NFPA 1150
Standard on Fire-Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas

1999 Edition

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An International Codes and Standards Organization

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NFPA 1150

Standard on

Fire-Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas

1999 Edition

This edition of NFPA 1150, *Standard on Fire-Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas*, was prepared by the Technical Committee on Forest and Rural Fire Protection and acted on by the National Fire Protection Association, Inc., at its May Meeting held May 17–20, 1999, in Baltimore, MD. It was issued by the Standards Council on July 22, 1999, with an effective date of August 13, 1999, and supersedes all previous editions.

This edition of NFPA 1150 was approved as an American National Standard on August 13, 1999.

Origin and Development of NFPA 1150

NFPA 1150 originated with the first edition of NFPA 298, which was developed by the Technical Committee on Forest and Rural Fire Protection in 1989 in response to a perceived need for a performance standard dealing with foam chemicals used in control of wildland fires. The 1994 edition was a complete revision, which was necessary to make the document consistent with the changes in Class A foam technology that have been developed since the 1989 edition was adopted.

NFPA 1150 is the second complete revision, also necessary due to further advancements in technology and a greater number of Class A concentrates and delivery systems available for use since the 1994 edition was adopted. The NFPA number designation was changed with this current edition to move the documents under the scope of the Committee on Forest and Rural Fire Protection to numerical groupings.

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Committee Scope: This Committee shall have primary responsibility for documents on fire protection for rural, suburban, forest, grass, brush, and tundra areas. This Committee shall also have primary responsibility for documents on Class A foam and its utilization for all wildland and structural fire fighting. This excludes fixed fire protection systems.

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Standard on

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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 Appendix A.

Information on referenced publications can be found in Chapter 4 and Appendix B.

Chapter 1 Introduction

1-1 Scope. This standard specifies requirements and test procedures for foam chemicals used on Class A fuels.

1-2 Purpose.

1-2.1 This standard specifies requirements for foam chemicals that are used to help control fires in Class A fuels.

1-2.2 Tests are performed to ensure compliance with the requirements of this standard. Tests shall not be deemed as establishing performance levels in actual fire-fighting situations.

1-3 Definitions.

Approved.* Acceptable to the authority having jurisdiction.

Authority Having Jurisdiction.* The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

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

Class A Foam.* An aggregation of bubbles that has a lower density than water, generally referred to as foam in this standard.

Class A Fuel. Combustibles such as vegetation, wood, cloth, paper, rubber, and some plastics.

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

Expansion (or Expansion Ratio). The ratio of the volume of the foam in its aerated state to the original volume of the non-aerated foam solution.

Fixed Tank. A tank that is internal or attached directly to an aircraft.

Flash Point. The minimum temperature of a liquid at which it gives off vapor sufficient to form an ignitable mixture with a gaseous oxidant (i.e., oxygen) near the surface of the liquid under specified environmental conditions.

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.

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

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

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

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

LC_{50}. The concentration at which 50 percent of test animals die within a specified time frame.

LD_{50}. The dosage at which 50 percent of test animals die within a specified time frame.

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

Miscibility. The property of being capable of mixing in any ratio without separation of two phases.

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

Shall. Indicates a mandatory requirement.

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

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

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

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

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

Water, Artificial Sea.* 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.

Water, Fresh. Deionized or distilled water to which 140 ppm of calcium chloride have been added.

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

Chapter 2 Acceptance Requirements

2-1* Foam Concentrate.

2-1.1* Health, Safety, and Environmental Considerations.

2-1.1.1 Mammalian Toxicity. The foam concentrate shall not exceed the toxicity limits defined in Table 2-1.1.1 when tested in accordance with 3-2.1.

2-1.1.2 Aquatic Toxicity. The foam concentrate shall be tested in accordance with 3-2.2. The LC_{50} of rainbow trout shall be greater than 10 mg/L when measured after 96 hours of exposure.

2-1.1.3* Biodegradability. The foam concentrate shall be tested in accordance with 3-2.3. A minimum of 60 percent biodegradation shall be obtained within 42 days.

2-1.1.4 Flash Point. The foam concentrate shall not exhibit a flash point below 140°F (60°C) when tested in accordance with 3-2.4.

2-1.1.5 Documentation. On request, the manufacturer shall provide a product data sheet (PDS), which summarizes the results of testing described in Section 3-2, and a copy of a current material safety data sheet (MSDS).

2-1.2 Physical Properties.

2-1.2.1* Stability. Foam concentrate shall be tested in accordance with 3-3.1. The foam concentrate shall not be stratified, crystallized, or otherwise separated when the test is completed. In addition, expansion and drain time shall be determined in accordance with 3-3.7, using foam solution prepared from the stored concentrate samples. The values for fresh and stored concentrates shall differ by no more than ±15 percent expansion and ±2 minutes drain time.

2-1.2.2 Viscosity. The viscosity of the concentrate shall be measured as described in 3-3.2 at temperatures of 35°F, 70°F, and 120°F ± 2°F (2°C, 21°C, and 49°C ± 1°C). The viscosity values obtained shall be reported on the product data sheet.

2-1.2.3* Miscibility. The miscibility of the foam concentrate shall be determined in accordance with 3-3.3. The concentrate, at the specified dilutions, shall be miscible in water at 70°F ± 2°F (21°C ± 1°C). The miscibility of the concentrate in water at 40°F ± 2°F (4°C ± 1°C), as required in the procedure, shall be reported on the product data sheet.

2-1.2.4* Pour Point. The pour point of the concentrate shall be less than 35°F (2°C) when tested in accordance with the procedure described in 3-3.4. The pour point shall be reported on the product data sheet.

2-1.3* Corrosion and Materials Compatibility.

2-1.3.1 Uniform Corrosion. The foam concentrate shall not exhibit values that exceed those specified in Table 2-1.3.1 when tested in accordance with 3-4.1.

2-1.3.2* Compatibility with Nonmetallic Materials. The effects of foam concentrate on the hardness and volume of nonmetallic materials shall be tested in accordance with 3-4.3. The degree of change in hardness and the volume of the test piece shall be reported on the product data sheet. The following nonmetallic materials shall be subject to testing:

(1) PVC plastic
(2) MIL-S-8802 sealant
(3) MIL-S-81733 sealant
(4) Neoprene rubber AMS (SAE Aerospace Materials Specification) 3208 synthetic rubber chloroprene 45-55
(5) Fiberglass with epoxy resin
(6) Cross-linked polyethylene MIL-C-38359A
(7) High-density polyethylene MIL-P-51431A
(8) Teflon AMS 3660
(9) Flexible polyolefin MIL-I-23053/5

2-1.4 Packaging. The packaging of foam concentrates shall conform with regulations that govern the ground and air transport of materials. Containers shall meet performance-oriented packaging criteria that is established and recommended by the United Nations, as referenced in Chapter 4.

Table 2-1.1.1 Toxicity Limits for Class A Foam Concentrates and Solutions

				Primary Eye Irritation	
	Acute Oral Toxicity[1]	Acute Dermal Toxicity[2]	Primary Dermal Irritation	Unwashed Eyes	Washed Eyes
Foam concentrate	$LD_{50} > 500$ mg/kg	$LD_{50} > 2000$ mg/kg	Primary irritation score: < 5.0	Mildly irritating or less	Mildly irritating
	If $LD_{50} \geq 50$ but ≤ 500, recommend protective gear/handling procedures; no $LD_{50} < 50$ shall be permitted.	If $LD_{50} \geq 200$ but ≤ 2000, recommend protective gear/handling procedures; no $LD_{50} < 200$ shall be permitted.	If more irritating, recommend protective gear/handling procedures	If more irritating, recommend protective gear/handling procedures	If more irritating, recommend protective gear/handling procedures
Foam solution	$LD_{50} > 5000$ mg/kg	$LD_{50} > 2000$ mg/kg	Primary irritation score: < 5.0	Mildly irritating or less	Mildly irritating or less

[1] If the acute oral toxicity of the concentrate is less than or equal to 500 mg/kg, the acute inhalation toxicity test shall be performed. An $LC_{50} > 2.0$ mg/L shall be permitted.

[2] If the acute dermal toxicity of the concentrate is less than or equal to 1000 mg/kg, the acute inhalation toxicity test shall be performed. An $LC_{50} > 2.0$ mg/L shall be permitted.

Table 2-1.3.1 Maximum Allowable Corrosion Rates (milliinches per year)

	2024-T3 Aluminum				**4130 Steel**				**Brass (65% Cu & 35% Zn)**				**Az-31-B Magnesium**			
	Total Immersion		**Partial Immersion**		**Total Immersion**		**Partial Immersion**		**Total Immersion**		**Partial Immersion**		**Total Immersion**		**Partial Immersion**	
	70°F (21°C)	**120°F (49°C)**	**70°F (21°C)**	**120°F (49°C)**	**70°F (21°C)**	**120°F (49°C)**	**70°F (21°C)**	**120°F (49°C)**	**70°F (21°C)**	**120°F (49°C)**	**70°F (21°C)**	**120°F (49°C)**	**70°F (21°C)**	**120°F (49°C)**	**70°F (21°C)**	**120°F (49°C)**
Foam Concentrates	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	10.0[a]	10.0[a]	10.0[a]	10.0[a]
Foam Solutions																
Fixed-wing aircraft	2.0[b]	2.0[b]	2.0[b]	2.0[b]	2.0	2.0	5.0	5.0	2.0	2.0	5.0	5.0	—	—	—	—
Helicopter with fixed tank	2.0[b]	2.0[b]	2.0[b]	2.0[b]	2.0	2.0	5.0	5.0	2.0	2.0	5.0	5.0	2.0[b]	4.0[b]	2.0[b]	4.0[b]
Helicopter with bucket	2.0	2.0	2.0	2.0	2.0	2.0	5.0	5.0	2.0	2.0	5.0	5.0	—	—	—	—
Ground application[c]	2.0	2.0	2.0	2.0	2.0	2.0	5.0	5.0	2.0	2.0	5.0	5.0	—	—	—	—

[a] Only required if submitted for use in "helicopters equipped with fixed tanks" or if the concentrate is contained on board.

[b] Intergranular corrosion tests shall be performed; no intergranular corrosion shall be permitted.

[c] Including apparatus, portable pumps, backpacks, and other such devices.

2-1.5 Labeling and Product Data Sheet.

2-1.5.1 In addition to other requirements that might apply, 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) Manufacturer-recommended mix ratios
(4) Emergency and first-aid instructions
(5) Volume (U.S. gallons and liters) of concentrate in container
(6) Statement certifying that product meets all requirements of NFPA 1150 (1999 edition), which supersedes NFPA 298 (1994 edition)
(7) Statement directing attention of user to product data sheet

2-1.5.2 A product data sheet shall be prepared by the manufacturer and supplied on request. The information to be included on the sheet is identified in the applicable paragraphs of this standard.

2-2 Foam Solution.

2-2.1* Health, Safety, and Environmental Concerns.

2-2.1.1 Mammalian Toxicity. A 1.0 percent foam solution shall not exceed the toxicity limits specified in Table 2-1.1.1 when tested in accordance with 3-2.1.

2-2.1.2 Documentation. On request, the manufacturer shall provide a summary of the results of toxicity testing as described in Section 3-2.

2-2.2* Physical Properties.

2-2.2.1 Surface Tension. Surface-tension values of foam solutions, at 0.3 percent and 1.0 percent concentrations, as measured in accordance with 3-3.5, shall be provided by the manufacturer on the product data sheet.

2-2.2.2 Wetting Ability. The wetting ability of a 0.3 percent and a 1.0 percent foam solution shall be determined in accordance with 3-3.6. The results shall be reported on the product data sheet.

2-2.2.3 Expansion. Expansion shall be determined for a 0.3 percent foam solution in deionized water, fresh water, and sea water in accordance with 3-3.7. The results shall be reported on the product data sheet.

2-2.3* Corrosion and Materials Compatibility.

2-2.3.1 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 2-1.3.1 when tested in accordance with 3-4.1.

2-2.3.2 Intergranular Corrosion. Intergranular corrosion testing shall be required for the various methods of application as specified in 2-2.3.2.1 through 2-2.3.2.3.

2-2.3.2.1 Fixed-Wing Aircraft. The aluminum coupons that are exposed to the foam solution during uniform corrosion testing shall exhibit no intergranular corrosion when examined in accordance with 3-4.2.

2-2.3.2.2 Helicopters with Fixed Tanks. The magnesium and aluminum coupons that are exposed to the foam solution during uniform corrosion testing shall exhibit no intergranular corrosion when examined in accordance with 3-4.2.

2-2.3.2.3 Ground Engines and Helicopters with Buckets. No intergranular corrosion testing shall be required.

2-2.3.3* Compatibility with Nonmetallic Materials. The effects of foam solution, at 0.1 percent and 1.0 percent concentration by volume, on the hardness and volume of nonmetallic materials shall be tested in accordance with 3-4.3. The degree of change in hardness and the volume of the test piece shall be reported on the product data sheet. The following nonmetallic materials shall be subject to testing:

(1) PVC plastic
(2) MIL-S-8802 sealant
(3) MIL-S-81733 sealant
(4) Neoprene rubber AMS (SAE Aerospace Materials Specification) 3208 synthetic rubber chloroprene 45-55
(5) Fiberglass with epoxy resin
(6) Cross-linked polyethylene MIL-C-38359A
(7) High-density polyethylene MIL-P-51431A
(8) Teflon AMS 3660
(9) Flexible polyolefin MIL-I-23053/5

2-3 Drain Time. The 25 percent drain time shall be determined for the foam prepared as specified in 2-2.2.3 in accordance with 3-3.7. The results shall be reported on the product data sheet.

Chapter 3 Test Methods

3-1 General. All testing shall be conducted by an independent laboratory that is certified as adhering to good laboratory practice standards as defined in the 40 *CFR* 792, "Good Laboratory Practice Standards," and by the "OECD Principles of Good Laboratory Practice," or by other laboratories acceptable to the authority having jurisdiction.

3-2 Health, Safety, and Environmental Considerations.

3-2.1 Mammalian Toxicity. The foam concentrate and a 1.0 percent by volume solution shall be tested in accordance with EPA, "Pesticide Assessment Guidelines, Subdivision F, Hazard Evaluation: Human and Domestic Animals," *Protocols: Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) Guidelines*, Series 81.

3-2.2 Aquatic Toxicity. Foam concentrate samples shall be tested, using *Oncorhynchus mykiss* (rainbow trout), in accordance with ASTM E 729, *Standard Guide for Conducting Acute Toxicity Tests on Test Materials with Fishes, Macroinvertebrates, and Amphibians,* or with an equivalent test procedure that is recognized by the authority having jurisdiction where the foam concentrate is to be used.

In accordance with ASTM E 729, 10 fish that are 60 days ± 15 days post-hatch shall be exposed under static conditions to each level of a foam solution that contains soft water for 96 hours at 54°F ± 2°F (12°C ± 1°C).

3-2.3 Biodegradability. The biodegradability of the foam concentrate shall be determined in accordance with OECD *Guidelines for Testing of Chemicals,* Method 301D, "Ready Biodegradability: Closed Bottle Test," adopted 17 July 1992. Degradation shall be expressed as a percentage of chemical oxygen demand (COD), as measured by an established procedure, such as ISO 6060, *Water Quality — Determination of the Chemical Oxygen Demand.* A nonadapted inoculum shall be used. Testing shall be conducted for a minimum of 28 days and shall be continued until an oxygen depletion plateau is reached. However, testing shall be discontinued at the end of 42 days, even if the plateau has not been reached. At least one reference substance shall be used to monitor inoculum activity.

As a minimum, the laboratory test report shall identify the COD method used, the COD of the test material, the source of the inoculum, the reference substance, the percent biodegradation of the reference test after 28 days and on completion of the test, the test substance, and all results obtained therefrom.

3-2.4 Flash Point. The open-cup flash point shall be determined in accordance with ASTM D 92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup.*

3-3 Physical Properties.

3-3.1 Stability of Concentrate.

3-3.1.1 Three 5-gal to 5.28-gal (19-L to 20-L) 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 3-3.1.2 through 3-3.1.6.

3-3.1.2 The containers shall be designated as Samples 1, 2, and 3. The contents of the containers shall not be agitated or mixed until the temperature storage sequence is completed.

3-3.1.3 Sample 1 shall be stored in the following sequence:

(1) 120°F ± 5°F (49°C ± 3°C) for 30 days
(2) 70°F ± 5°F (21°C ± 3°C) for 7 days

The total time sequence is 37 continuous days. Sample 1 shall then be tested in accordance with 3-3.1.6.

3-3.1.4 Sample 2 shall be stored in the following sequence:

(1) 120°F ± 5°F (49°C ± 3°C) for 30 days
(2) 70°F ± 5°F (21°C ± 3°C) for 1 day
(3) 15°F ± 5°F (−9°C ± 3°C) for 30 days
(4) 70°F ± 5°F (21°C ± 3°C) for 7 days

The total time sequence is 68 continuous days. Sample 2 shall then be tested in accordance with 3-3.1.6.

3-3.1.5 Sample 3 shall be stored in the following sequence:

(1) 15°F ± 5°F (−9°C ± 3°C) for 30 days
(2) 70°F ± 5°F (21°C ± 3°C) for 7 days

The total time sequence is 37 continuous days. Sample 3 shall then be tested in accordance with 3-3.1.6.

3-3.1.6 Within one day following the end of the storage periods described in 3-3.1.3 through 3-3.1.5, the sealed sample containers shall be inverted four times within a 1-minute period. Each sample shall then be opened, and the foam concentrate shall be poured into separate open-head transparent containers and allowed to sit undisturbed for 10 minutes to allow bubbles to rise to the surface. The samples shall then be visually examined for separation, stratification, and crystallization. The empty storage container also shall be examined for evidence of residual sediment or crystals. The expansion and the drain time of each sample of the concentrate shall be determined in accordance with the procedure in 3-3.7 and shall be compared with the expansion and the drain time obtained with the original sample.

3-3.2 Viscosity. The viscosity of the foam concentrate shall be tested in the following manner as required in 2-1.2.2:

(1) A Brookfield viscometer, model LVT or LVF, or the equivalent, set at 60 revolutions per minute 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.
(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 appropriate multiplier (5 for spindle No. 2 and 100 for spindle No. 4).

3-3.3 Miscibility. The miscibility of the foam concentrate shall be tested in the following manner as required in 2-1.2.3:

(1) Five hundred (500) mL of deionized water at the test temperature shall be added to a 1-L glass beaker.
(2) A stirrer, as illustrated in Figure 3-3.3, shall be inserted into the water to the depth shown in the illustration.
(3) The speed of the stirrer motor shall be adjusted to 60 rpm ± 10 rpm.
(4) The required amount of concentrate (1.5 mL for a 0.3 percent solution and 5.0 mL for a 1.0 percent 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 solution is not visually homogeneous, it shall be stirred for an additional 10 revolutions.
(7) The procedure shall be repeated until the 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. (If the solution is not visually homogeneous after 100 revolutions, the result shall be recorded as *not miscible.*)

Miscibility tests shall be made using foam concentrate at 70°F ± 2°F (21°C ± 1°C) mixed into deionized water at 40°F and 70°F (4°C and 21°C) in accordance with the test method described in this subsection.

A second series of tests shall be conducted using foam concentrate at 40°F ± 2°F (4°C ± 1°C) and water at the temperatures specified in the second paragraph of this subsection.

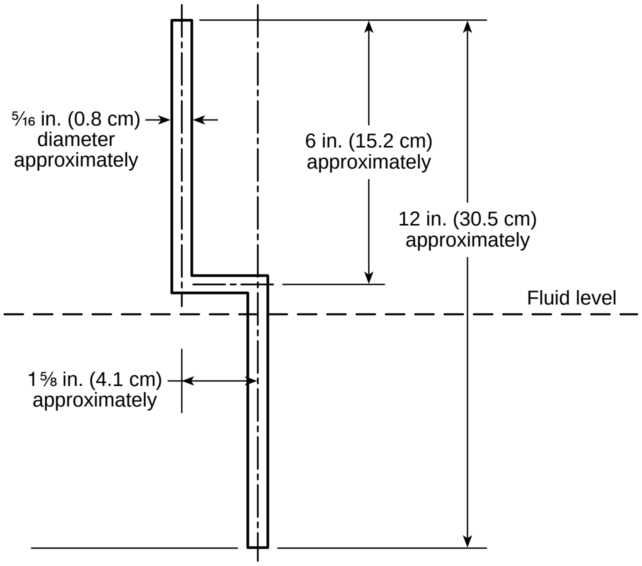
3-3.4 Pour Point. The pour point of the foam concentrate shall be tested as required in 2-1.2.4, according to a modification of ASTM D 97, *Standard Test Method for Pour Point of Petroleum Products,* as herein described. A 150-mL beaker that contains 50 mL of the foam concentrate shall be cooled to a temperature within 33°F to 35°F (1°C to 2°C), without disturbance. Sufficient time shall be allowed for the entire contents of the beaker to reach the test temperature. The beaker shall then be tilted slightly, and the behavior of the concentrate shall be observed. If any visible movement of the concentrate occurs, the concentrate has a pour point below 35°F (2°C).

3-3.5 Surface Tension. Foam solutions (0.3 percent and 1.0 percent by volume) shall be prepared with deionized water that is preadjusted to 70°F ± 5°F (21°C ± 3°C). As required in 2-2.2.1, the surface tension of each sample shall be determined in accordance with ISO 304, *Surface Active Agents — Determination of Surface Tension by Drawing Up Liquid Films.*

3-3.6 Wetting Ability. As required in 2-2.2.2, the ability of 0.3 percent and 1.0 percent foam solutions that are prepared with deionized or distilled water to wet a cotton skein shall be determined in accordance with ASTM D 2281, *Standard Test Method for Evaluation of Wetting Agents by the Skein Test,* and shall be modified as follows:

(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.
(4) The wetting ability test shall be conducted on three freshly prepared solutions, and the average value shall be reported.

Figure 3-3.3 Stirrer shaft for miscibility test.



3-3.7* Foam Expansion and Drain Time.

3-3.7.1* Test Method. As required in 2-2.2.3 and Section 2-3, the foaming ability of 0.3 percent foam solutions that are prepared with freshwater, deionized or distilled water, or artificial seawater shall be determined as follows:

(1) Place 10 mL of foam solution in a 100-mL stoppered, graduated cylinder.
(2) Shake forcefully until all the liquid is incorporated in the foam structure.
(3) Immediately after shaking, start a stopwatch, and note the volume of foam in the cylinder and the volume of solution.
(4) Record the volume of drained solution in the bottom of the graduate at 1-minute intervals for 5 minutes and after 10 and 15 minutes.
    a. Foam expansion shall be calculated by dividing the volume of foam by 10.
    b. The 25 percent drain time is the time required for 2.5 mL of solution to drain from the foam.
(5) Repeat the test at least three times using fresh solution for each test.

3-3.7.2 Deionized Water. Testing shall be conducted in accordance with 3-3.7.1 using foam solution prepared with distilled or deionized water.

3-3.7.3 Fresh Water. Testing shall be conducted in accordance with 3-3.7.1 using foam solution prepared with fresh water, as specified in Section 1-3.

3-3.7.4 Artificial Sea Water. Testing shall be conducted in accordance with 3-3.7.1 using foam solution prepared with artificial sea water, as specified in Section 1-3.

3-4 Corrosion and Materials Compatibility.

3-4.1* Uniform Corrosion. The foam concentrate and foam solution shall be tested for uniform corrosion in accordance with 2-1.3.1 and 2-2.3.1.

Each coupon with a nominal size of 1 in. × 4 in. × $^{1}/_{8}$ in. (2.54 cm × 10.16 cm × 0.32 cm) that has a $^{1}/_{8}$-in. to $^{1}/_{4}$-in. (0.32-cm to 0.64-cm) hole in the upper center shall be engraved with a unique identification code. The coupon dimensions shall be measured to the nearest 0.04 in. (0.001 cm). Immediately prior to use, each coupon shall be degreased using an all-purpose liquid cleaner and shall be rinsed in tap water. Contamination of the degreased coupon shall be avoided by proper handling. The coupons then shall be cleaned chemically as specified in Table 3-4.1, rinsed in distilled water, wiped with clean lint-free toweling, and dried at 130°F ± 5°F (55°C ± 3°C) to constant weight. After the coupons are cooled to room temperature in a desiccator, they shall be weighed to 0.1 mg and used immediately or stored in a desiccator. After cleaning, each coupon shall be suspended by a length of braided 18-lb to 20-lb (8.16-kg to 9.07-kg) test Dacron fishing line in a wide-mouth, 32-oz or 1-L, straight-sided glass jar in such a way that the coupon does not touch the sides or bottom of the jar. Each jar shall contain 800 mL of liquid for total immersion tests or 400 mL of liquid for partial immersion tests. The coupon shall be completely covered with liquid for total immersion tests. In 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. Each jar shall be closed with a screw cap that has been hand tightened, labeled with coupon identification and starting date, and stored at controlled temperatures of 70°F ± 3°F or 120°F ± 3°F (21°C ± 2°C or 49°C ± 2°C), depending on the desired test condition. Jars that contain the test liquid (three jars at each immersion condition and temperature) shall stand undisturbed for 90 days.

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 lightly scrubbed with a toothbrush or other nonmetallic brush to aid in removing scale. The coupons then shall be cleaned chemically using the same procedures that were used initially, in accordance with Table 3-4.1. A clean, unexposed coupon of known weight that is to serve as a control for weight during cleaning shall be cleaned in the same manner. After rinsing in distilled water, oven-drying, and cooling as previously specified in this subsection, the final weight of each coupon shall be determined to the nearest 0.1 mg.

The corrosion rate, *C*, in milliinches per year (MPY), shall be calculated for each sample, as follows:

$$C = \frac{82.77(W_I - W_F - W_C)}{Atd}$$

where:

W_I = initial coupon weight (mg)
W_F = final coupon weight (mg)
W_C = weight loss of the control (mg)
A = area of the coupon (cm^2)
t = exposure (hr)
d = density of the alloy (g/cm^3), as follows:
  2024-T-3 aluminum = 2.77 (g/cm^3)
  4130 steel = 7.86 (g/cm^3)
  Brass (65% Cu, 35% Zn) = 8.47(g/cm^3)
  AZ-31-B magnesium = 1.77 (g/cm^3)

The results of replicate tests shall be averaged.

Table 3-4.1 Procedures for Cleaning Corrosion Coupons

Alloy	Chemical[1]	Time (minutes)	Temperature	Remarks
Aluminum	70% HNO_3	2–3	Room	Follow with light scrub using nonmetallic brush or scrub pad[2]
Brass	15–20% HCl	2–3	Room	Follow with light scrub using nonmetallic brush or scrub pad[3]
Steel	50 g SnCl + 20 g $SbCl_3$ in 1 L conc HCl	3–5	Cold (ice bath)	Follow with light scrub using nonmetallic brush or scrub pad[3]
Magnesium	15 g CrO_3 + 1 g $AgCrO_4$ in 84 mL distilled H_2O	15	Boiling	Follow with light scrub using nonmetallic brush or scrub pad[3]

Source: from NACE, International Standard TM0169, *Standard Test Method for Laboratory Corrosion Testing of Metals.*

[1] Cleaning solutions shall be discarded as they become used or discolored. If in doubt, they shall be replaced. Where cleaning exposed coupons, special care is needed to prevent erroneous results, and, in the case of magnesium solution, fresh chemical shall be used for each coupon.

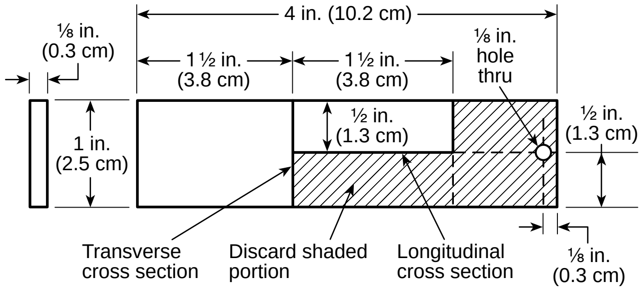
[2] If corrosion film resists cleaning by the specified procedure, alternate with 10-minute immersion in a solution that contains 2 g CrO_3 and 5 g H_3PO_4 in 93 mL of 175°F to 185°F (70°C to 85°C) distilled water.

[3] A rubber stopper, Scotch Brite or equivalent, nonmetallic scourer, or scrubber shall be permitted to be used to scrub coupons with hard or severe coating.

3-4.2* Intergranular Corrosion Test. The foam solution shall be tested for intergranular corrosion as required by 2-2.3.2 as follows:

(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 3-4.2, mounted.
(2) The coupon shall be polished to 0.3 μm alumina finish.
(3) The coupon shall be etched with Keller's reagent using standard metallurgical techniques.
(4) The coupon shall be examined at a magnification of 500 × on both the transverse and longitudinal cross sections.

Figure 3-4.2 Intergranular corrosion coupon.



3-4.3* Nonmetallic Materials Compatibility Test. Unused samples of each test material shall be measured to determine volume and hardness as specified in 3-4.3.1 and 3-4.3.2, before and after exposure to the foam concentrate or solution, as follows:

(1) A wide-mouth bottle of nominal 4-oz (125-mL) volume, sealable with a nonmetallic screw cap, shall be used as the test container.
(2) A sample of the nonmetallic material that has a volume of 10 cm^3 to 20 cm^3 shall be prepared with dimensions chosen so that it can be placed in the test container.
(3) The sample shall be placed in the container, and the container shall be filled with the test concentrate or solution so that the sample is totally immersed.
(4) The test container shall be closed tightly to prevent liquid evaporation and shall be maintained at 70°F (21°C) during the test.
(5) The sample shall be removed (without wiping, rinsing, or drying) from the concentrate or solution and placed on top of the container lid for 8 consecutive hours during each 24-hour period of 5 consecutive days. The container shall be sealed during atmospheric exposure of the sample.
(6) At the end of each atmospheric exposure period, the sample shall be returned to the test container.
(7) At the end of five 24-hour test periods, the sample shall remain in the solution for 48 to 63 hours.
(8) The cycle shall be repeated until the sample has been subjected to four cycles.
(9) Any lost material shall be replenished during the test period so that the sample is totally immersed while in the test solution.
(10) At the end of the test period, the sample shall be removed from the liquid, rinsed with distilled water, and air dried.

3-4.3.1 Volume Test. The volume of the sample shall be measured to within 1 cm^3 by means of liquid displacement before and after exposure to the foam concentrate or solution as specified in 3-4.3. The volume shall be recorded. The change in volume shall be calculated and reported as a percentage of the initial volume. The average of three such tests shall be reported.

3-4.3.2 Hardness Test. In accordance with 2-1.3.2 and 2-2.3.3, the hardness of the samples shall be determined in accordance with Federal Test Standard No. 601, Methods 3021 and 3025, prior to and following the procedure described in 3-4.3. Shore D gauge shall be used for fiberglass, high-density polyethylene, and Teflon®. A Shore A2 gauge shall be used for all other materials specified in 2-1.3.2 and 2-2.3.3. The hardness of each sample shall be recorded.

The change in hardness shall be calculated and reported as a percentage of initial hardness. The average of the three results shall be reported.

Chapter 4 Referenced Publications

4-1 The following documents or portions thereof are referenced within this standard as mandatory requirements and shall be considered part of the requirements of this standard. The edition indicated for each referenced mandatory document is the current edition as of the date of the NFPA issuance of this standard. Some of these mandatory documents might also be referenced in this standard for specific informational purposes and, therefore, are also listed in Appendix B.

4-1.1 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup,* 1997.

ASTM D 97, *Standard Method of Test for Pour Point,* 1996.

ASTM D 2281, *Standard Method for Evaluation of Wetting Agents by the Skein Test,* 1997.

ASTM E 729, *Standard Guide for Conducting Acute Toxicity Tests on Test Materials with Fishes, Macroinvertebrates, and Amphibians,* 1996.

4-1.2 CGSB Publication. Canadian General Standards Board, Ottawa, Canada K1A 1G6.

CAN/CGSB-28.74, *Liquid Concentrate, Firefighting, Aqueous Film-Forming Foam (AFFF),* February 1990, par. 7.5.1, "Synthetic Sea Water," p. 10.

4-1.3 ISO Publications. International Standards Organization, 1 Rue de Varembé, Case Postale 56, CH-1211, Genève 20, Switzerland.

ISO 304, *Surface Active Agents—Determination of Surface Tension by Drawing Up Liquid Films,* second edition, 1985.

ISO 6060, *Water Quality —Determination of the Chemical Oxygen Demand,* 1989.

4-1.4 NACE International Publication. National Association of Corrosion Engineers International, P.O. Box 218340, Houston, TX 77218-8340.

NACE Standard TM0169, *Standard Test Method for Laboratory Corrosion Testing of Metals,* 1995.

4-1.5 OECD Publication. Organization for Economic Co-operation and Development, 2, rue André-Pascal, 75775 Paris Cedex 16, France.

OECD *Guidelines for the Testing of Chemicals,* Method 301D, "Ready Biodegradability: Closed Bottle Test," July 17, 1992.

"OECD Principles of Good Laboratory Practice," Annex 2, C(89)87(Final).

4-1.6 U.S. Government Publications. U.S. Government Printing Office, Washington, DC 20402.

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

U.S. Department of Transportation, "Performance Oriented Packaging Standards: Changes to Classification, Hazard Communication, Packaging and Handling Requirements Based on United Nations Standards and Agency Initiative: Final Rule, 55FR-52401 – 52729 (December 21, 1990).

U.S. Environmental Protection Agency, Federal Register, Vol. 43, No. 163. "Pesticide Assessment Guidelines, Subdivision F, Hazard Evaluation: Human and Domestic Animals."

Federal Test Standard No. 601, Methods 3021 and 3025 (April 12, 1985).

Appendix A Explanatory Material

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

A-1-3 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A-1-3 Authority Having Jurisdiction. The phrase "authority having jurisdiction" 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-1-3 Class A Foam. Class A foam concentrates, where 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 solutions and foams are used for a variety of situations that are encountered when fighting fire 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 solution and foam need to be varied over a range of performance characteristics. Those who use foam need to become knowledgeable of and proficient in the conditions of preparation and application that are most suitable to each fire situation.

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

(a) *Compressed Air Foam System (CAFS).* Foam is produced by injecting air or nitrogen into the foam solution ahead of the nozzle. Expansion depends on mix ratio, air/solution ratio, and hose and nozzle selection.

(b) *Air-Aspirating Foam Nozzle.* Foam is produced by entraining and mixing air with the foam solution at the nozzle. Expansion depends on mix ratio, nozzle selection, and operating pressure.

(c) *Conventional Nozzle.* Such a nozzle is not specifically designed for the production of foam. Foam is produced by entraining and mixing air with the foam solution after discharge from the nozzle. Expansion is generally low and depends on mix ratio and application technique.

(d) *Fixed and Rotor-Wing Aircraft.* Foam is produced by cascading solution through the air. Expansion depends on drop speed, drop height, and mix ratio.

Referenced information on each of these foam development and application methods is provided in Appendix C.

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 can be absorbed by the fuels. Where applied in adequate quantities, the foam excludes air from the fuel-air interface, envelopes combustible vapors, and resists disruption due to wind, heat, and flame.

A-1-3 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A-1-3 Water, Artificial Sea. This composition meets CAN/CGSB-28.74.

A-2-1 Product brands and types are not necessarily compatible. Users should flush and rinse containers that hold concentrate before adding another brand or type of concentrate. Advice from the manufacturer should be obtained before mixing different concentrates.

A-2-1.1 For occupational safety and health and protection of the environment, handling, mixing, and applying foam concentrate should follow specific operational procedures for water source protection and meet specific conditions for safety in the workplace.

(a) *Water Source Protection.* 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 mixing and applying Class A fire suppressant foams:

(1) *Filling Fire Engines.* Proper methods and equipment should be used to avoid water source contamination. Tanks should not leak, and operators should avoid overflow spills and discharge hose spills.

(2) *Filling Helicopter Buckets.* A closed, portable, concentrate container with a long spout, onboard injection system, or similar device should be provided to prevent splashes and concentrate spills caused by rotor downwash.

Portable tanks or sumps that are used to premix solution or to fill buckets should be located so that foam solution does not come closer than 100 ft (30 m) from bodies of water.

(3) *Filling Fixed-Wing Aircraft and Fixed Tank–Equipped Helicopters.* Mixing operations should be conducted in such a manner as to avoid spilling concentrate or solution. Spillage should not enter drainage systems that empty into fish habitats or waterways that flow into fish-inhabited water.

Air drops should be conducted so that foam solution does not come closer than 100 ft (30 m) from bodies of water.

Referenced information on foam applications is provided in Appendix C.

(4) *Personal Protection.* All personnel involved in handling, mixing, and applying foam concentrate and solutions should be trained in the proper procedure with respect to occupational safety and health and environmental impact. All personnel should follow the manufacturer's recommendations on the product label and on the material safety data sheet.

Prolonged contact with concentrate should be avoided. Showering is recommended as soon as possible after prolonged contact with concentrate. Clothing that is wetted with concentrate should be changed and washed. Soiled clothes should be cleaned daily.

Individuals who have ingested concentrate should be examined by a doctor as soon as possible. Skin or eyes that come in contact with concentrate should be rinsed and washed immediately. Fresh water should be available on site for such purposes.

Personnel who handle foam concentrate should wear protective clothing that includes eye protection and should avoid ingesting concentrate.

(b) *Personal Responsibility.* Users of Class A foam concentrates, solutions, or products should ensure that the following conditions are met:

(1) A material safety data sheet should be made available in the workplace in a location that allows examination by the workers.
(2) Foam concentrate should not be used at a workplace unless a label and a material safety data sheet are provided and worker instruction and training have been completed.
(3) Labels and material safety data sheets should be available in English or other languages as prescribed by the authority having jurisdiction. Foam concentrate should not be used at a workplace unless a label and a material safety data sheet are provided and worker instruction and training have been completed.
(4) Every container in the workplace that contains foam concentrate should be 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 USDA Forest Service's "Chemicals Used in Wildland Fire Suppression: A Risk Assessment," in Appendix B.

A-2-1.1.3 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 such a situation. The test method uses a fresh bacterial culture that has not been previously exposed to the test product, and the test period has been increased to 42 days 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-2-1.2.1 The purpose of the test for stability is to help ensure that the foam concentrate has a useful shelf life. It is impractical to test every potential storage circumstance, and it is, therefore, possible that stability problems can occur. In particular, 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-2-1.2.3 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 functions uniformly. Under some conditions, opalescence (turbidity) can occur when the concentrate and water are mixed. Opalescence is not necessarily related to miscibility, provided the solution is homogeneous uniformly. Miscibility is measured at different temperatures, since the viscosity of the foam concentrate can be impacted by temperature. Variations in viscosity, in turn, can impact the ability to achieve a uniform solution. Increasing the temperature of the concentrate prior to mixing it with water can improve its miscibility. Products with good miscibility should be chosen in situations where the performance of the mixing equipment can be inadequate.

A-2-1.2.4 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 rate of 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. This test can be accomplished easily in the field.

A-2-1.3 Foam concentrate can cause corrosion of metal surfaces. Corrosion requirements exist for several commonly used metals. Storage of foam concentrate in other than the original containers or in containers that are constructed of nontested materials should be avoided. The foam manufacturer should be consulted regarding materials compatibility.

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. If nonmetallic materials are used with foam concentrate, such materials should be tested in accordance with 3-4.3.

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 should be carefully examined. Such joints, seams, or connections include valve packing, retainers, bushings, threaded joints, and screw unions.

A-2-1.3.2 Tests for compatibility with nonmetallic materials are conducted on samples removed from parts that are constructed of nonmetallic materials. The origin of the materials that are used is not traceable. Given the variability of nonmetallic material composition, such tests provide a guide but do not provide assurance of nonmetallic material compatibility. Changes in test results can occur due to variations in the constituent components of the materials while still meeting the material specifications. The nonmetallic compatibility tests required in this standard do not take into account any degrading effects of temperature, aging, 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.

A-2-2.1 The discussion in A-2-1.1 applies and should be reviewed.

A-2-2.2 The fire fighter should be aware that, by changing the characteristics of the foam, the amount of foam solution that is available to spread and wet the fuel changes. Fast-draining foams provide more solution to the fuel in a shorter time than do slow-draining foams. Consequently, more foam is not always better; to obtain the optimal foam for the application, the fire fighter needs to adjust 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 impacts physical properties such as surface tension and the wetting ability of the foam solution. Mix ratios in the range of 0.1 percent to 1.0 percent reduce surface tension values below those exhibited by water, which results in improved spreading and in improved wetting of the fuel.

The mix ratio also has an impact on the characteristics of the foam that can be produced with a specific foam-generating system. The foam expansion and drain time control where and how fast the foam solution is released to the fuel. Generating systems that increase the amount of air that is captured within the foam solution generally result in greater expansion and slower drain times. Higher mix ratios generally increase the production of highly expanded foams with slower drain times. Slower drain times decrease the rate of penetration and wetting.

A-2-2.3 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 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 3-4.3.

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

A-2-2.3.3 The discussion in A-2-1.3.2 applies and should be reviewed.

A-3-3.7 Class A foams are characterized by expansion ratio, drain time, and appearance. Class A foams can have significantly different fire suppression and exposure protection capabilities, depending on their expansion ratio and drain time. It is important to be able to identify the type of foam that is produced based on its appearance and to understand which type of foam is needed for a given fire situation. Class A foams are generally wet, fluid, or dry, as follows:

(a) *Wet foams.* Wet foam can range from a foam solution that has an expansion ratio of 1 and a drain time of 0 seconds to a watery mass of large and small bubbles that can have an expansion ratio of up to 5 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.

(b) *Fluid foams.* 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 6 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.

(c) *Dry or stiff foams.* Dry or stiff foams have an appearance similar to shaving cream and expansion ratios greater than 10; 25 percent drain times are 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-3-3.7.1 This test method was developed to provide the user with a means of determining the foaming performance of concentrates and 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 concentrates or solutions. The user should note that, in practice, foam expansion is dependent on mix ratio, water quality, and the system used to generate the foam. 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 conducting the test, the graduated cylinder should be shaken in the manner shown in Figure A-3-3.7.1. 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.