# 1150

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Standard on  
Foam Chemicals for Fires  
in Class A Fuels

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**2022**



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## NFPA® 1150

### Standard on

## Foam Chemicals for Fires in Class A Fuels

### 2022 Edition

This edition of NFPA 1150, *Standard on Foam Chemicals for Fires in Class A Fuels*, was prepared by the Technical Committee on Water Additives for Fire Control and Vapor Mitigation. It was issued by the Standards Council on July 8, 2021, with an effective date of July 28, 2021, and supersedes all previous editions.

This edition of NFPA 1150 was approved as an American National Standard on July 28, 2021.

### Origin and Development of NFPA 1150

The first edition of this document was issued in 1989 as NFPA 298, *Standard on Foam Chemicals for Wildland Fire Control*, in response to a perceived need for a performance standard dealing with the foam chemicals being used in controlling wildland fires. The 1994 edition was a complete revision to make the document consistent with the developing changes in Class A foam technology. The title was changed to *Standard on Fire Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas*.

In 1999, the document was again revised to reflect further advancements in technology and a greater number of Class A concentrates and delivery systems available for use. The document was renumbered as NFPA 1150, which put it within the numerical grouping of documents under the responsibility of the Technical Committee on Forest and Rural Fire Protection.

The 2004 edition was a complete revision to bring the document into conformance with the *Manual of Style for NFPA Technical Committee Documents*. The title was changed to *Standard on Foam Chemicals for Fires in Class A Fuels* to recognize that these chemicals are being used not only in rural and wildland areas but in structural fire fighting and urban areas as well. The test procedures for the chemicals as well as the lists of materials tested for compatibility with the chemicals were updated to ensure the product is consistent with the needs of fire suppression personnel who are using the chemicals to control, suppress, or prevent fires in Class A fuels.

In the 2010 edition, an entirely new section was added regarding exposure protection effectiveness of Class A foams and included a test methodology involving lateral ignition flame spread on substrate treated with foam solutions. That important information is useful for fire departments as well as manufacturers and producers of Class A foam products.

For the 2017 edition, a new section was created within Chapter 5 to provide requirements for alternate viscosity test methods for situations in which the viscosity is too low to obtain meaningful results. Editorial changes included updating the standard to comply with the *Manual of Style for NFPA Technical Committee Documents*.

For the 2022 edition, a new chapter has been added to identify qualifying fire test methodology for testing foam extinguishing agents for class A fires. This update guides the user on how the fire test should be conducted for testing, approval, and listing purposes. Editorial changes include updating references and extracted text.

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

**Committee Scope:** This Committee shall have primary responsibility for documents on the manufacture, testing, application, and use of water additives for the control and/or suppression of fire and flammable vapor mitigation including water additives used to prevent or reduce the spread of fire and the use of water additives in fixed, semi-fixed, mobile, and portable fire suppression systems.

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## NFPA 1150

## Standard on

## Foam Chemicals for Fires in Class A Fuels

2022 Edition

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

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

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

## Chapter 1 Administration

**1.1\* Scope.** This standard specifies requirements for Class A foam and the chemicals used to produce Class A foam that is used to control, suppress, or prevent fires in Class A fuels.

**1.2\* Purpose.**

**1.2.1** The purpose of this standard is to define the acceptance requirements and test methods for fire-fighting foam chemicals that are used to control, suppress, or prevent fires in Class A fuels.

**1.2.2** Acceptance requirements shall not be deemed as establishing performance levels in actual fire-fighting situations.

## 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. (Reserved)****2.3 Other Publications.**

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

ASTM D92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester*, 2018.

ASTM D97, *Standard Test Method for Pour Point of Petroleum Products*, 2017b.

ASTM D1331, *Standard Test Methods for Surface and Interfacial Tension of Solutions of Paints, Solvents, Solutions of Surface-Active Agents, and Related Materials*, 2014.

ASTM D2196, *Standard Test Methods for Rheological Properties of Non-Newtonian Materials by Rotational Viscometer*, 2018.

ASTM D2281, *Standard Test Method for Evaluation of Wetting Agents by the Skein Test*, 2010, reapproved 2016.

ASTM D4976, *Standard Specification for Polyethylene Plastics Molding and Extrusion Materials*, 2012a.

ASTM E3, *Standard Guide for Preparation of Metallographic Specimens*, 2011, reapproved 2017.

ASTM E407, *Standard Practice for Microetching Metals and Alloys*, 2011, reapproved 2015e1.

ASTM E729, *Standard Guide for Conducting Acute Toxicity Tests on Test Materials with Fishes, Macroinvertebrates, and Amphibians*, 1996, reapproved 2014.

ASTM E1321, *Standard Test Method for Determining Material Ignition and Flame Spread Properties*, 2018.

**2.3.2 EPA Publications.** Environmental Protection Agency, William Jefferson Clinton East Building, 1200 Pennsylvania Avenue, NW, Washington, DC 20460.

EPA Method 537.1, *Determination of Selected Per- and Polyfluorinated Alkyl Substances in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)*, 2018.

OPPTS 835.3110, "Ready Biodegradability," *Test, Fate, Transport and Transformation Test Guidelines*, January 1998.

OPPTS 850.1075, "Fish Acute Toxicity Test, Freshwater and Marine," *Ecological Effects Test Guidelines*, April 1996 (December 2002).

OPPTS 870.1100, "Acute Oral Toxicity," *Health Effects Test Guidelines*, August 2002.

OPPTS 870.1200, "Acute Dermal Toxicity," *Health Effects Test Guidelines*, June 1996.

OPPTS 870.2400, "Acute Eye Irritation," *Health Effects Test Guidelines*, August 1998.

OPPTS 870.2500, "Acute Dermal Irritation," *Health Effects Test Guidelines*, August 1998.

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

ISO 304, *Surface active agents — Determination of surface tension by drawing up liquid films*, 1985, confirmed 2019.

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*, 2017.

**2.3.4 NACE Publications.** NACE International, 15835 Park Ten Place, Houston, TX 77084-4906.

NACE TM0169, *Standard Guide for Laboratory Immersion Corrosion Testing of Metals*, 2012a.

**2.3.5 OECD Publications.** Organisation for Economic Cooperation and Development, 2, rue André-Pascal, 75775 Paris Cedex 16, France.

*OECD Principles of Good Laboratory Practice*, 1998.

**2.3.6 SAE Publications.** SAE International, Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

SAE AMS-3208N, *Chloroprene (CR) Rubber, Weather Resistant, 45–55*, 1942, stabilized 2014.

SAE AMS-C-9084, *Cloth, Glass, Finished for Resin Laminates*, 1999, reaffirmed 2013.

SAE AMS-DTL-23053/5B, *Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Flexible, Crosslinked*, 2012.

SAE AMS-S-8802E, *Sealing Compound, Fuel Resistant, Integral Fuel Tanks and Fuel Cell Cavities, High Adhesion*, 1999, revised 2019.

**2.3.7 UL Publications.** Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 711 CAN/ULC S508, *Rating and Fire Testing of Fire Extinguishers*, 2018.

**2.3.8 US Government Publications.** US Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001.

Title 40, Code of Federal Regulations, Part 160, "Good Laboratory Practice Standards."

Title 40, Code of Federal Regulations, Part 792, "Good Laboratory Practice Standards."

Federal Test Standard No. 601, *Rubber: Sampling and Testing*, 1985.

Wildland Fire Chemicals STP 2.2, "Lateral Ignition and Flame Spread Test (LIFT)," U.S.D.A. Forest Service, 2007.

**2.3.9 U.S. Military Specifications.** Defense Standardization Program Office, 8725 John J Kingman Road, Stop 5100, Fort Belvoir, VA 22060-6220.

MIL-A-A-55859A, *Tube, Nonmetallic, Polyvinyl Chloride (PVC), Flexible (General Use)*, October 31, 2002.

MIL-PRF-81733D, *Sealing and Coating Compound, Corrosion Inhibitive*, May 15, 1998.

**2.3.10 Other Publications.**

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

**2.4 References for Extracts in Mandatory Sections.**

NFPA 18, *Standard on Wetting Agents*, 2021 edition.

NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, 2018 edition.

## Chapter 3 Definitions

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

**3.2 NFPA Official Definitions.**

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

**3.2.2 Shall.** Indicates a mandatory requirement.

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

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

**3.3 General Definitions.**

**3.3.1 Artificial Sea Water.** A solution that consists of 1.10 percent magnesium chloride hexahydrate, 0.16 percent calcium chloride dihydrate, 0.40 percent anhydrous sodium sulfate, 2.50 percent sodium chloride, and 95.84 percent deionized or distilled water.



**3.3.2 Biodegradability.** A measure of the decomposition of organic matter through the action of microorganisms.

**3.3.3 Class A Foam.** Foam for use on fires in Class A fuels.

**3.3.4 Class A Fuel.** Materials such as vegetation, wood, cloth, paper, rubber, and some plastics in which combustion can occur at or below the surface of the material.

**3.3.5 Drain Time.** The time that it takes for a specified percent (customarily 25 percent) of the total solution that is contained in the foam to revert to liquid and drain out of the bubble structure.

**3.3.6 Expansion Ratio.** The ratio of the volume of the foam in its aerated state to the original volume of the non-aerated foam solution.

**3.3.7 Exposure Protection Effectiveness.** The ability of a product to increase the time to ignition of a substrate subjected to a prescribed radiant heat source.

**3.3.8 Fixed Tank.** A tank that is internal to or attached directly to a helicopter.

**3.3.9 Flash Point.** The minimum temperature of a liquid at which it gives off vapor sufficient to form an ignitable mixture with air near the surface of the liquid under specified environmental conditions.

**3.3.10 Foam.** An aggregation of bubbles lighter than water created by forcing or entraining air into a foam solution by means of suitably designed equipment or by cascading it through the air.

**3.3.11 Foam Chemicals.** A generic name for the liquid foam concentrate, foam solution, and foam in whatever form it is being used.

**3.3.12\* Foam Concentrate.** The foaming agent as received from the supplier that, when mixed with water, becomes foam solution.

**3.3.13 Foam Solution.** A homogeneous mixture of foam concentrate and water in the mix ratio required to meet the needs of the user.

**3.3.14 Intergranular Corrosion.** A corrosive attack on metal at the grain boundary.

**3.3.15\* Laboratory Fresh Water.** Deionized or distilled water to which calcium chloride has been added to provide a hardness measure of 120 to 140 ppm of calcium carbonate.

**3.3.16 LC<sub>50</sub> (Lethal Concentration<sub>50</sub>).** The concentration of agent in water, usually expressed as milligrams of agent in a liter of solution, that results in the death of 50 percent of the aquatic test specimens within a specified time frame.

**3.3.17 LD<sub>50</sub> (Lethal Dosage<sub>50</sub>).** The dosage of a chemical, usually expressed as milligrams of the chemical per kilogram of body weight of the test animal, at which 50 percent of the test animals die within a specified time frame.

**3.3.18 Miscibility.** The ability of concentrate to mix with water under specified conditions without separation into phases.

**3.3.19 Mix Ratio.** The proportion of foam concentrate in the foam solution, expressed as a volume percentage.

**3.3.20\* Safety Data Sheet (SDS).** Formatted information provided by chemical manufacturers and distributors of hazardous products that contains information about chemical composition, physical and chemical properties, health and safety hazards, emergency response, and waste disposal of the material. [472, 2018]

**3.3.21 Surface Tension.** The elastic-like force at the surface of a liquid, which tends to minimize the surface area, causing drops to form.

**3.3.22 Uniform Corrosion.** Removal of metal by chemical means over the entire surface.

**3.3.23 Viscosity.** A measure of the resistance of a liquid to flow.

**3.3.24 Wetting Ability.** The ability of foam solution to penetrate and soak into a solid.

## Chapter 4 Characteristics and Acceptance Requirements

### 4.1 General.

**4.1.1\*** The characteristics, requirements, and handling of Class A foam concentrates, foam solutions, and foam shall be in accordance with this chapter.

**4.1.2** A minimum of six 20 L or six 5 gal sealed containers of foam concentrate taken from a single production lot shall be used for the purpose of evaluating the foam concentrate properties and requirements of this standard.

**4.1.2.1** The test product shall be identified by a unique product identifier, lot number, and production date.

**4.1.2.2** Three of the containers shall be used for the stability test required in 4.2.2.1.

**4.1.2.3** Three containers shall be used for evaluating the other properties and requirements of this standard.

### 4.2 Foam Concentrate.

#### 4.2.1\* Health, Safety, and Environmental Considerations.

**4.2.1.1 Mammalian Toxicity.** The foam concentrate shall not exceed the toxicity limits defined in Table 4.2.1.1 when tested in accordance with 5.3.1.

**4.2.1.2 Aquatic Toxicity.** The LC<sub>50</sub> of the foam concentrate shall be greater than 10 mg/L when tested in accordance with 5.3.2.

**4.2.1.3 Biodegradability.** The foam concentrate shall have a minimum of 60 percent biodegradation within 42 days when tested in accordance with 5.3.3.

**4.2.1.4 Flash Point.** The foam concentrate shall not exhibit a flash point below 60°C (140°F) when tested in accordance with 5.3.4.

#### 4.2.2 Physical Properties.

##### 4.2.2.1\* Stability.

**4.2.2.1.1** The foam concentrate shall not be stratified, crystallized, or otherwise separated when tested in accordance with 5.4.1.

**Table 4.2.1.1 Toxicity Limits for Class A Foam Concentrates and Solutions**

	Acute Oral Toxicity	Acute Dermal Toxicity	Primary Dermal Irritation	Primary Eye Irritation	
				Unwashed Eyes	Washed Eyes
<b>Foam concentrate</b>	LD <sub>50</sub> > 500 mg/kg	LD <sub>50</sub> > 2000 mg/kg	Primary irritation score: <5.0 If more irritating, recommend protective gear and safe handling procedures	Mildly irritating or less If more irritating, recommend protective gear and safe handling procedures	Mildly irritating or less If more irritating, recommend protective gear and safe handling procedures
<b>Foam solution</b>	LD <sub>50</sub> > 5000 mg/kg	LD <sub>50</sub> > 2000 mg/kg	Primary irritation score: <5.0	Mildly irritating or less	Mildly irritating or less

**4.2.2.1.2** The expansion ratio and drain time, as determined in accordance with 5.4.8, shall differ by no more than ±15 percent expansion ratio or ±2 minutes drain time when compared with the expansion ratio and drain time from fresh concentrate determined by Section 4.4.

**4.2.2.2 Viscosity.** The viscosity of the concentrate at temperatures of 2°C ± 1°C (35°F ± 2°F), 21°C ± 1°C (70°F ± 2°F), and 49°C ± 1°C (120°F ± 2°F) shall be measured as described in 5.4.2, and the viscosity values obtained shall be reported on the product data sheet.

**4.2.2.3\* Miscibility.**

**4.2.2.3.1** The foam concentrate shall be miscible in water at 21°C ± 1°C (70°F ± 2°F) when tested in accordance with 5.4.4, and the results shall be reported on the product data sheet.

**4.2.2.3.2** The foam concentrate miscibility in water at 4°C ± 1°C (40°F ± 2°F) shall be determined in accordance with 5.4.4 and shall be reported on the product data sheet.

**4.2.2.4\* Pour Point.** The pour point of the concentrate, when determined in accordance with 5.4.5, shall be less than 2°C (35°F) and shall be reported on the product data sheet.

**4.2.3\* Corrosion and Materials Compatibility.**

**4.2.3.1\* Uniform Corrosion.** The foam concentrate shall not exhibit values that exceed those specified in Table 4.2.3.1 when tested in accordance with 5.5.1.

**4.2.3.2\* Compatibility with Nonmetallic Materials.**

**4.2.3.2.1** The effects of foam concentrate on the hardness and volume of the nonmetallic materials listed in 4.2.3.2.2 shall be tested in accordance with 5.5.3.

**Table 4.2.3.1 Maximum Allowable Corrosion Rates**

Application	2024-T3 Aluminum				4130 Steel				UNS C27000 Brass (65% Cu, 35% Zn)	AZ31B Magnesium			
	Total Immersion		Partial Immersion		Total Immersion		Partial Immersion		Partial Immersion	Total Immersion		Partial Immersion	
	21°C (70°F)	49°C (120°F)	21°C (70°F)	49°C (120°F)	21°C (70°F)	49°C (120°F)	21°C (70°F)	49°C (120°F)	49°C (120°F)	21°C (70°F)	49°C (120°F)	21°C (70°F)	49°C (120°F)
<b>Foam Concentrates</b>	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0 <sup>a</sup>	5.0 <sup>a</sup>	5.0 <sup>a</sup>	5.0 <sup>a</sup>
<b>Foam Solutions</b>													
Fixed-wing aircraft	2.0 <sup>b</sup>	2.0 <sup>b</sup>	2.0 <sup>b</sup>	2.0 <sup>b</sup>	5.0	5.0	5.0	5.0	5.0	—	—	—	—
Helicopter with fixed tank	2.0 <sup>b</sup>	2.0 <sup>b</sup>	2.0 <sup>b</sup>	2.0 <sup>b</sup>	5.0	5.0	5.0	5.0	5.0	4.0 <sup>b</sup>	4.0 <sup>b</sup>	4.0 <sup>b</sup>	4.0 <sup>b</sup>
Helicopter with bucket	2.0	2.0	2.0	2.0	5.0	5.0	5.0	5.0	5.0	—	—	—	—
Ground application <sup>c</sup>	2.0	2.0	2.0	2.0	5.0	5.0	5.0	5.0	5.0	—	—	—	—

Note: All values in milli-inches per year; 1 milli-inch = 2.54 × 10<sup>-2</sup> millimeters.

<sup>a</sup>Only required if submitted for use in “helicopters equipped with fixed tanks” or if the concentrate is contained on board the helicopter.

<sup>b</sup>Intergranular corrosion tests also required; see 4.3.4.2.

<sup>c</sup>Includes fire apparatus, portable pumps, backpacks, and other such devices.

**4.2.3.2.2** The following nonmetallic materials shall be subject to testing:

- (1) PVC plastic, MIL-A-A-55859A, *Tube, Nonmetallic, Polyvinyl Chloride (PVC), Flexible (General Use)*
- (2) Sealant, SAE AMS-S-8802E, *Sealing Compound, Fuel Resistant, Integral Fuel Tanks and Fuel Cell Cavities, High Adhesion*
- (3) Sealant, MIL-PRF-81733D, *Sealing and Coating Compound, Corrosion Inhibitive*
- (4) Neoprene rubber, SAE AMS-3208N, *Chloroprene (CR) Rubber, Weather Resistant, 45–55*
- (5) Fiberglass, SAE AMS-C-9084, *Cloth, Glass, Finished for Resin Laminates*
- (6) High-density polyethylene, ASTM D4976, *Standard Specification for Polyethylene Plastics Molding and Extrusion Materials*
- (7) Flexible polyolefin, SAE AMS-DTL-23053/5B, *Insulation Sleaving, Electrical, Heat Shrinkable, Polyolefin, Flexible, Cross-linked*
- (8) Low-density polyethylene, ASTM D4976, *Standard Specification for Polyethylene Plastics Molding and Extrusion Materials*

**4.2.3.2.3** The hardness of the test piece shall not decrease by more than 10 percent or increase by more than 20 percent and shall be reported on the product data sheet.

**4.2.3.2.4** The volume of the test piece shall not change by more than  $\pm 0.5 \text{ cm}^3$  and shall be reported on the product data sheet.

#### **4.2.4 Packaging.**

**4.2.4.1\*** The packaging of foam concentrates shall conform with regulations that govern the ground and air transport of materials.

#### **4.3\* Foam Solution.**

**4.3.1\*** Foam solution shall be tested within the range of 0.1 to 1.0 percent by volume, as specified in Section 4.3.

#### **4.3.2 Health, Safety, and Environmental Concerns.**

**4.3.2.1 Mammalian Toxicity.** A 1.0 percent foam solution shall not exceed the toxicity limits specified in Table 4.2.1.1 when tested in accordance with 5.3.1.

**4.3.2.2 Documentation.** On request, the manufacturer shall provide a summary of the results of toxicity testing as described in Section 5.3.

#### **4.3.3\* Physical Properties.**

**4.3.3.1 Surface Tension.** Surface tension of foam solutions at 0.1 percent, 0.3 percent, and 1.0 percent concentrations shall be measured in accordance with 5.4.6 and shall be reported on the product data sheet.

**4.3.3.2\* Wetting Ability.** The wetting ability of a 0.1 percent, a 0.3 percent, and a 1.0 percent foam solution shall be determined in accordance with 5.4.7 and shall be reported on the product data sheet.

#### **4.3.4\* Corrosion and Materials Compatibility.**

**4.3.4.1 Uniform Corrosion.** The foam solution, at 0.1 percent and 1.0 percent concentration by volume, shall not exhibit values that exceed those specified in Table 4.2.3.1 when tested in accordance with 5.5.1.

**4.3.4.2 Intergranular Corrosion.** Intergranular corrosion testing shall be performed as required in 4.3.4.2.1 through 4.3.4.2.2 and the results reported on the product data sheet.

**4.3.4.2.1** If the foam solution is to be applied using fixed-wing aircraft, aluminum coupons that are exposed to the foam solution during uniform corrosion testing shall be examined in accordance with 5.5.2 and shall exhibit no intergranular corrosion.

**4.3.4.2.2** If the foam solution is to be applied using helicopters with fixed tanks, magnesium and aluminum coupons that are exposed to the foam solution during uniform corrosion testing shall be examined in accordance with 5.5.2 and shall exhibit no intergranular corrosion.

#### **4.3.4.3\* Compatibility with Nonmetallic Materials.**

**4.3.4.3.1** The effects of foam solution, at 0.1 percent and 1.0 percent concentration by volume, on the hardness and volume of the nonmetallic materials listed in 4.3.4.3.2 shall be tested in accordance with 5.5.3.

**4.3.4.3.2** The following nonmetallic materials shall be subject to testing:

- (1) PVC plastic, MIL-A-A-55859A, *Tube, Nonmetallic, Polyvinyl Chloride (PVC), Flexible (General Use)*
- (2) Sealant, SAE AMS-S-8802E, *Sealing Compound, Fuel Resistant, Integral Fuel Tanks and Fuel Cell Cavities, High Adhesion*
- (3) Sealant, MIL-PRF-81733D, *Sealing and Coating Compound, Corrosion Inhibitive*
- (4) Neoprene rubber, SAE AMS-3208N, *Chloroprene (CR) Rubber, Weather Resistant, 45–55*
- (5) Fiberglass, SAE AMS-C-9084, *Cloth, Glass, Finished for Resin Laminates*
- (6) High-density polyethylene, ASTM D4976, *Standard Specification for Polyethylene Plastics Molding and Extrusion Materials*
- (7) Flexible polyolefin, SAE AMS-DTL-23053/5B, *Insulation Sleaving, Electrical, Heat Shrinkable, Polyolefin, Flexible, Cross-linked*
- (8) Low-density polyethylene, ASTM D4976, *Standard Specification for Polyethylene Plastics Molding and Extrusion Materials*

**4.3.4.3.3** The degree of hardness of the test piece shall not decrease by more than 10 percent or increase by more than 20 percent and shall be reported on the product data sheet.

**4.3.4.3.4** The volume of the test piece shall not change by more than  $\pm 0.5 \text{ cm}^3$  and shall be reported on the product data sheet.

**4.3.5 Exposure Protection Effectiveness.** Foam solutions at 0.4 and 1.0 percent concentrations shall be characterized and tested for exposure protection effectiveness in accordance with Section 5.2. The results will be made available to users as performance information.

#### **4.4 Foam.**

**4.4.1 Expansion Ratio.** The expansion ratio of 1.0 percent foam solutions in deionized or distilled water, laboratory fresh water, and artificial sea water shall be determined in accordance with 5.4.8 and the results reported on the product data sheet.

**4.4.2 Drain Time.** The 25 percent drain time of a 1.0 percent foam solution in deionized or distilled water, laboratory fresh

water, and artificial sea water shall be determined in accordance with 5.4.8 and the results reported on the product data sheet.

**4.4.3 Exposure Protection Effectiveness.** Foam produced from 0.4 and 1.0 percent foam solution shall be prepared as described in Section 5.2 and tested for exposure protection effectiveness using the Lateral Ignition Flame Spread Test (LIFT) described in Section 5.2. The results for untreated, water-treated, and foam-treated samples shall be reported on the product data sheet.

#### 4.5 Labeling and Documentation.

**4.5.1 Labeling.** The manufacturer shall provide the following information on a label that is permanently attached to the concentrate container:

- (1) Manufacturer name and address
- (2) Product name, lot number, and date of manufacture
- (3) Emergency and first-aid instructions
- (4) Volume (liters and U.S. gallons) of concentrate in container
- (5) Statement that product meets all requirements of the current edition of this standard when used within the range of 0.1 and 1.0 percent
- (6) Statement directing attention of user to product data sheet

#### 4.5.2 Documentation.

**4.5.2.1** A product data sheet that contains the information identified in this standard shall be prepared by the manufacturer.

**4.5.2.2** On request, the manufacturer shall provide a product data sheet that documents the results of the tests required by this standard, and a copy of a current safety data sheet (SDS).

**4.5.2.3** Where water additive is to be used, foam prepared at the maximum concentrations specified for use by the manufacturer's water additives listing shall be tested for toxic fluorinated ingredients in accordance with EPA Method 537.1, *Determination of Selected Per- and Polyfluorinated Alkyl Substances in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)*, by an EPA-approved laboratory or a laboratory that is recognized by the authority having jurisdiction.

## Chapter 5 Test Methods

### 5.1 General.

**5.1.1 Good Laboratory Practices.** All testing required by this standard shall be conducted by an independent laboratory that is adhering to good laboratory practice standards as defined in 40 CFR 792, "Good Laboratory Practice Standards," 40 CFR 160, "Good Laboratory Practice Standards," or *OECD Principles of Good Laboratory Practice*. Those laboratories that conduct LIFT testing shall adhere to the requirements of ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*.

**5.1.2 Safety Data Sheets (SDSs).** The SDS for each product and reagent chemical used during the evaluation shall be obtained. The recommendations for safe handling and personal protective equipment (PPE) shall be followed.

**5.2 Exposure Protection Effectiveness.** Foam prepared from water solutions of the foam concentrate shall be characterized and tested for exposure protection effectiveness using the vertical LIFT apparatus and general method in ASTM E1321, *Standard Test Method for Determining Material Ignition and Flame Spread Properties*, as well as the details described in this section.

**5.2.1 Foam Preparation.** Two identical samples of the foam shall be prepared and tested to determine foam characteristics as described in 5.2.2 and the exposure protection effectiveness as described in 5.2.3.

**5.2.1.1\*** Foam shall be generated in a blender having four 1.25 in. angled blades and a speed of 3150 rpm  $\pm$  150 rpm.

**5.2.1.2** All test products shall be prepared using 250 mL (250 g) of room temperature [ $21^{\circ}\text{C} \pm 2.8^{\circ}\text{C}$  ( $70^{\circ}\text{F} \pm 5^{\circ}\text{F}$ )], deionized water.

**5.2.1.3** The indicated volume of foam concentrate shall be injected into the required amount of water in the blender container just before blending to obtain the desired solution.

- (1) 0.4 percent foam solution = 1.0 mL of foam concentrate in 250 mL of water
- (2) 1.0 percent foam solution = 2.5 mL of foam concentrate in 250 mL of water

**5.2.1.4** The foam shall be mixed at high speed (3150 rpm  $\pm$  150 rpm) for one minute, and the start/stop times shall be recorded on the data sheet.

**5.2.2 Characteristics of Foam Samples.** The foam characteristics shall be recorded as described in 5.2.2.1 through 5.2.2.3.

**5.2.2.1** Using one set of samples prepared in accordance with 5.2.1, the volume of foam generated shall be measured by pouring the foam into a graduated cylinder immediately upon discontinuing the blending and the measurement recorded.

**5.2.2.2** The expansion ratio and drain time shall be determined using the procedure, calculation, and number of repetitions used in 5.4.8.1(4) through 5.4.8.1(8).

**5.2.2.3** The results (average of expansion ratio values and drain times) for each of the foam solutions shall be recorded.

**5.2.3 Exposure Protection Effectiveness Test Method.** The exposure protection effectiveness shall be determined in accordance with the method below.

#### 5.2.3.1 Equipment Set-Up and Calibration.

**5.2.3.1.1\*** The radiant heat panel shall provide a stable heat flux of 40 kW/m<sup>2</sup>.

**5.2.3.1.2** The pilot ignition flame, located in front of the sample container where the radiant panel is closest to the sample holder, shall be ignited.

**5.2.3.1.3** The equipment shall be calibrated prior to initiating tests.

**5.2.3.1.4\*** A control test on an untreated board shall be performed at the beginning and end of each test period, and throughout the test period as necessary, to assure a heat flux of 40 kW/m<sup>2</sup> is maintained.

**5.2.3.1.5** Additional calibrations of equipment shall be performed throughout the test series and any time that repeat tests have significant differences in results.

**5.2.3.1.6** The performance of the test apparatus shall be monitored and recorded.

#### **5.2.3.2 Data Collection.**

**5.2.3.2.1** A video camera with a time-stamp capability and a clear view of the test piece during exposure to the radiant panel shall be used to record the test, and the video shall be included with the test records.

**5.2.3.2.2** All product information, test information, and measured data shall be recorded on the standard data sheet.

**5.2.3.2.3** Data from the radiant panel performance shall be recorded and copies maintained with the test records.

#### **5.2.3.3 Substrate Preparation.**

**5.2.3.3.1** Substrate samples shall be Douglas fir T1-11 siding from a single source, cut to a dimension of 14.6 cm × 14.6 cm × 1.3 cm (5.75 in. × 5.75 in. × 0.5 in.), free of grooves and plugs.

**5.2.3.3.2** All substrate samples shall be conditioned for at least 30 days before use at 21°C ± 2.8°C (70°F ± 5°F) with a relative humidity (RH) of 50 percent ± 5 percent.

**5.2.3.3.3\*** A stack of three substrate samples shall be used for each test.

**5.2.3.3.4** Each test board (the top sample piece in a stack of three) shall be marked with a unique identifier (e.g., number or letter) on the back (smooth) side with a permanent marker.

**5.2.3.3.5** The initial weight of each test board shall be recorded.

**5.2.3.3.6\*** Using an electronic moisture meter, three measurements of the moisture content of each test board taken on the smooth side of each test board shall be averaged and the result recorded.

#### **5.2.3.4 Loading the Sample Holder.**

**5.2.3.4.1\*** Three sample substrate panels shall be placed in the sample holder so that the rough side of the test board is exposed and the micro-grooves are perpendicular to the length of the sample holder.

**5.2.3.4.2** Metal wedges shall be inserted between the T1-11 and the sample holder to ensure that the T1-11 panels are held firmly in place and do not float.

**5.2.3.4.3** The sample holder shall be firmly attached in the test apparatus and leveled.

#### **5.2.3.5 Application of Test Agent.**

**5.2.3.5.1\*** The prepared foam shall be poured into the pan containing the T1-11.

**5.2.3.5.2** When measuring the performance of agent with a 0.4 percent solution, the panel holder shall sit undisturbed for 5 minutes.

**5.2.3.5.3** When measuring the performance of agent with a 1.0 percent solution, the panel holder shall be raised to the vertical position immediately after agent addition.

**5.2.3.5.4** The panel holder shall be tipped to vertical, bringing the left side to the top and allowing the sample to drain for 10 seconds.

**5.2.3.5.5** The panel holder shall be returned to the horizontal position, ready to move it to the exposure apparatus.

#### **5.2.3.6 Exposure of Panel to Radiant Heat.**

**5.2.3.6.1** The heat shield shall be removed from the exposure apparatus about 30 seconds prior to inserting the test holder into the apparatus.

**5.2.3.6.2** The panel holder shall be made vertical, rotated counterclockwise one-quarter turn (to bring the right side to the top), and inserted into the exposure apparatus.

**5.2.3.6.3** The time in seconds from initial exposure of the sample surface to the radiant panel to ignition of the substrate shall be measured and recorded.

**5.2.3.6.4** If foam-treated substrate does not ignite after 600 seconds (10 minutes) of exposure, the test shall be ended and the note “no ignition” recorded on the data sheet.

**5.2.3.6.5\*** If flash or transient ignitions occur, the time and frequency shall be noted. If the flash continues for 30 seconds or if intermittent flashing continues for 30 seconds, the sample shall be considered to have ignited.

**5.2.3.6.6** Once ignition has occurred or the test discontinued, the sample panel holder shall be removed from the radiant heat source and allowed to cool.

**5.2.3.6.7\*** Once the sample panel has cooled so it can be handled comfortably, the test board shall be removed from the sample container and the sample identification on the back verified, if possible.

**5.2.3.6.8** Repeat the process steps in 5.2.3.6.1 through 5.2.3.6.7 for a minimum of five sample panels.

#### **5.2.3.7 Determination of the Performance Rating.**

**5.2.3.7.1** The performance rating shall be determined separately for the 0.4 percent and the 1.0 percent foam, by comparing the time from exposure to ignition of the foam-treated panel to the time to ignition for the water-treated samples.

**5.2.3.7.2** The time to ignition for each treatment (soak time and concentration) shall be determined by averaging all samples of the same treatment.

**5.2.3.7.3** The performance rating shall be calculated as shown below where all ignition times are given in seconds.

[5.2.3.7.3]

$$\text{Rating} = \frac{(\text{Ignition time, foam treated} - \text{Ignition time, water treated})}{\text{Ignition time, water treated}}$$

### **5.3 Health, Safety, and Environmental Considerations.**

#### **5.3.1 Mammalian Toxicity.**

**5.3.1.1** The foam concentrate and a 1.0 percent by volume foam solution shall be tested in accordance with the following guidelines:

- (1) OPPTS 870.1100, “Acute Oral Toxicity”
- (2) OPPTS 870.1200, “Acute Dermal Toxicity”
- (3) OPPTS 870.2500, “Acute Dermal Irritation”
- (4) OPPTS 870.2400, “Acute Eye Irritation,” including the optional test defined in 4(iii) of the guidelines

### 5.3.2 Aquatic Toxicity.

**5.3.2.1** Foam concentrate samples shall be tested, using rainbow trout (*Oncorhynchus mykiss*), in accordance with OPPTS 850.1075, "Fish Acute Toxicity Test, Freshwater and Marine," in soft water as defined in ASTM E729, *Standard Guide for Conducting Acute Toxicity Tests on Test Materials with Fishes, Macroinvertebrates, and Amphibians*.

**5.3.2.2** In accordance with OPPTS 850.1075, "Fish Acute Toxicity Test, Freshwater and Marine," 10 fish that are 60 days  $\pm$  15 days post-hatch shall be exposed under static conditions to each level of a foam solution that contains ASTM soft water for 96 hours at  $12^{\circ}\text{C} \pm 1^{\circ}\text{C}$  ( $54^{\circ}\text{F} \pm 2^{\circ}\text{F}$ ).

### 5.3.3\* Biodegradability.

**5.3.3.1** The biodegradability of the foam concentrate shall be determined in accordance with Section M,  $\text{CO}_2$  Evolution (Modified Sturm) Test, of OPPTS 835.3110, "Ready Biodegradability."

**5.3.3.2** Testing shall be conducted for a minimum of 28 days.

**5.3.3.3** Testing shall be discontinued at the end of 42 days, or when the oxygen depletion plateau has been reached, whichever is sooner.

**5.3.3.4** At least one reference substance shall be used to monitor inoculum activity.

**5.3.4 Flash Point.** The open-cup flash point shall be determined in accordance with ASTM D92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester*.

### 5.4 Physical Properties.

#### 5.4.1 Stability of Concentrate.

**5.4.1.1** Three 20 L or 5 gal containers of foam concentrate that are taken from a single production lot and packaged in sealed containers, as received from the manufacturer, shall be marked, handled, stored, and tested as described in 5.4.1.2 through 5.4.1.7.

**5.4.1.2** The containers shall be designated as Samples 1, 2, and 3.

**5.4.1.3** Prior to starting the test, the containers shall be inverted four times within a one-minute period. The contents of the containers shall not subsequently be agitated, mixed, or otherwise disturbed, except as required to complete the testing, until the temperature storage sequence is completed.

**5.4.1.4** Sample 1 shall be tested in accordance with 5.4.1.7 after it has been stored for 37 continuous days under the following conditions in the following sequence:

- (1)  $49^{\circ}\text{C} \pm 3^{\circ}\text{C}$  ( $120^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ) for 30 days
- (2)  $21^{\circ}\text{C} \pm 3^{\circ}\text{C}$  ( $70^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ) for 7 days

**5.4.1.5** Sample 2 shall be tested in accordance with 5.4.1.7 after it has been stored for 68 continuous days under the following conditions in the following sequence:

- (1)  $49^{\circ}\text{C} \pm 3^{\circ}\text{C}$  ( $120^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ) for 30 days
- (2)  $21^{\circ}\text{C} \pm 3^{\circ}\text{C}$  ( $70^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ) for 1 day
- (3)  $-9^{\circ}\text{C} \pm 3^{\circ}\text{C}$  ( $15^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ) for 30 days
- (4)  $21^{\circ}\text{C} \pm 3^{\circ}\text{C}$  ( $70^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ) for 7 days

**5.4.1.6** Sample 3 shall be tested in accordance with 5.4.1.7 after it has been stored for 37 continuous days under the following conditions in the following sequence:

- (1)  $-9^{\circ}\text{C} \pm 3^{\circ}\text{C}$  ( $15^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ) for 30 days
- (2)  $21^{\circ}\text{C} \pm 3^{\circ}\text{C}$  ( $70^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ) for 7 days

**5.4.1.7** Within one day following the end of the storage periods described in 5.4.1.4 through 5.4.1.6, the sealed sample containers shall be inverted four times within a 1-minute period.

**5.4.1.7.1** Each sample shall then be opened, and the foam concentrate shall be poured into separate, clean, open-head transparent containers and allowed to sit undisturbed for 10 minutes to allow bubbles to rise to the surface.

**5.4.1.7.2** The samples shall then be visually examined for separation, stratification, and crystallization.

**5.4.1.7.3** The empty storage container shall be examined for evidence of residual sediment or crystals.

**5.4.1.7.4** The expansion ratio and the drain time of solutions prepared from each sample of the concentrate shall be determined in accordance with the procedure in 5.4.8 and shall be compared with the expansion ratio and the drain time obtained with the original sample.

**5.4.1.7.5** The wetting ability of freshly prepared solutions from each stored concentrate shall be compared with the wetting ability of the original sample, in accordance with the procedure in 5.4.7. The result shall be recorded.

**5.4.2 Viscosity.** The viscosity of the foam concentrate shall be measured at the temperatures of  $2^{\circ}\text{C}$  ( $35^{\circ}\text{F}$ ),  $21^{\circ}\text{C}$  ( $70^{\circ}\text{F}$ ), and  $49^{\circ}\text{C}$  ( $120^{\circ}\text{F}$ ) according to the following:

- (1)\* A Brookfield viscometer, model LVT or LVF, or the equivalent, set at 60 rpm with the appropriate spindle (No. 2 for viscosities from 1 to 500 centipoise and No. 4 for viscosities greater than 500 centipoise), shall be used to measure the viscosity in accordance with ASTM D2196, *Standard Test Methods for Rheological Properties of Non-Newtonian Materials by Rotational Viscometer*.
- (2) A straight-sided glass beaker that contains approximately 800 mL of the test sample shall be positioned under the viscometer.
- (3) The spindle shall be immersed in the concentrate to the indicated depth.
- (4) The viscometer then shall be turned on, and the spindle shall be allowed to rotate for 1 minute prior to taking the measurement.
- (5) Triplicate measurements shall be made, stirring gently between each measurement, and the viscosity of the sample shall be calculated in centipoise, using the applicable multiplier (5 for spindle No. 2 and 100 for spindle No. 4).
- (6) When reporting results, the spindle size (number) and rotational speed shall also be reported.

#### 5.4.3 Alternate Viscosity Test Methods.

**5.4.3.1\*** Where the preferred method does not provide usable results, an alternative test method shall be permitted.

**5.4.3.2** Where an alternative test method is used, the method and test conditions shall be documented and reported with the results.

#### 5.4.4 Miscibility.

**5.4.4.1** The temperature combinations of foam concentrate and water shown in Table 5.4.4.1 shall be tested in accordance with the test method described in 5.4.4.2 using foam concentrate mixed into deionized or distilled water.

**5.4.4.2** The miscibility of the foam concentrate shall be measured according to the following procedures:

- (1) Five hundred (500) mL of deionized or distilled water at the test temperature shall be added to a 1 L glass beaker.
- (2) A stirrer, as illustrated in Figure 5.4.4.2, shall be inserted into the water to the depth shown in the figure.
- (3) The speed of the stirrer motor shall be adjusted to 60 rpm  $\pm$  10 rpm.
- (4) The required amount of foam concentrate (1.5 mL for a 0.3 percent foam solution and 5.0 mL for a 1.0 percent foam solution) shall be added over 2 seconds.
- (5) After 10 revolutions of the stirrer, rotation shall be stopped and the liquid mixture shall be observed.
- (6) If the foam solution is not visually homogeneous, it shall be stirred for an additional 10 revolutions.
- (7) The procedure shall be repeated until the foam solution is visually homogeneous or until the total number of revolutions is equal to 100.
- (8) The observations made at each 10-revolution interval shall be recorded.
- (9) If the foam solution is not visually homogeneous after 100 revolutions, the result shall be recorded as not miscible.

**5.4.5 Pour Point.** The pour point of the foam concentrate shall be measured in accordance with ASTM D97, *Standard Test Method for Pour Point of Petroleum Products*.

#### 5.4.6 Surface Tension.

**5.4.6.1** Foam solutions (0.1 percent, 0.3 percent, and 1.0 percent by volume) shall be prepared with 21°C  $\pm$  3°C (70°F  $\pm$  5°F) deionized or distilled water.

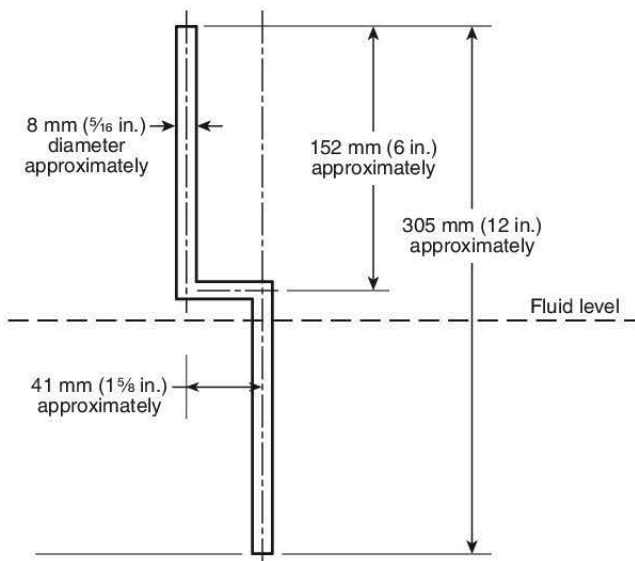
**5.4.6.2** The surface tension of each sample shall be determined in accordance with ASTM D1331, *Standard Test Methods for Surface and Interfacial Tension of Solutions of Paints, Solvents, Solutions of Surface-Active Agents, and Related Materials*, or ISO 304, *Surface active agents — Determination of surface tension by drawing up liquid films*.

#### 5.4.7 Wetting Ability.

**5.4.7.1** Three freshly prepared samples each of 0.1 percent, 0.3 percent, and 1.0 percent by volume foam solution shall be prepared with deionized or distilled water.

**Table 5.4.4.1 Temperature Combinations of Foam Concentrate and Water for Miscibility Testing**

Water Temperature		Foam Concentrate Temperature	
°C	°F	°C	°F
4 $\pm$ 1	40 $\pm$ 2	21 $\pm$ 1	70 $\pm$ 2
21 $\pm$ 1	70 $\pm$ 2	21 $\pm$ 1	70 $\pm$ 2
4 $\pm$ 1	40 $\pm$ 2	4 $\pm$ 1	40 $\pm$ 2
21 $\pm$ 1	70 $\pm$ 2	4 $\pm$ 1	40 $\pm$ 2



**FIGURE 5.4.4.2 Stirrer Shaft for Miscibility Test.**

**5.4.7.2** The ability of each sample to wet a cotton skein shall be determined in accordance with ASTM D2281, *Standard Test Method for Evaluation of Wetting Agents by the Skein Test*, except the test shall be modified as required by the following:

- (1) A 1.50 g S-hook shall be used.
- (2) The weight of each test skein shall be corrected to 5.00 g.
- (3) The time it takes for the skein to sink when immersed in the test solution shall be measured to the nearest second.

**5.4.7.3** The average value of the replicate tests shall be reported.

#### 5.4.8\* Foam Expansion Ratio and Drain Time.

**5.4.8.1\* Test Method.** The foaming ability of 1.0 percent foam solutions that are prepared with laboratory fresh water, deionized or distilled water, and artificial seawater shall be determined in accordance with the following:

- (1) Ten (10) mL of foam solution shall be placed in a 100 mL stoppered, graduated cylinder having 1.0 mL graduations between the 0 and 10 mL marks.
- (2) The cylinder shall be shaken forcefully until all the liquid is incorporated in the foam structure.
- (3) Immediately after shaking is ceased, a stopwatch shall be started, and the volume of foam and the volume of solution in the cylinder recorded.
- (4) The volume of drained solution in the bottom of the cylinder shall be recorded at 1-minute intervals for 5 minutes and then after 10 minutes and 15 minutes or until such time that 2.5 mL of foam solution has drained from the foam.
- (5) The foam expansion ratio shall be calculated by dividing the volume of foam recorded in 5.4.8.1(3) by 10.
- (6) The 25 percent drain time shall be determined by subtracting the volume of solution recorded in 5.4.8.1 from the volume of drained solution recorded at each time interval in 5.4.8.1(4) and extrapolating the data to determine the time when 2.5 mL of solution has drained from the foam.
- (7) The test shall be repeated at least three times using fresh foam solution for each test.

- (8) The average of all expansion ratio values and the average of all drain time values shall be calculated and reported.

### 5.5 Corrosion and Materials Compatibility.

**5.5.1 Uniform Corrosion Test.** The foam concentrate and foam solution shall be tested for uniform corrosion.

**5.5.1.1** Three coupons each of 2024-T3 aluminum and 4130 steel shall be tested to the conditions specified in 5.5.1.4.

**5.5.1.2** Three coupons of brass (65 percent Cu and 35 percent Zn) shall be tested to the conditions specified in 5.5.1.4(4).

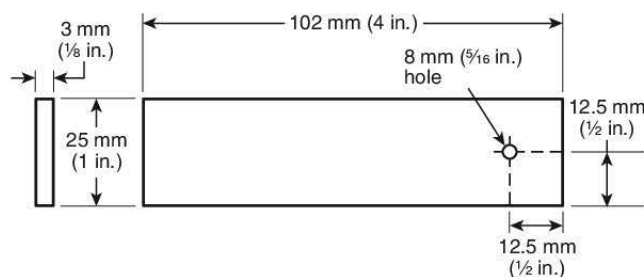
**5.5.1.3** If the foam concentrate or foam solution is used in helicopters equipped with fixed tanks or if the concentrate is contained on board the helicopter, three coupons of AZ31B magnesium shall be tested to the conditions specified in 5.5.1.4.

**5.5.1.4** The following condition(s) shall be tested as required by 5.5.1.1 through 5.5.1.3:

- (1) Total immersion at  $21^{\circ}\text{C} \pm 2^{\circ}\text{C}$  ( $70^{\circ}\text{F} \pm 3^{\circ}\text{F}$ )
- (2) Total immersion at  $49^{\circ}\text{C} \pm 2^{\circ}\text{C}$  ( $120^{\circ}\text{F} \pm 3^{\circ}\text{F}$ )
- (3) Partial immersion at  $21^{\circ}\text{C} \pm 2^{\circ}\text{C}$  ( $70^{\circ}\text{F} \pm 3^{\circ}\text{F}$ )
- (4) Partial immersion at  $49^{\circ}\text{C} \pm 2^{\circ}\text{C}$  ( $120^{\circ}\text{F} \pm 3^{\circ}\text{F}$ )

**5.5.1.5\*** Each coupon shall have a nominal size as shown in either of the following and shall be engraved with a unique identification code:

- (1) The coupon shall be 1 in.  $\times$  4 in.  $\times$   $\frac{1}{8}$  in. with a  $\frac{5}{16}$  in. hole located  $\frac{1}{2}$  in. from one end and centered from each side as shown in Figure 5.5.1.5.
- (2) The coupon shall be 25 mm  $\times$  102 mm  $\times$  3 mm with an 8 mm hole located 12.5 mm from one end and centered from each side as shown in Figure 5.5.1.5.



**FIGURE 5.5.1.5 Test Coupon.**

**5.5.1.6** Each coupon shall be measured to the nearest 0.01 mm (0.0004 in.) in each of the three dimensions.

### 5.5.1.7\* Cleaning and Conditioning.

**5.5.1.7.1** Immediately prior to use, each coupon shall be degreased using an all-purpose liquid cleaner and shall be rinsed in tap water.

**5.5.1.7.2** Contamination, including contact with bare skin, of the degreased coupon shall be avoided.

**5.5.1.7.3** The coupons then shall be cleaned chemically as described in Table 5.5.1.7.3, rinsed in deionized or distilled water, wiped with clean lint-free toweling, and dried at  $55^{\circ}\text{C} \pm 3^{\circ}\text{C}$  ( $130^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ) for 15 to 30 minutes.

**5.5.1.7.4** After the coupons are cooled to room temperature in a desiccator, they shall be weighed to an accuracy of 0.1 mg ( $3.5 \times 10^{-6}$  oz) and used immediately.

### 5.5.1.8 Test Procedure.

**5.5.1.8.1** Each 1 L (32 oz) wide-mouth, straight-sided glass jar shall contain 800 mL (27 oz) of liquid for total immersion tests or 400 mL (13.5 oz) of liquid for partial immersion tests.

**Table 5.5.1.7.3 Procedures for Cleaning Corrosion Coupons**

Alloy	Cleaning Solution*	Immersion Time (minutes)	Solution Temperature	Remarks
Aluminum	70% HNO <sub>3</sub>	2–3	Room temperature	Lightly scrub using nonmetallic brush or scrub pad after immersion. If the corrosion film resists cleaning with the HNO <sub>3</sub> , alternate with 10-minute immersion in a solution that contains 2 g CrO <sub>3</sub> and 5 g H <sub>3</sub> PO <sub>4</sub> in 93 mL of 80°C to 85°C (175°F to 185°F) deionized or distilled water.
Brass	15–20% HCl	2–3	Room temperature	Lightly scrub using nonmetallic brush or scrub pad after immersion.
Steel	50 g SnCl + 20 g SbCl <sub>3</sub> in 1 L conc HCl	3–5	Ice bath	A rubber stopper, [scour pad] or equivalent, nonmetallic scourer, or scrubber can be used to scrub coupons with hard or severe coating.
Magnesium	15 g CrO <sub>3</sub> + 1 g Ag <sub>2</sub> CrO <sub>4</sub> in 84 mL deionized or distilled H <sub>2</sub> O	15	Boiling water bath	

\*Discard cleaning solutions when changing from one product to another and as the cleaning solutions become discolored. Use fresh chemical to clean each magnesium coupon. Exercise care to prevent cross-contamination.

Source: NACE TM0169, *Standard Guide for Laboratory Immersion Corrosion Testing of Metals*.



**5.5.1.8.2** One test coupon shall be suspended in each jar in such a way that the coupon does not touch the sides or bottom of the jar, using a length of braided 8 kg to 9 kg (18 lb to 20 lb) test Dacron fishing line.

**5.5.1.8.3** For total immersion tests, the coupon shall be completely covered with liquid.

**5.5.1.8.4** For partial immersion tests, the coupon shall be suspended so that one-half its length is immersed in the liquid and one-half its length is exposed to the vapor space above the liquid.

**5.5.1.8.5\*** Each jar shall be closed with a vinyl-lined Bakelite screw cap that has been firmly hand-tightened, labeled with coupon identification and starting date, and placed in the test chamber.

**5.5.1.8.6** The jars containing the test samples shall be stored undisturbed at the controlled temperatures defined in 5.5.1.4 for 90 days.

**5.5.1.8.7** At the end of the 90-day test, the coupons shall be removed from the liquid and rinsed under running tap water to remove loosely attached corrosion products and test solution. If necessary, the coupons shall be scrubbed lightly with a toothbrush or other nonmetallic brush to aid in removing scale.

**5.5.1.8.8** Following the procedures of 5.5.1.8.7, the coupons shall be cleaned chemically in accordance with Table 5.5.1.7.3, rinsed in deionized or distilled water, wiped with clean lint-free toweling, and dried at  $55^{\circ}\text{C} \pm 3^{\circ}\text{C}$  ( $130^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ) for 15 to 30 minutes.

**5.5.1.8.9** A clean, unexposed coupon of known weight that is to serve as a control for weight loss during cleaning shall be cleaned in the same manner.

**5.5.1.8.10** Following the procedures of 5.5.1.8.8 and 5.5.1.8.9, the test coupons shall be cooled to room temperature and the final weight of each coupon determined to the nearest 0.1 mg ( $3.5 \times 10^{-6}$  oz).

### 5.5.1.9 Test Results.

**5.5.1.9.1** The corrosion rate,  $C$ , in milli-inches per year (MPY), shall be calculated for each sample using the equation below, in accordance with NACE TM0169, *Standard Guide for Laboratory Immersion Corrosion Testing of Metals*.

[5.5.1.9.1]

$$C = \frac{ML \times 534.57}{SA \times ET \times MD}$$

where:

$C$  = corrosion rate (milli-inches per year)

$ML$  = mass loss (mg)

$SA$  = surface area ( $\text{in.}^2$ )

$ET$  = exposure time (hours)

$MD$  = metal density ( $\text{g}/\text{cm}^3$ )

**CAUTION:** Be sure all measurements are converted to the units shown above prior to performing the calculation.

**5.5.1.9.2** The alloy densities in Table 5.5.1.9.2 shall be used in the calculation of the corrosion rate.

**5.5.1.9.3** The results of replicate tests shall be averaged and the results reported to the nearest 0.1 milli-inch per year.

**5.5.2 Intergranular Corrosion Test.** The foam solution shall be tested for intergranular corrosion according to the following procedures:

- (1) One coupon for each immersion condition and temperature that is used in the 90-day weight loss tests on the specified alloys shall be sliced as shown in Figure 5.5.2, and mounted in accordance with ASTM E3, *Standard Guide for Preparation of Metallographic Specimens*.
- (2) The coupon shall be polished to  $0.3 \mu\text{m}$  alumina finish.
- (3) The aluminum coupon shall be etched with Keller's reagent; the magnesium coupon shall be etched with Nital reagent, in accordance with ASTM E407, *Standard Practice for Microetching Metals and Alloys*.
- (4) The coupon shall be examined at a magnification of  $500\times$  on both the transverse and longitudinal cross-sections as shown in Figure 5.5.2.

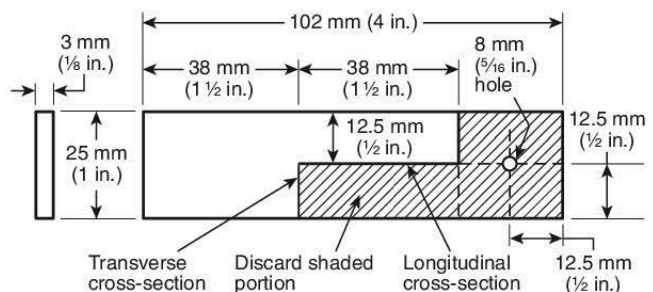
### 5.5.3 Nonmetallic Materials Compatibility Test.

**5.5.3.1 Preparation.** Unused samples of each nonmetallic material to be tested shall be cut into coupons with a nominal size of  $13 \text{ mm} \times 76 \text{ mm} \times 3 \text{ mm}$  ( $\frac{1}{2} \text{ in.} \times 3.0 \text{ in.} \times \frac{1}{8} \text{ in.}$ ) and tested according to the following procedures:

- (1) A wide-mouth bottle of nominal 1 L or 1 qt volume shall be used as the test container.
- (2) The volume of each test coupon shall be measured as specified in 5.5.3.5.1 and shall be recorded.
- (3) The hardness of each test coupon shall be measured as specified in 5.5.3.6.1 and shall be recorded.

**Table 5.5.1.9.2 Alloy Densities**

Alloy	Density	
	$\text{g}/\text{cm}^3$	$\text{oz}/\text{in.}^3$
2024-T3 aluminum	2.77	1.60
4130 steel	7.86	4.54
UNS C27000 Brass (65% Cu, 35% Zn)	8.47	4.90
AZ31B magnesium	1.77	1.02



**FIGURE 5.5.2 Intergranular Corrosion Coupon.**

**5.5.3.2 Exposure.** The samples prepared according to 5.3.3.1 shall be exposed to the test concentrate or test solution according to the following procedures:

- (1) The container shall be filled with 800 mL (27 oz) of the test concentrate or test solution.
- (2) Three coupons of the same test material shall be suspended in a single container such that they are totally immersed and not touching each other or the jar.
- (3) The test container shall be loosely covered to minimize liquid evaporation and shall be maintained at room temperature [approximately 21°C (70°F)] during the test.
- (4) The test coupons shall be immersed for 16 consecutive hours in the concentrate or solution, and then removed from the concentrate or solution (without wiping, rinsing, or drying) and suspended in the air without contact with any surface for 8 consecutive hours during each 24-hour period.
- (5) During the weekends, the sample shall be permitted to remain in the solution.
- (6) The immersion cycles shall be repeated until the sample has been subjected to 20 cycles.
- (7) Any lost concentrate or solution shall be replenished during the test period so that the sample is totally immersed.
- (8) At the end of the test period, each coupon shall be rinsed and wiped with a disposable, lint-free tissue.
- (9) The volume and hardness of each coupon shall be determined on the same day that exposure ends.

#### 5.5.3.3 Calculation of Change.

- (1) The change in volume and hardness of each coupon shall be determined in accordance with 5.5.3.5 and 5.5.3.6.
- (2) If either the hardness or volume of a test coupon exceeds the allowable variation, they shall both be determined again 24 hours later, and the results recalculated.

**5.5.3.4 Reporting Results.** For each test material, the set of measurements giving the results showing the least change shall be reported.

#### 5.5.3.5 Volume Test.

**5.5.3.5.1** The volume of each test coupon shall be calculated from the measurements of each dimension or by means of liquid displacement and shall be recorded to the nearest cubic centimeter.

**5.5.3.5.2** The change in volume shall be calculated by subtracting the final value from the initial value.

**5.5.3.5.3** The average volume change for the three coupons of each material shall be reported.

#### 5.5.3.6 Hardness Test.

**5.5.3.6.1** The hardness of the samples shall be determined in accordance with Methods 3021 and 3025 of Federal Test Standard No. 601, *Rubber: Sampling and Testing*.

**5.5.3.6.1.1** A Shore D gauge shall be used for fiberglass and high-density polyethylene.

**5.5.3.6.1.2** A Shore A2 gauge shall be used for all other materials specified in 4.2.3.2.2 and 4.3.4.3.2.

**5.5.3.6.2** The hardness of each sample shall be recorded.

**5.5.3.6.3** The percent change in hardness shall be calculated as follows:

[5.5.3.6.3]

$$\frac{\text{initial hardness} - \text{final hardness}}{\text{initial hardness}} \times 100 = \text{percent change}$$

**5.5.3.6.4** The average hardness change for the three coupons of each material shall be reported.

## Chapter 6 Class A Fire Extinguishment Tests

**6.1 General.** Products listed for use on Class A fires shall pass all the fire tests specified in this chapter. [18:6.1]

### 6.2 Wood Crib Fire Test.

**6.2.1** The ability of a wetting agent solution to extinguish wood crib fires shall be determined with the solution prepared at the minimum concentration specified for use by the manufacturer. [18:6.2.1]

**6.2.2** Tests shall be conducted according to the procedures detailed in this section and UL 711 CAN/ULC S508, *Rating and Fire Testing of Fire Extinguishers*, for Class A fires utilizing a 3-A wood crib. [18:6.2.2]

**6.2.3** The solution shall be applied with a nominal 9.5 L (2.5 gal) listed 2-A rated water extinguisher. [18:6.2.3]

### 6.3 Deep-Seated Fire Test.

**6.3.1** Wetting agent solutions shall extinguish deep-seated cotton fires and exhibit less runoff than water when tested in accordance with 6.3.2 and 6.3.3. [18:6.3.1]

**6.3.2** Tests shall be conducted three times with plain water and three times with the wetting agent solution prepared at the manufacturer's recommended concentrations. [18:6.3.2]

**6.3.3** The tests shall be conducted using a cylindrical basket of perforated sheet steel, 114 mm (4½ in.) in diameter and 178 mm (7 in.) high, and ginned cotton weighing 100 g (3.5 oz) shall be used and the test conducted as follows:

- (1) Stuff 50 g (1.75 oz) of cotton into the bottom half of the basket.
- (2) Heat a steel rod 35 mm (1.38 in.) in diameter and 33 mm (1.3 in.) long to 593°C (1100°F).
- (3) Place the rod on the cotton in the basket.
- (4) Immediately insert 50 g (1.75 oz) of cotton into the basket on top of the rod.
- (5) Pour 250 mL (8.5 fl oz) of test liquid (water or wetting agent solution) onto the cotton and catch the runoff in a pan placed below the basket.
- (6) Measure and record the volume of runoff. [18:6.3.3]

### 6.4 Wood Fiberboard Penetration.

**6.4.1** Wetting agent solutions shall extinguish wood fiberboard fires and exhibit less runoff and weight loss than water when tested in accordance with 6.4.2 and 6.4.3. [18:6.4.1]

**6.4.2** Tests shall be conducted three times with plain water and three times with the wetting agent solution prepared at the manufacturer's recommended concentrations. [18:6.4.2]

**6.4.3** Penetration tests shall be conducted as follows:

- (1) Weigh fiber insulation board squares measuring 305 mm × 305 mm × 13 mm (12 in. × 12 in. × ½ in.) and place them on a wire grid.
- (2) Expose each insulating board sample to an alcohol flame from a burning pan that is placed immediately below the sample board.
- (3) Expose the flame to the board for 1¼ minutes (105 seconds).
- (4) Remove the fuel pan and place a clean, dry pan under the board to collect the water or agent runoff.
- (5) Spray 250 mL (8.5 fl oz) of test liquid (water or wetting agent solution) on the upper surface of the insulation board using a small sprinkler bottle.
- (6) Place pans underneath the board to catch any runoff that occurs.
- (7) Measure and record the volume of runoff.
- (8) Dry and weigh the boards and calculate the weight loss.

[18:6.4.3]

### Annex A Explanatory Material

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

**A.1.1** Class A foam solutions are generally used at concentrations in the range of 0.1 percent to 1.0 percent, and testing over this range of concentrations is required by this standard. However, situations can occur when either lower- or higher-concentration solutions would be more effective. For example, Class A foam solutions lower than 0.1 percent concentration can, in some cases, be as effective as higher concentrations in wetting and penetrating into deep-seated fires. Also, concentrations higher than 1.0 percent can have benefits in some situations. See NFPA 1145.

**A.1.2** When evaluating health, safety, and environmental concerns of fire-fighting chemicals, there are numerous aspects that need to be considered, not all of which are addressed by the testing included in this document. To address the varied concerns of these types of products, there is a need to develop fire testing.

Of particular concern with respect to these products is fire performance, which has been evaluated under various research programs. The results of such research suggest that concerns related to resistance to ignition and suppression ability of the solutions and foams need further evaluation. Research to develop reproducible testing procedures continues.

**A.3.2.1 Authority Having Jurisdiction (AHJ).** The phrase “authority having jurisdiction,” or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction;

at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

**A.3.3.12 Foam Concentrate.** Class A foam concentrates, when mixed with water at concentrations in the range of 0.1 percent to 1.0 percent by volume, produce an array of foam solutions and foams. Such foam solutions and foams are used for a variety of situations that are encountered when fighting fires in Class A fuels. Fires in Class A fuels occur in an infinite number of configurations that are affected by fuel types, amounts, and geometries. Class A foam concentrates are used in applications for flame knockdown, overhaul or mop-up, and fuel pretreatment. Because of the diversity of applications, the foam solution and foam should be varied over a range of performance characteristics. Those who use foam need to be knowledgeable of and proficient in the conditions of preparation and application that are most suitable to each fire situation.

Foam solutions prepared at the lower end of their recommended concentration range can be used as wetting agents on Class A fuels. For more information, see NFPA 1145.

Types of systems for producing Class A fire-fighting foam are as follows:

- (1) Compressed air foam system (CAFS), from which foam is produced by injecting air or nitrogen into the foam solution ahead of the nozzle. The expansion ratio depends on mix ratio, air/foam solution ratio, and hose and nozzle selection.
- (2) Air-aspirating foam nozzle from which foam is produced by entraining and mixing air with the foam solution at the nozzle. The expansion ratio depends on mix ratio, nozzle selection, and operating pressure.
- (3) Conventional nozzles that are not specifically designed for the production of foam but that are able to produce foam by entraining and mixing air with the foam solution after discharge from the nozzle. The expansion ratio is generally low and depends on mix ratio and application technique.
- (4) Fixed- and rotor-wing aircraft from which foam is produced by cascading foam solution through the air. The expansion ratio depends on drop speed, drop height, and mix ratio.

Referenced information on each of these foam development and application methods is provided in Annex B.

The foam bubbles and the solution that drains from them attach to and penetrate Class A fuels due to the reduced surface tension imparted to the water by the foam concentrate. The bubbles hold moisture and release it as the foam breaks down, prolonging the time the moisture is in contact with the fuel. Where applied in adequate quantities, the foam excludes air from the fuel-air interface; envelops combustible vapors; and resists disruption due to wind, heat, and flame.

**A.3.3.15 Laboratory Fresh Water.** Water meeting the definitions of hard water and soft water can be prepared using the method shown in Table A.3.3.15 as defined in ASTM E729, *Standard Guide for Conducting Acute Toxicity Tests on Test Materials with Fishes, Macroinvertebrates, and Amphibians*.

**A.3.3.20 Safety Data Sheet (SDS).** SDS is a component of the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) and replaces the term material safety data sheet (MSDS). GHS is an internationally agreed-upon system,

**Table A.3.3.15 Preparing Laboratory Fresh Water**

	Soft Water	Hard Water
Sodium bicarbonate	48 mg	192 mg
Calcium sulfate, dihydrate	30 mg	120 mg
Magnesium sulfate	30 mg	120 mg
Potassium chloride	2 mg	8 mg

Notes:

(1) Add the listed quantities of the specified chemicals to a 1-liter volumetric flask.

(2) Dilute to the mark with deionized water.

(3) Mix well to ensure all chemicals are dissolved.

Source: Table 1 of ASTM E729, *Standard Guide for Conducting Acute Toxicity Tests on Test Materials with Fishes, Macroinvertebrates, and Amphibians*.

created by the United Nations in 1992. It replaces the various classification and labeling standards used in different countries by using consistent criteria on a global level. It supersedes the relevant European Union (EU) system, which has implemented the GHS into EU law as the Classification, Labelling and Packaging (CLP) Regulation, and United States Occupational Safety and Health Administration (OSHA) standards. The SDS requires more information than MSDS regulations and provides a standardized structure for presenting the required information. [472, 2018]

**A.4.1.1** Product brands and types of foam concentrate are not necessarily compatible. Tanks or containers that hold concentrate should be flushed and rinsed before adding another brand or type of concentrate. Advice from the manufacturer(s) should be obtained before mixing different concentrates.

**A.4.2.1** The handling, mixing, and application of foam concentrate should follow specific operational procedures to protect the water source and to provide safety in the workplace. Secondary containment devices such as berms should be used to isolate potential foam concentrate spills from the aquatic environment.

The following procedures should be used where Class A fire suppressant foams are mixed and applied:

- (1) Fire apparatus tanks should not leak, and operators should use appropriate methods and equipment to avoid overflow spills and discharge hose spills when filling the tanks.
- (2) Helicopter buckets and fixed tank systems should be filled using a closed, portable, concentrate container with a long spout, an onboard injection system, or a similar device to prevent splashes and concentrate spills.
- (3) Portable tanks or sumps that are used to premix solution or to fill application vehicles should be located at least 30 m (100 ft) from bodies of water. Mixing operations should be conducted in such a manner as to avoid spilling foam concentrate or foam solution. Spillage should not enter drainage systems that empty into fish habitats or waterways that flow into fish-inhabited water.
- (4) All aerial applications should be conducted so that foam solution does not come closer than 91.4 m (300 ft) to bodies of water.

Informational references on foam applications are provided in Annex B.

All personnel involved in handling, mixing, and applying foam concentrate and foam solutions should be trained in the recommended procedures that address occupational safety and health and environmental impact. All personnel should follow the manufacturer's recommendations on the product label and safety data sheet (SDS).

Contact with concentrate should be avoided due to its tendency to irritate skin and eyes. Thorough washing of the affected area is recommended as soon as possible after contact with concentrate. Clothing that is wetted with concentrate should be changed and washed before reuse.

As a minimum, personnel who handle foam concentrate should wear impermeable gloves and eye protection. Skin or eyes that come in contact with concentrate should be rinsed and washed immediately. Large amounts of potable or reasonably clear water should be available on site for such purposes. Personnel should avoid ingesting concentrate. An individual who has ingested concentrate should be examined by a doctor as soon as possible.

Users of Class A foam products should ensure that the following conditions are met:

- (1) An SDS should be available at a location in the workplace that allows examination by the workers.
- (2) Foam concentrate should not be used at a workplace unless a product label and an SDS are provided and worker instruction and training have been completed.
- (3) Labels and SDSs should be available in English and other languages as prescribed by the authority having jurisdiction.
- (4) Every container in the workplace that contains foam concentrate should be labeled and should remain labeled in the prescribed manner.
- (5) Prescribed safe-handling equipment should be provided, should be in proper repair, and should be used at the workplace.

Additional information on safety is included in the U.S.D.A. Forest Service's "Human Health Risk Assessment: Wildland Fire-Fighting Chemicals," and "Ecological Risk Assessment: Wildland Fire-Fighting Chemicals."

**A.4.2.2.1** The purpose of the stability requirement is to ensure that the foam concentrate has a useful shelf life. However, because it is impractical to test every potential storage circumstance, it is possible that stability problems will occur.

Foam concentrate should be stored in sealed containers to avoid evaporation of solvents that are necessary for the stability of the concentrate. Instability of the product can result in malfunction of the proportioning and dispensing equipment.

**A.4.2.2.3** Miscibility relates to the ease of mixing foam concentrate and water to form homogeneous foam solutions, that is, a foam solution that contains the desired mix ratio of components in all portions thereof and that consequently performs uniformly. Under some conditions, opalescence (turbidity) can occur when the concentrate and water are mixed.

Opalescence is not necessarily related to miscibility, provided the foam solution is homogeneous. Miscibility is measured at different temperatures because the viscosity and the miscibility of the foam concentrate can be affected by both its temperature and the temperature of the water with which it is being mixed. Variations in viscosity, in turn, can affect the ability to

achieve a uniform foam solution. Warming the concentrate to between 15.6°C (60°F) and 21°C (70°F) prior to mixing it with water can improve its miscibility.

Foam concentrates should be chosen that are miscible in the water available for use in the preparation of foam solutions. For example, if sea water is frequently used in fire-fighting operations, a product that is compatible with sea water should be used.

**A.4.2.2.4** The pour point of a liquid is the lowest temperature at which it flows. The pour point of Class A foam concentrates is measured to demonstrate the changes in the flow characteristics of the product that occur with changes in temperature. The pour point test procedure can be used to measure the impact of temperature on ability to flow. It should be recognized, however, that the rate of flow of the concentrate at the measured pour point is not necessarily adequate for use in many proportioning and transport systems.

**A.4.2.3** Foam concentrate can cause corrosion of metal surfaces. Corrosion requirements exist for several commonly used metals. Foam concentrate should be stored in its original container. The foam manufacturer should be consulted regarding materials compatibility if the concentrate is to be stored in other than the original container.

Coatings, such as paints and galvanized surfaces, adhesives, sealants, and lubricants should be evaluated, and those that react with foam concentrate should not be used where contact between the two is likely.

Foam concentrate is capable of passing through openings that are too small for water. Therefore, all joints, seams, or connections that are conceivably subject to leakage (e.g., valve packing, retainers, bushings, threaded joints, and screw unions) should be carefully examined.

**A.4.2.3.1** Corrosion induced by fire chemicals in ground and aerial delivery system equipment has been a problem since the beginning of wildland fire chemicals programs. The corrosive effects of fire suppression chemicals (primarily fire retardants, although studies also included a number of foams) have been tested on metals commonly used in equipment since the early 1960s. The results showed that the chemicals could be corrosive in varying degrees, from failures within a few days to only small pits after a year's time, depending on the chemical-metal combination and the type of exposures examined.

An examination of fire suppression equipment, including aircraft, after several seasons of use of a variety of chemicals led wildland fire management agencies to recommend alloys for construction of application equipment, use of protective coatings, and housekeeping practices in addition to methods of testing for new suppression chemicals. By the early 1970s, these same agencies outlined performance requirements and test methods for use in fire suppression chemical standards and specifications. In 1974, the U.S.D.A. Forest Service contracted to assess the corrosion effects of wildland fire chemicals on storage, mixing, and application equipment to determine corrosion rates on critical alloys, correlate findings to actual field damage, and recommend methods of reducing corrosion effects. Special emphasis was placed on aerial delivery systems because of the potential risk of catastrophic failure of aircraft components exposed to the wildland fire chemicals. Results of these and following studies provided guidance for use and performance requirements for corrosion reduction in Forest

Service specifications and standards and have been in use for many years. They have been adopted for use by numerous agencies in the United States and internationally. These requirements were also adapted by NFPA in 1989 in the first "Standard on Fire Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas" and in subsequent editions [NFPA 298 (withdrawn and incorporated into NFPA 1143) and NFPA 1150].

**A.4.2.3.2** Tests for compatibility with nonmetallic materials can be conducted on samples removed from unused parts that are constructed of nonmetallic materials of defined composition. Given the variability of nonmetallic material composition, such tests are useful but do not provide assurance of nonmetallic material compatibility. Changes in test results can occur due to variations in the constituent components of the material even though the finished material meets specification. The nonmetallic compatibility tests required in this standard do not take into account any degrading effects of temperature, aging, or ultraviolet or infrared exposure conditions that are known to exist.

Foam concentrates and solutions come into contact with a broad range of nonmetallic materials. All such materials are not included in the list of those tested in this standard. The materials that are included are generally representative of those that are encountered in foam-proportioning and foam-handling systems. It is recommended that the foam concentrate manufacturer be contacted for information on specific materials.

**A.4.2.4.1** Regulations for packaging and shipping are established by government or international agencies such as U.S. Department of Transportation, Transport Canada, the United Nations, and IATA (International Air Transport Association).

**A.4.3** Freshly prepared foam solutions should be used for all laboratory testing, unless otherwise specified in the test method. Foam solutions stored for prolonged periods of time will degrade, resulting in reduced wetting and foaming.

**A.4.3.1** See A.4.2.1 and A.I.1.

**A.4.3.3** The foam expansion ratio and drain time control where and how fast the foam solution is released to the fuel. To obtain the desired foam for the application, the fire fighter needs to determine (1) the mix ratio, (2) the application technique, (3) the type of foam-generating hardware, and/or (4) the operating pressure of the foam-generating system.

The mix ratio affects physical properties such as the quantity and characteristics of the foam solution obtained. Mix ratios in the range of 0.1 percent to 1.0 percent foam solutions exhibit reduced surface tension values compared to water, resulting in improved spreading and improved wetting of the fuel.

The mix ratio also has an impact on the characteristics of the foam. Depending on the foam-generating system, different mix ratios are frequently necessary to produce desired foam characteristics. For additional information, refer to NFPA 1145.

**A.4.3.3.2** For additional information, refer to NFPA 1145 and A.5.4.8.

**A.4.3.4** Generally, foam solutions have a cleansing action. Some can affect or interact with substances that normally protect against corrosion or lubricate metals. Such substances include natural oxides, grease, oil, paint, and other protective coatings.

Foam solutions can cause corrosion of metal surfaces. Corrosion requirements exist for several commonly used metals. Storage of foam solutions in containers other than those constructed of tested materials should be avoided. The foam manufacturer should be consulted regarding compatibility of materials.

Coatings, such as paints and galvanized surfaces, adhesives, sealants, and lubricants, should be evaluated, and those that react with foam solution should not be used where contact between the two is likely. If nonmetallic materials are used with foam solution, such materials should be tested in accordance with 5.5.3.

Foam solution is capable of passing through openings that are too small for water. Therefore, all joints, seams, or connections that are conceivably subject to leakage (e.g., valve packing, retainers, bushings, threaded joints, and screw unions) should be carefully examined.

**A.4.3.4.3** The discussion in A.4.2.3.2 applies and should be reviewed.

**A.5.2.1.1** A Waring Blender model 18BL93 or equivalent will meet this requirement. Routine assessment of blender performance should be conducted at least annually.

**A.5.2.3.1.1** Allow sufficient time for the radiant heat panel to heat up in order to provide the desired stable heat flux prior to conducting the test.

**A.5.2.3.1.4** Ignition for untreated substrate typically occurs 75 to 95 seconds after initial exposure.

**A.5.2.3.3.3** Three test panels are stacked within the sample holder. The top panel will be subjected to the heat source. The two panels serving as backing material are selected from pieces of T1-11 that have grooves from the tongue and groove finish. These panels can be used over and over again. The middle piece of T1-11 can also be used many times but should be allowed to dry between uses.

**A.5.2.3.3.6** If there is a choice on the electronic moisture meter, the setting for Douglas fir shall be used.

**A.5.2.3.4.1** When the sample holder is in place in the LIFT apparatus the micro-grooves should be in a vertical orientation. This will place the primary groove of the tongue and groove siding in a horizontal orientation.

**A.5.2.3.5.1** If all of the test product cannot be contained in the sample box, estimate and record the volume applied.

**A.5.2.3.6.5** Ignition of untreated substrate typically occurs 75 to 95 seconds after exposure. Ignition of plain water-treated substrate typically occurs 100 to 145 seconds after exposure. Ignition of foam-treated substrate typically occurs 110 to 600 seconds after exposure, depending on the concentration and pre-exposure soak time.

**A.5.2.3.6.7** When ignition occurs, the back of the panel might be charred so that identification is not possible. Sample identification verification should always be done prior to initiation of the test.

**A.5.3.3** The use of foam during fire-fighting operations typically moves from site to site, depending on fire activity. Environmental releases are likely to be infrequent at a given location. The test method for determining biodegradability was selected to reflect this fact. The test method uses a fresh bacte-

rial culture that has not been previously exposed to the test product, and the test period has been increased to 42 days, as allowed by OPPTS 835.3110, "Ready Biodegradability," to allow time for the bacteria to adjust to the foam concentrate. The test measures the susceptibility of the product to decomposition under laboratory conditions and is not necessarily identical to the rate of breakdown in the environment.

**A.5.4.2(1)** The results achieved are specific to rotating spindle type viscometers, such as a Brookfield viscometer. Irrespective of the manufacturer of the particular instrument, it should be calibrated per the manufacturer's instructions using traceable viscosity standards.

**A.5.4.3.1** One example of a case where an alternative test method might be used is when the viscosity is too low to produce meaningful results.

**A.5.4.8** Class A foams are characterized by expansion ratio, drain time, and appearance. Class A foams can have significantly differing fire suppression and exposure protection capabilities, depending on these properties. It is important to be able to identify the type of foam that is produced on the basis of its appearance and to understand which type of foam is needed for a given fire. Class A foams are generally wet, fluid, or dry, as described here and depicted in Figure A.5.4.8.1.

- (1) Wet foam can have a range from an unexpanded solution with a 25 percent drain time of 0 seconds to a watery mass of large and small bubbles that can have an expansion ratio of up to 6 and a 25 percent drain time of less than 30 seconds. Wet foam can be used for direct and indirect fire attack. Wet foam is well suited for quickly penetrating and wetting fuels, making it an ideal mop-up (overhaul) tool.
- (2) Fluid foams have an appearance that is similar to watery shaving cream with smaller and more-uniform bubbles than wet foam. Expansion ratios are typically in the range of 5 to 10, with 25 percent drain times that are typically less than 90 seconds. Fluid foams can be used for direct and indirect fire attack and for mop-up (overhaul) where blanketing is desired. They also can be used to coat horizontal and vertical fuel surfaces to provide cooling for suppression.
- (3) Dry or stiff foams have an appearance similar to shaving cream and expansion ratios greater than 10 and 25 percent drain times greater than those of fluid foams. Dry or stiff foams contain a large volume of air and are well suited for exposure protection, especially on vertical and inverted surfaces.

It should be understood that Class A foams depend entirely on their contained water for fire suppression. Wet and fluid foams contain more water per unit volume than dry foams and are consequently more effective in fire suppression. However, dry foams, which contain the least amount of water per unit volume, can be more appropriate where used for exposure protection.

**A.5.4.8.1** This test method was developed to provide the user or laboratory with a means of determining the foaming performance of foam solutions. The test allows the user to examine any effects of different types of water or any effects of storage time or conditions on the foaming ability of foam solutions. The user should note that, in practice, foam expansion ratios are dependent on mix ratio, water quality, and the system used to generate the foam. For field evaluation, it might be

desirable to conduct this test using water that is available locally for fire fighting. Increasing the mix ratio can be necessary to generate the desired foam consistency where consistency is affected by poor water quality, cold water, or degradation of concentrate or solution.

When the test is conducted, the graduated cylinder should be shaken in the manner shown in Figure A.5.4.8.1. The stopper is placed in the graduated cylinder and held in place with the thumb, as illustrated. The cylinder is then shaken vigorously in a 90-degree arc until all the liquid is incorporated in the foam structure.

**A.5.5.1.5** Coupons can be obtained from Corrosion Test Supplies Inc., 18818 Highway 22, Maurepas, LA 70449, or other suppliers of corrosion test coupons. Coupons from other suppliers might produce different results.

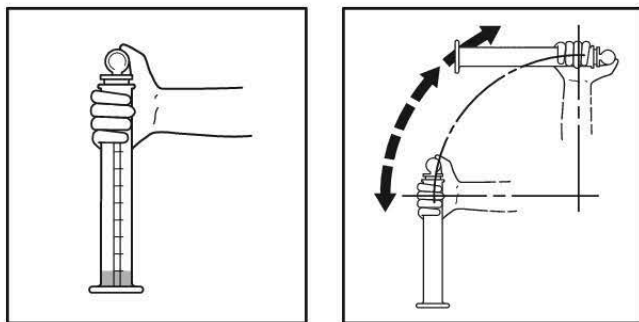
**A.5.5.1.7** The coupon cleaning reagents can be particularly hazardous. For the hazards associated with each, personnel should refer to the appropriate safety data sheet (SDS). Personal protective equipment (eye glasses and/or goggles, a chemical apron, and appropriate protective gloves) should be worn when handling all of them. In addition, they should be used in a forced-draft laboratory hood.

It should be noted that reproductive effects have been observed in laboratory animals tested with antimony trichloride (CAS No. 10025-91-9). It should also be noted that chromium trioxide (CAS No. 1333-82-0) and silver chromate (CAS No. 7784-01-2) are known carcinogens and might cause reduced fertility.

**A.5.5.1.8.5** The corrosion rate is strongly influenced by the extent to which the jar is sealed or vented. Venting eliminates the possibility of pressurizing the corrosion cell while allowing corrosive vapors to escape the jar rather than be held in contact with the test coupon. A firm but not forced twist by hand provides an appropriate closure.

Do not use tools to tighten further than the firm hand-twist. Lids might loosen somewhat during the 90-day test period but they should NOT be retightened during this period.

The lids should not be loosened or removed during the test period as the effects of the test temperature on the lid and jar can affect the seal.



**FIGURE A.5.4.8.1** Shaking Motion for Cylinder with Stopper in Place.

## Annex B Informational References

**B.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.

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

NFPA 298, *Standard on Foam Chemicals for Wildland Fire Control*, 2003 edition (withdrawn).

NFPA 1143, *Standard for Wildland Fire Management*, 2018 edition.

NFPA 1145, *Guide for the Use of Class A Foams in Fire Fighting*, 2022 edition.

**B.1.2 Other Publications.**

**B.1.2.1 ASTM Publications.** ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM E729, *Standard Guide for Conducting Acute Toxicity Tests on Test Materials with Fishes, Macroinvertebrates, and Amphibians*, 1996, reapproved 2014.

**B.1.2.2 EPA Publications.** Environmental Protection Agency, William Jefferson Clinton East Building, 1200 Pennsylvania Avenue, NW, Washington, DC 20460.

OPPTS 835.3110, "Ready Biodegradability," *Test, Fate, Transport, and Transformation Test Guidelines*, January 1998.

**B.1.2.3 U.S.D.A. Forest Service Publications.** U.S. Department of Agriculture, Forest Service, 5785 Highway 10 West, Missoula, MT 59808.

"Ecological Risk Assessment: Wildland Fire-Fighting Chemicals," Labat-Anderson Incorporated, Missoula Technology and Development Center, 2007.

"Human Health Risk Assessment: Wildland Fire-Fighting Chemicals," Labat-Anderson Incorporated, Missoula Technology and Development Center, 2003 with revisions.

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

**B.2.1 Additional Foam Development and Application Publications.**

Coletti, Dominic J., *Class A Foam — Best Practice for Structural Fire Fighters*, Lyons Publishing, Royersford, PA, 1998.

Coletti, Dominic J., Davis, Larry, *Foam Firefighting Operations 1: The Essentials of Class A Foam — Awareness Level*, Lyons Publishing, Royersford, PA, 2003.

NFES 1845, "Foam vs. Fire: Aerial Application," National Interagency Fire Center, National Wildfire Coordinating Group, Boise, ID, 1995.

NFES 2246, "Foam vs. Fire: Class A Foam for Wildland Fires," National Interagency Fire Center, National Wildfire Coordinating Group, Boise, ID, 1993.

NFES 2270, "Foam vs. Fire: Primer," National Interagency Fire Center, National Wildfire Coordinating Group, Boise, ID, 1992.

Liebson, J., *An Introduction to Class A Foam and Compressed Air Foam Systems*, International Society of Fire Service Instructors (IFSI), Stafford, VA, 1993.

*Principles of Foam Fire Fighting*, Fire Protection Publications, Oklahoma State University, Stillwater, OK, 2003.

"Proceedings: International Wildland Fire Foam Symposium," Forestry Canada, Publication Distribution Centre, Chalk River, Ontario, Canada, 1994.

U.S.D.A. Forest Service Specification 5100-307a, "Specification for Fire Suppressant Foam for Wildland Firefighting (Class A Foam)," 2007, amendments 2010.

Wildland Fire Chemicals STP 2.2, "Lateral Ignition and Flame Spread Test (LIFT)," U.S.D.A. Forest Service, 2007.

### **B.3 References for Extracts in Informational Sections.**

NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, 2018 edition.



## Index

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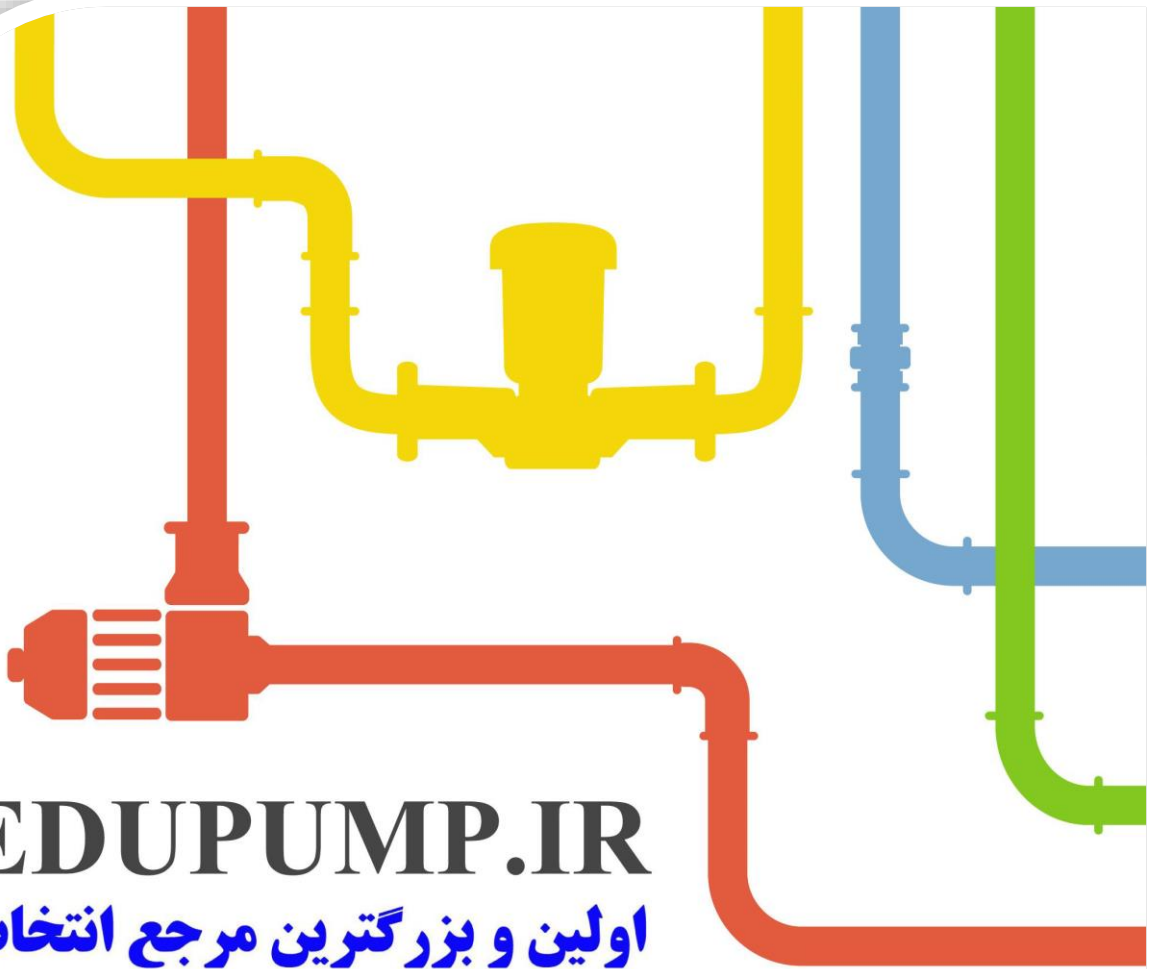
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- الکتروپمپ زمینی

- الکتروپمپ طبقاتی عمودی

- الکتروپمپ طبقاتی افقی

- الکتروپمپ خطی

- الکتروپمپ کفکش

- الکتروپمپ لجنکش

- الکتروپمپ شناور

- الکتروپمپ استخری

### انتخاب آنلاین بوسترپمپ :

- بر اساس نوع فضای کاربری

- بر اساس اطلاعات بوسترپمپ

ارائه مقالات و مطالب آموزشی  
سیستم آب و فاضلاب



ارائه مقالات و مطالب آموزشی  
سیستم اطفاء حریق و مهندسی ایمنی



دانلود کاتالوگ تفکیک شده  
به ازای هر الکتروپمپ



مشاهده اطلاعات مربوط  
به هر الکتروپمپ

