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NFPA 298
Standard on Fire Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas
1994 Edition

NFPA

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101

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The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

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NFPA 298

Standard on

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

1994 Edition

This edition of NFPA 298, *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 Annual Meeting held May 16–18, 1994, in San Francisco, CA. It was issued by the Standards Council on July 14, 1994, with an effective date of August 5, 1994, and supersedes all previous editions.

The 1994 edition of this document has been approved by the American National Standards Institute.

Origin and Development of NFPA 298

The first edition of NFPA 298 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 is 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.

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Committee Scope: This Committee shall have primary responsibility for documents on fire protection and prevention for rural and suburban areas and forest, grass, brush, and tundra areas.

Contents

NFPA 298

Standard on

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

1994 Edition

NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates explanatory material on that paragraph 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 The standard specifies requirements for foam chemicals that are used to help control fires in Class A fuels.

1-2.2 Tests are used 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.

NOTE: 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 concerned with product evaluations that is in a position to determine compliance with appropriate standards for the current production of listed items.

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

NOTE: 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.

Biodegradability. The decomposition of organic matter through the action of microorganisms, which results in the evolution of carbon dioxide.

Class A Foam.* An aggregation of bubbles having a lower density than water. The foam bubbles and the solution draining 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. The foam acts to exclude air from the fuel, envelopes the volatile combustible vapor and the fuel interfaces where applied in adequate quantities, and resists disruption due to wind, heat, and flame.

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

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

Expansion. The ratio of the volume of the foam in its aerated state to the original volume of the nonaerated foam solution.

Foam. The aerated solution created by forcing or entraining air into a foam solution by means of suitably designed equipment or by cascading it through the air at a high velocity.

Foam Concentrate. The concentrated foaming agent as received by the manufacturer and approved by the authority having jurisdiction for use on Class A fuels.

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

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 (milligrams of test material per liter of solution) at which 50 percent of the test animals die.

LD_{50}. The dosage (milligrams of test material per kilogram of body weight) at which 50 percent of the test animals die.

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

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which 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.

Shall. Indicates a mandatory requirement.

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

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

Use Level. The proportion of foam concentrate in the foam solution, expressed as a percentage. (Use levels for Class A foam solutions generally fall within the range of 0.1 percent to 1.0 percent.)

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

Water, Synthetic or Artificial Sea. A solution consisting of 1.10 percent magnesium chloride, 0.16 percent calcium chloride, 0.40 percent anhydrous sodium sulfate, 2.50 percent sodium chloride, and 95.84 percent deionized or distilled water. This composition meets Canadian General Standards Board Standard 28-GP-74M.

Chapter 2 Acceptance Criteria

2-1 Foam Concentrate.

2-1.1* Corrosion.

2-1.1.1 Uniform Corrosion. The foam concentrate shall not exhibit values exceeding those given in Table 2-1.1 when tested in accordance with 3-1.1.

2-1.1.2* Corrosion of Nonmetallic Materials. The effects of foam concentrate on the hardness and volume of the following nonmetallic materials shall be tested in accordance with 3-1.3. Tested materials shall not exhibit changes in hardness exceeding 10 percent nor changes in volume exceeding 5 percent.

(a) PVC plastic
(b) MIL-S-8802 sealant
(c) MIL-S-81733 sealant
(d) Neoprene rubber AMS (SAE Aerospace Materials Specification) 3208 synthetic rubber CL-Prene 45-55 share
(e) Fiberglass with epoxy resin
(f) Cross-linked polyethylene MIL-C-38359A
(g) High density polyethylene MIL-P-51431A
(h) Teflon AMS 3660
(i) Flexible polyolefin MIL-I-23053/5.

2-1.2* Health and Safety.

2-1.2.1 Toxicity. The foam concentrate shall not exceed the toxicity limits defined in Table 2-1.2.1 when tested in accordance with Section 3-2 by a biological testing laboratory that is certified as adhering to good laboratory practice standards as defined in the *Code of Federal Regulations*, 40 CFR, Part 792 or Part 160.

2-1.2.1.1 Documentation. Upon request, the manufacturer shall provide a summary of the results of toxicity testing described in 2-1.2.1 and a copy of a current material safety data sheet.

2-1.3* Biodegradability. The foam concentrate shall be tested in accordance with Section 3-3. The concentrate shall be classified as readily biodegradable according to the *Code of Federal Regulations*, 40 CFR, Part 796.3100, as exemplified by a minimum of 60 percent biodegradation within 28 days.

2-1.3.1 Fish Toxicity. The foam concentrate shall be tested in accordance with Section 3-4. The LC_{50} shall be greater than 10 mg/L when measured after 96 hours of exposure.

2-1.4 Characteristics.

2-1.4.1* Temperature Stability. Foam concentrate shall be tested in accordance with Section 3-7. The foam concentrate shall not be stratified, crystallized, or otherwise separated at the end of the test. In addition, expansion and drain time shall be determined in accordance with Section 3-5, 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.

2-1.4.2 Viscosity. The viscosity of the concentrate shall be measured as described in Section 3-8, at temperatures of 0°, 35°, 70°, and 120°F (−18°, 2°, 21°, and 49°C). The viscosity values obtained shall be reported on the Product Data Sheet.

2-1.4.3 Miscibility. The miscibility of the foam concentrate shall be determined in accordance with Section 3-6 where mixing concentrate and water in the amounts required to prepare 0.3 and 1.0 percent foam solutions. The concentrate at 70°F (21°C) shall be miscible in water at 70°F (21°C). The miscibility of the concentrate in water at the additional temperatures included in Section 3-6 shall be reported on the additional Product Data Sheet.

2-1.4.4 Flash Point. The foam concentrate shall not exhibit a flash point below 140°F (60°C) when tested in accordance with Section 3-10.

2-1.5 Packaging and Labeling.

2.1.5.1 Packaging. Packaging of foam concentrates shall conform with regulations governing ground and air transport of materials. Containers shall meet performance oriented packaging criteria established and recommended by the United Nations as described in 4-1.3.

2-1.5.2 Labeling. In addition to other requirements that might apply, the manufacturer shall provide the following information on a label permanently attached to the concentrate container:

(a) Manufacturer name and address
(b) Product name, lot number, and date of manufacture
(c) 25 percent drain time in deionized water as required in 2-3.1
(d) Expansion in deionized water as required in 2-2.3.2
(e) Manufacturer recommended use levels
(f) Emergency and first aid instructions
(g) Volume (U.S. gallons and liters) of concentrate in the container
(h) Statement certifying that the product has been tested and meets all requirements of this standard.

Table 2-1.1 Maximum Allowable Corrosion Rates (in millinches per year)

	2024-T3 Aluminum				4130 Steel				Yellow Brass				Az-31-B Magnesium			
	Total Immersion 70°F (21°C)	Total Immersion 120°F (49°C)	Partial Immersion 70°F (21°C)	Partial Immersion 120°F (49°C)	Total Immersion 70°F (21°C)	Total Immersion 120°F (49°C)	Partial Immersion 70°F (21°C)	Partial Immersion 120°F (49°C)	Total Immersion 70°F (21°C)	Total Immersion 120°F (49°C)	Partial Immersion 70°F (21°C)	Partial Immersion 120°F (49°C)	Total Immersion 70°F (21°C)	Total Immersion 120°F (49°C)	Partial Immersion 70°F (21°C)	Partial Immersion 120°F (49°C)
								mils per year								
Premix Components																
Liquid 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[1]	10.0[1]	10.0[1]	10.0[1]
Mixed Solutions																
Fixed wing	2.0[3]	2.0[3]	2.0[3]	2.0[3]	2.0	2.0	5.0	5.0	2.0	2.0	5.0	5.0	–[2]	–[2]	–[2]	–[2]
Helicopter with internal or fixed tank	2.0[3]	2.0[3]	2.0[3]	2.0[3]	2.0	2.0	5.0	5.0	2.0	2.0	5.0	5.0	2.0[3]	4.0[3]	2.0[3]	4.0[3]
Ground application or 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	–[2]	–[2]	–[2]	–[2]

[1] If submitted for "helicopter with internal or fixed tank"; for all types, refer to footnote 2.

[2] Test shall be conducted for performance information.

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

Table 2-1.2.1 Toxicity Limits for Class A Foam Concentrates and Solutions

	Acute Oral Toxicity[1]	Acute Dermal Toxicity[2]	Primary Dermal Irritation	Primary Eye Irritation	
				Unwashed	Washed
Requirements	$LD_{50} > 500$ mg/kg	$LD_{50} > 2000$ mg/kg	Primary irritation	Mildly irritating	Mildly irritating
Foam concentrate	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.	Primary irritation score: < 5.0. If more irritating, demonstrate protective gear/handling procedures.	If more irritating, demonstrate protective gear/handling procedures.	If more irritating, demonstrate protective gear/handling procedures.
Requirements	$LD_{50} > 5000$ mg/kg	$LD_{50} > 2000$ mg/kg	Primary irritation score: < 5.0	Mildly irritating	Mildly irritating

[1] If the acute oral toxicity of the concentrate is ≤ 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 ≤ 1000 mg/kg, the acute inhalation toxicity test shall be performed An $LC_{50} > 2.0$ mg/L shall be permitted.

2-2 Foam Solution.

2-2.1 Corrosion.

2-2.1.1 Uniform Corrosion. The foam solution, over the range of recommended use levels, shall not exhibit values exceeding those given in Table 2-1.1 when tested in accordance with 3-1.1.

2-2.1.2 Intergranular Corrosion. The magnesium and aluminum coupons exposed to the foam solution during uniform corrosion testing shall exhibit no intergranular corrosion when examined in accordance with 3-1.2.

2-2.1.3* Corrosion of Nonmetallic Materials. The effects of foam solution, over the manufacturer's range of recommended use level concentrations, on the hardness and volume of the following nonmetallic materials shall be tested in accordance with 3-1.3. Tested materials shall not exhibit changes in hardness exceeding 10 percent nor changes in volume exceeding 5 percent.

(a) PVC plastic

(b) MIL-S-8802 sealant

(c) MIL-S-81733 sealant

(d) Neoprene rubber AMS (SAE Aerospace Materials Specification) 3208 synthetic rubber CL-Prene 45-55 share

(e) Fiberglass with epoxy resin

(f) Cross-linked polyethylene MIL-C-38359A

(g) High density polyethylene MIL-P-51431A

(h) Teflon AMS 3660

(i) Flexible polyolefin MIL-I-23053/5.

2-2.2 Health and Safety.

2-2.2.1 Toxicity. The foam solution, at the maximum recommended use level, shall not exceed the toxicity limits defined in Table 2-1.2.1 when tested in accordance with Section 3-2 by a biological testing laboratory that is certified as adhering to good laboratory practice standards as defined in the *Code of Federal Regulations*, 40 CFR, Part 792 or Part 160.

2-2.2.1.1 Documentation. Upon request, the manufacturer shall provide a summary of the results of toxicity testing described in 2-2.2.1.

2-2.3 Characterization.

2-2.3.1 Surface Tension. Surface tension values of foam solutions, as measured in accordance with Section 3-9, shall be provided by the manufacturer on the Product Data Sheet at 0.1, 0.3, 0.6, and 1.0 percent concentrations.

2-2.3.2 Expansion. Expansion shall be determined for a foam solution prepared at a 0.3 percent use level in deionized, fresh, and sea water in accordance with Section 3-5. The results shall be reported in accordance with 2-1.5.2 and on the Product Data Sheet.

2-3 Foam.

2-3.1 Drain Rate. The 25 percent drain time shall be determined for the foam prepared in 2-2.3.2 in accordance with Section 3-5. The results of these tests shall be reported in accordance with 2-1.5.2 and on the Product Data Sheet.

Chapter 3 Test Methods

3-1 Corrosion.

3-1.1 Uniform Corrosion. Each coupon, 2.5 cm × 10.26 cm × 0.32 cm (1 in. × 4 in. × 1/8 in.), shall be marked (by vibrating engraver) with a unique identification code, drilled in the upper center to insert the braided dacron string used to suspend it, and then measured to the nearest 0.001 cm (0.000394 in.) for each dimension (length, width, and thickness). Just prior to use, each coupon shall be degreased using an all-purpose liquid cleaner and shall be rinsed in tap water. The coupons then shall be cleaned chemically as described in Table 3-1, rinsed in distilled water, wiped to remove most of the water film, and dried at about 130°F (55°C) for 15 to 30 minutes. After the coupons are cooled to room temperature, they shall be weighed to 0.1 mg (0.00154 grain) and either used immediately or stored in a desiccator. After cleaning, coupons shall be suspended by a length of braided dacron fishing line in a 0.95-L (32-oz) glass jar in such a way that the coupon does not touch the sides or bottom of the jar. Each jar shall contain 0.8 L (24 oz) of liquid for total immersion tests or 0.4 L (12 oz) of liquid 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 for partial immersion tests. The coupon shall be completely covered with liquid for total immersion tests. Each jar shall be closed with a screw cap, labeled with coupon identification and starting date, and put in an incubator at 70°F or 120°F (21°C or 49°C), dependent on the desired test condition.

Jars containing the test liquid (three at each exposure and temperature) shall stand undisturbed for 90 days.

At the end of the 90-day test period, the coupons shall be removed from the liquid and rinsed under running water to remove loosely attached corrosion products. If necessary, the coupons shall be lightly scrubbed with a toothbrush or other nonmetallic brush to aid in removal of scale. The coupons then shall be cleaned chemically using the same procedures that were used initially in accordance with Table 3-1. A clean, unused coupon shall be cleaned in the same manner to serve as a control for weight lost during the cleaning process. After rinsing in distilled water, oven-drying, and cooling as before, the final weight of each coupon shall be determined to 0.1 mg (0.00154 grain).

The corrosion weight (Cr) in mils per year (MPY) shall be calculated for each sample as follows:

$$\mathrm{Cr} = 534\ \frac{\mathrm{Wt}_I - \mathrm{Wt}_F - \mathrm{Wt}_C}{\mathrm{Atp}}$$

Where:

Wt_I = initial coupon weight (milligrams).
Wt_F = final coupon weight (milligrams).
Wt_C = weight loss of the control (milligrams).
A = area of the coupon (square inches).
t = exposure (hours).
p = density of the alloy (grams per cubic centimeter) as follows:

2024-T-3 aluminum = 2.77 grams per cubic centimeter.
4130 steel = 7.86 grams per cubic centimeter.
Yellow brass = 8.53 grams per cubic centimeter.
AZ-31-B magnesium = 1.77 grams per cubic centimeter.

Results of replicate tests shall be averaged.

Table 3-1 Procedure for Cleaning Corrosion Coupons

Alloy	Chemical	Time	Temperature	Remarks
Aluminum	70% HNO_3	2–3 min	Room	Follow with light scrub using nonmetallic brush[1]
	2% CrO_3		175° - 185°F	Use when film resists HNO_3 – alternate two treat-
Aluminum	5% H_3PO_4 Soln	10 min	(79°C - 85°C)	ments as needed
Brass	15–20% HCl	2–3 min	Room	Follow with light scrub using nonmetallic brush[1]
Steel	50g SnC1 + 20 g $SbCl_3$ in 1 liter conc. HCl	3–5 min	Cold	Follow with light scrub using nonmetallic brush[1]
Magnesium	15% CrO_3 + 1% $AgCrO_4$ in distilled H_2O	15 min	Boiling	Follow with light scrub using nonmetallic brush[1]

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

3-1.2 Intergranular Corrosion Test. The mixed solution shall be tested for intergranular corrosion as required by 2-2.1.2 as follows:

At least one coupon for each exposure and temperature from 90-day weight loss tests on the specified alloys shall be sliced as shown in Figure 3-1.2, mounted, polished to 0.3 micron alumina finish, etched with Keller's reagent using standard metallurgical techniques, and examined at a magnification of 500X on both the transverse and longitudinal cross sections.

3-1.3 Nonmetallic Corrosion Tests.

3-1.3.1 Volume Test. A wide-mouth bottle of approximately 0.12 L (4 oz) with a tightly fitted screw cap shall be used as the test container. A piece of the nonmetallic material to be tested shall be prepared with dimensions chosen so that it can be placed in the test container. The volume of the test piece shall be measured using calipers capable of measuring with an accuracy of 0.03 cm (0.01 in.) or volumetrically using a pycnometer to the nearest 0.01 g (0.0003 oz). This value shall be recorded. The test coupon shall be placed in the container and then the container shall be filled with the test concentrate or solution so that the coupon is totally immersed. The test container shall be closed tightly to prevent liquid evaporation for the duration of the test. Triplicate determinations shall be made on each test material and liquid.

The test chamber and sample shall be stored at 70°F (21°C) for 28 days. 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 hours each day during the normal 5-day work week. At the end of this period and on weekends, the test materials shall be returned to the test chamber. Any lost material shall be replenished so that the coupon continues to be totally immersed.

At the end of the 28-day period, the test material shall be removed from the liquid, rinsed with distilled water, and dried. The dimensions of the test piece shall be measured and its total volume calculated. The change in volume shall be calculated and compared with its initial volume to determine the change that occurred during the test. The average of the triplicate results shall be reported.

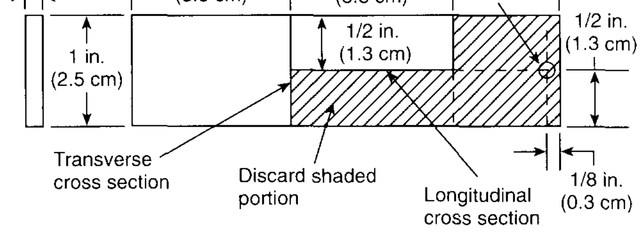

Figure 3-1.2 Intergranular corrosion test.

3-1.3.2 Hardness Test. The hardness of the nonmetallic coupons described in 3-1.3.1 shall be determined according to Federal Test Standard No. 601, Methods 3021 and 3025, both prior to and following the submerged storage described in 3-1.3.1.

Material	Apparatus
PVC plastic	Shore A2
MIL-S-8802 sealant	Shore A2
MIL-S-81733 sealant	Shore A2
Neoprene rubber	Shore A2
Fiberglass	Shore D
Cross-linked polyethlene	Shore A2
High density polyethylene MIL-P-51431A	Shore D
Teflon AMS 3660	Shore D
Flexible polyolefin, MIL-I-23053/5	Shore A2

The average of the triplicate results shall be reported.

3-2 Toxicity. The foam concentrate shall be tested in accordance with "Pesticide Assessment Guidelines, Subdivision F, Hazard Evaluation: Human and Domestic Animals," U.S. Environmental Protection Agency, Washington, D.C., Protocols: FIFRA Guidelines series 81, Acute Toxicity and Irritations Studies.

3-3 Biodegradability Test.

3-3.1 Aerobic Aquatic Biodegradation, CFR 40, Part 796.3100. This test is designed to develop data on the rate and extent of aerobic biodegradation that might occur when chemical substances are released to aquatic environments. A high biodegradability result for this test provides evidence that the test substance is biodegradable in natural aerobic freshwater environments. On the contrary, a low biodegradation result might have causes other than poor biodegradability of the test substance. Inhibition of the microbial inoculum by the test substance at the test concentration might be observed. In such cases, further work is needed to assess the aerobic aquatic biodegradability and to determine the concentrations at which toxic effects are evident. An estimate of the expected environmental concentration shall help to put toxic effects into perspective.

3-3.2 Definitions.

Adaption. The process by which a substance induces the synthesis of any degradative enzymes necessary to catalyze the transformation of that substance.

Ready Biodegradability. An expression used to describe those substances that, in certain biodegradation test procedures, produce positive results that are unequivocal and that lead to the reasonable assumption that the substance will undergo rapid and ultimate biodegradation in aerobic aquatic environments.

Ultimate Biodegradability. The breakdown of an organic compound to CO_2, water, the oxides or mineral salts of other elements, or to products associated with normal metabolic processes of microorganisms or to a combination of these.

3-3.3 This test method is based on the method described by William Gledhill. The method consists of a 2-week inoculum build-up period during which soil and sewage microorganisms are provided the opportunity to adapt to the test compound. This inoculum is added to a specially equipped Erlenmeyer flask containing a defined medium with test substance. A reservoir holding barium hydroxide solution is suspended in the test flask. After inoculation, the test flasks are purged with CO_2-free air, sealed, and incubated with shaking in the dark. Periodically, samples of the test mixture containing water-soluble test substances are analyzed for dissolved organic carbon (DOC), and the $Ba(OH)_2$ from the reservoirs is titrated to measure the amount of CO_2 evolution. Differences in the extent of DOC disappearance and CO_2 evolution between control flasks containing no test substance and flasks containing test substance are used to estimate the degree of ultimate biodegradation.

3-3.4 Prerequisites. The total organic carbon (TOC) content of the test substance shall be calculated or, if this is not possible, analyzed to enable the percent of theoretical yield of carbon dioxide and percent of DOC loss to be calculated.

3-3.5 Test Information.

3-3.5.1 Information on the relative proportions of the major components of the test substance will be useful in interpreting the results obtained, particularly in those cases where the result lies close to a "pass level."

3-3.5.2 Information on the toxicity of the chemical might be useful in the interpretation of low results and in the selection of appropriate test concentrations.

3-3.6 Reference Substances. Where investigating a chemical substance, reference compounds might be useful and an inventory of suitable reference compounds shall be identified. In order to check the activity of the inoculum, the use of a reference compound shall be required desirable. Aniline, sodium citrate, dextrose, phthalic acid, and trimellitic acid will exhibit ultimate biodegradation under the conditions of this test guideline method. These reference substances shall yield 60 percent of theoretical maximum CO_2 and show a removal of 70 percent DOC within 28 days. Otherwise, the test shall be considered as invalid and shall be repeated using an inoculum from a different source.

3-3.7 Reproducibility. The reproducibility of the method has not yet been determined; however, it is believed to be appropriate for a screening test that has solely an acceptance (no rejective) function.

3-3.8 Sensitivity. The sensitivity of the method shall be determined by the ability to measure the endogenous CO_2 production of the inoculum in the blank flask and by the sensitivity limit of the dissolved organic carbon analysis. If the test is adapted to handle C^{14}-labeled test substances, the test substance concentration can be much lower.

3-3.9 Possibility of Standardization. This possibility exists. The major difficulty is to standardize the inoculum in such a way that interlaboratory reproducibility is ensured.

3-3.10 Possibility of Automation. There are none at present, although parts of the analyses might be automated.

3-3.11 Test Procedures.

3-3.11.1 Apparatus. The shake flask apparatus in Figure 3-3.11.1 shall consist of an open reservoir containing 10 ml of 0.2 N $Ba(OH)_2$ suspended over 1 L of culture medium in a 2-L Erlenmeyer flask.

The $Ba(OH)_2$ container shall be made by placing a constriction just above the 10-ml mark of a 50-ml heavy-duty centrifuge tube and attaching the centrifuge tube to a 2 mm I.D. × 9 mm O.D. (0.08 in. I.D. × 0.36 in. O.D.) glass tube by means of three glass support rods. The centrifuge tube opening shall be large enough to permit CO_2 to diffuse into the $Ba(OH)_2$, while the constriction permits transferal of the flask to and from the shaker without $Ba(OH)_2$ spillage into the medium. For periodic removal and addition of base from the center well, a polypropylene capillary tube, attached at one end to a 10-ml disposable syringe, shall be inserted through the 9-mm O.D. (0.36-in.) glass tube into the $Ba(OH)_2$ reservoir. The reservoir access port shall be sealed during incubation with a serum bottle stopper. Two glass tubes shall be added for purging, venting, and medium sampling. The tops of these tubes shall be connected with a short section of flexible tubing during incubation.

3-3.11.2 Reagents and Stock Solutions.

(a) Stock solutions, I, II, and III per Table 3-3.11.2
(b) Yeast extract
(c) Vitamin-free casamino acids
(d) 70 percent O_2 in nitrogen or CO_2-free air
(e) 0.2 N $Ba(OH)_2$
(f) 0.1 N HCl
(g) 20 percent H_2SO_4
(h) Phenolphthalein
(i) Dilution water — distilled, deionized water (DIW).

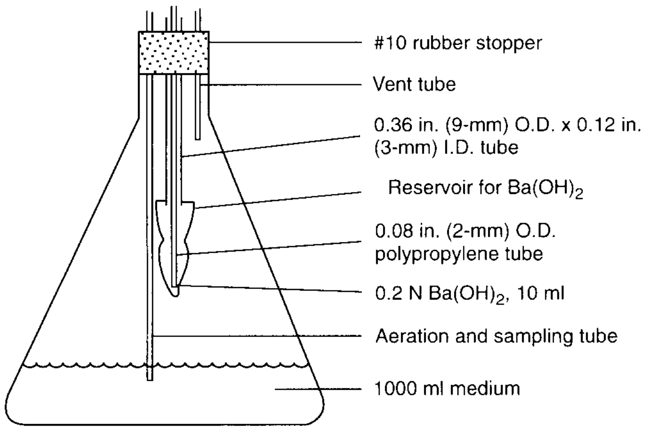

Figure 3-3.11.1 Shake-flask system for carbon dioxide evolution.

Table 3-3.11.2 Medium Employed for Assay of CO_2 Evolution

Solution[1]	Compound	Stock Solution Conc. (g/L)
I	NH_4Cl	35
	KNO_3	15
	K_2HPO_4–$3H_2O$	75
	NaH_2PO_4–H_2O	25
II[2]	KCl	10
	$MgSO_4$	20
	$FeSO_4$–$7H_2O$	1
III	$CaCl_2$	5
	$ZnCl_2$	0.05
	$MnCl_2$–$4H_2O$	0.5
	$CuCl_2$	0.05
	$CoCl_2$	0.001
	H_3BO_3	0.001
	MoO_3	0.0004

[1] Each liter of test medium contains 1 ml of each solution.

[2] Final pH is adjusted to 3.0 with 0.10 N HCl.

3-3.11.3 Soil Inoculum. A fresh sample of an organically rich soil shall be used as the inoculum in the ultimate biodegradation test. Soil shall be collected, prepared, and stored according to the recommendations of Pramer and Bartha. The soil surface shall be cleared of litter and a soil sample shall be obtained to 20 cm (0.8 in.) below the surface. The sample shall be screened through a sieve with 2 mm to 5 mm (0.08 in. to 0.2 in.) openings and stored in a polyethylene bag at 34°F to 39°F (2°C to 4°C) for not more than 30 days prior to use. The soil shall never be allowed to air-dry and shall not be frozen during storage.

3-3.11.4 Acclimation Medium. An acclimation medium shall be prepared by adding for each liter of distilled, deionized water (DIW): 1 ml (0.034 oz) each of solutions I, II, and III in Table 3-3.11.2, 1.0 g of soil inoculum, 2.0 ml (0.068 oz)of aerated mixed liquor (obtained from an activated sludge treatment plant not more than 2 days prior to commencing the acclimation phase, and stored in the interim at 39°F (4°C) and 50 ml (1.7 oz) raw domestic influent sewage. This medium shall be mixed for 15 minutes and filtered through a glass wool plug in a glass funnel. The filtrate shall be permitted to stand for 1 hour, refiltered through glass wool, and supplemented with 25 mg/L each of Difco vitamin-free casamino acids and yeast extract. Appropriate volumes shall be added to 2-L Erlenmeyer flasks. Test compounds shall be added incrementally during the acclimation period at concentrations equivalent to 4 and 8 mg/L carbon on days 7 and 11, respectively. On day 14, the medium shall be refiltered through glass wool prior to use in the test. For evaluating the biodegradability of a series of functionally or structurally related chemicals, media from all inoculum flasks shall be combined before final filtration.

3-3.12 Procedures.

3-3.12.1 Inoculum 100 ml (3.4 oz) of acclimation medium) shall be added to 900 ml (30.6 oz) DIW containing 1 ml (0.034 oz) each of solutions I, II, and III in accordance with Table 3-3.11.2 in a 2-L Erlenmeyer flask. Test compound equivalent to 10 mg/L carbon shall be added to each of the replicate flasks containing the test medium. Ten ml of 0.2 N $Ba(OH)_2$ shall be added to the suspended reservoir in each flask, and duplicate 10-ml samples of $Ba(OH)_2$ also shall be saved as titration blanks for analysis with test samples. Flasks shall be purged with CO_2-free air (for volatile test materials, purging shall be done prior to addition of the chemical), sealed, and placed on a gyrotary shaker (approximately 125 rpm) at 69°F to 77°F (20°C to 25°C) in the dark. For each set of experiments, each test, reference, inhibited, and control system shall be analyzed at time zero and at a minimum of four other times from time zero through day 28. Sampling shall be made with sufficient frequency to allow for a smooth plot of biodegradation with time. Sampling times shall be varied by the investigator as deemed appropriate to match the rate of degradation of the test substance. Tests shall be terminated when biodegradation reaches a plateau and is consistent (±10 percent) over three consecutive days or on day 28, whichever occurs first. For chemicals that are water soluble at the test concentration, an adequate volume [5 ml to 10 ml (0.17 oz to 0.34 oz)] of medium shall be removed for DOC analysis. Each sample for DOC analysis shall be filtered through a membrane filter of 0.45 micrometer pore diameter before DOC analysis. For all test and reference compounds, $Ba(OH)_2$ from the center well shall be removed for analysis. The center well shall be rinsed with 10 ml (0.34 oz) of CO_2-free DIW and shall be refilled with fresh base. Rinse water shall be combined with the $Ba(OH)_2$ sample to be analyzed. Flasks shall be resealed and placed on the shaker. On the day prior to terminating the test, 3 ml of 20 percent H_2SO_4 shall be added to the medium to release carbonate-bound CO_2.

3-3.12.2 For each set of experiments, each test substance shall be tested in triplicate.

3-3.12.3 For each set of experiments, one or two reference compounds shall be included to assess the microbial activity of the test medium. Duplicate reference flasks shall be prepared by adding reference compound equivalent to 10 mg/L carbon to each of two flasks containing the test medium. Reference compounds that are positive for ultimate biodegradability include sodium citrate, dextrose, phthalic acid, trimellitic acid, and aniline.

3-3.12.4 For each test set, triplicate controls receiving inoculated medium and no test compound, plus all test and reference flasks, shall be analyzed for CO_2 evolution and DOC removal. Results from analysis of the control flasks (DOC, CO_2 evolution, etc.) shall be subtracted from corresponding experimental flasks containing test compound in order to arrive at the net effect due to the test compound.

3-3.12.5 A test system containing a growth inhibitor shall be established as a control for each substance tested for biodegradation by this method. This inhibited system shall contain the same amount of water, mineral nutrients, inoculum, and test substance used in the uninhibited test systems, plus 50 mg/L mercuric chloride ($HgCl_2$) to inhibit microbial activity.

3-3.12.6 Flasks shall be incubated in the dark to minimize both photochemical reactions and algal growth. Appropriate sterile controls or controls containing a metabolic inhibitor, such as 50 mg/L $HgCl_2$, are needed to correct for interferences due to nonbiological degradation. With volatile organic materials, purging with CO_2-free air shall be performed only once just prior to addition of the test chemical. Analyses for CO_2 evolution and DOC removal shall be conducted within 2 to 3 hours of sampling to minimize interferences that could occur in storage. All glassware shall be free of organic carbon contaminants.

3-3.13 Analytical Measurements. The quantity of CO_2 evolved shall be measured by titration of the entire $Ba(OH)_2$ sample [10 ml (0.34 oz) $Ba(OH)_2$ + 10 ml (0.34 oz) rinse water with 0.1 N HCl] to the phenolphthalein end point. $Ba(OH)_2$ blanks also shall be supplemented with 10 ml (0.34 oz) CO_2-free DIW and titrated in a similar manner. Samples [5 ml (0.17 oz)] for DOC shall be centrifuged or filtered, or both, and supernatant or filtrate shall be analyzed by a suitable total organic carbon method.

3-3.14 Data and Reporting — Treatment of Results.

3-3.14.1 Test compound (10 mg carbon) is theoretically converted to 0.833 mmol CO_2. Absorbed CO_2 precipitates as $BaCO_2$ from $Ba(OH)_2$, causing a reduction in alkalinity by the equivalent of 16.67 ml of 0.1 N HCl for complete conversion of the test compound carbon to CO_2. Therefore, the percent theoretical CO_2 evolved from the test compound shall be calculated at any sampling time from the following equation:

Percent CO_2 evolution = [(TF - CF)/16.67] 100 (for 10 mg/L test compound carbon)

Where:

TF = ml 0.1 N HCl required to titrate $Ba(OH)_2$ samples from the test flask.

CF = ml 0.1 N HCl required to titrate $Ba(OH)_2$ samples from the control flask.

3-3.14.2 The cumulative percent CO_2 evolution at any sample time shall be calculated as the summation of the percent CO_2 evolved at all sample points of the test.

3-3.14.3 The percent DOC disappearance from the test compound shall be calculated from the following equation:

Percent DOC Removal = $[1 - (DTFx - DCFx)/DTF_0 - DCF_0)]$ 100

Where:

DTF = Dissolved organic carbon from test flask.
DCF = Dissolved organic carbon from control flask.
0 = Day zero measurements.
x = Day of measurements during test.

3-3.14.4 The difference between the amount of 0.1 N HCl used for the $Ba(OH)_2$ titration blank samples and the $Ba(OH)_2$ samples from the control units (no test compound) shall be an indication of the activity of the microorganisms in the test system. In general, this difference shall be approximately 1 to 3 ml of 0.1 N HCl at each sampling time. A finding of no difference in the titration volumes between these two samples indicates a poor inoculum. In this case, the test set shall be rerun for validity, beginning with the acclimation phase.

3-3.14.5 CO_2 evolution in the reference flasks also shall be indicative of the activity of the microbial test system. The suggested reference compounds shall all yield final CO_2 evolution values in the range 80 to 100 percent of theoretical CO_2. If, for any test set, the percent theoretical CO_2 evolution value for the reference flasks is outside this range, the test results shall be considered invalid and the test shall be rerun.

3-3.14.6 Inhibition by the test compound shall be indicated by lower CO_2 evolution in the test flasks than in the control flasks. If inhibition is noted, the study for this compound shall be rerun, beginning with the acclimation phase. During the test phase for inhibitory compounds, the test chemical shall be added incrementally according to the following schedule:

Day 0 — 0.5 mg/L as organic carbon
Day 2 — 1 mg/L C
Day 4 — 1.5 mg/L C
Day 7 — 2 mg/L C
Day 10 — 5 mg/L C. In this case, the $Ba(OH)_2$ shall be sampled on Day 10, and weekly thereafter. The total test duration remains 28 days.

3-3.14.7 The use of C^{14}-labeled chemicals shall not be required. If an appropriately labeled test substance is readily available and if the investigator chooses to use this procedure with a labeled test substance, this alternative shall be permitted. If this option is chosen, the investigator shall use lower test substance concentrations if those concentrations are more representative of environmental levels.

3-3.15 Test Report. For each test and reference compound, the following data shall be reported:

(a) Information on the inoculum, including source, collection date, handling, storage, and possible adaptation (e.g. the inoculum might have been exposed to the test substance either before or after collection and prior to use in the test).

(b) Results from each test, reference, inhibited (with $HgCl_2$), and control system at each sampling time, including an average test result for the triplicate test substance systems and the standard deviation for that average.

(c) Average cumulative percent theoretical CO_2 evolution for the test duration.

(d) Dissolved organic carbon due to test compound at each sampling time (DTF-DCF).

(e) Average percent DOC removal at each sampling time.

(f) Twenty-eight-day standard deviation for percent CO_2 evolution and DOC removal.

3-4 Fish Toxicity. Foam concentrate samples shall be tested, using *salmo gairdneri* (rainbow trout), in accordance with "Environmental Protection Series, Biological Test Method: Acute Lethality Test Using Rainbow Trout," Report EPS1/RM/9, or equivalent test procedure recognized by the authority having jurisdiction where the foam concentrate will be used.

3-5 Foam Expansion and Drain Time.

3-5.1 Test Method. One hundred fifty ml of a 0.3 percent foam solution, prepared using 70°F ± 5°F (21°C ± 3°C) water, shall be poured into the jar of an Oster 7-speed household blender or equivalent. The jar shall be calibrated and marked in 50-ml increments. The solution shall be blended for 45 seconds at the lowest speed and the volume of foam, as indicated by the container calibrations, recorded. The foam then shall be poured into a 1-L graduated cylinder and the foam volume again measured and recorded. The drain time shall be determined by recording the volume of foam solution drained from the foam at 1-minute intervals for 15 minutes or until 40 ml of solution have been drained, whichever is greater.

The volume of drained solution shall be plotted against time (minutes). The time required for 37.5 ml to drain shall be recorded as the 25 percent drain time.

3-5.1.1 Deionized Water. The test method shall be conducted according to 3-5.1, with the 0.3 percent foam solution prepared with deionized water.

3-5.1.2 Fresh Water. The test method shall be repeated according to 3-5.1, with the 0.3 percent foam solution prepared in accordance with the definition of fresh water in Section 1-3.

3-5.1.3 Artificial Sea Water. The test method shall be repeated once again according to 3-5.1, with the 0.3 percent foam solution prepared in accordance with the definition of artificial sea water in Section 1-3.

3-6 Miscibility. Five hundred ml of deionized water at the test temperature shall be added to a 1-L beaker. A stirrer, as illustrated in Figure 3-6, shall be inserted into the water to the depth shown on the illustration. The speed of the stirrer motor shall be adjusted to 60 rpm ± 10 rpm. Within approximately a 2-second period, the amount of concentrate needed to produce the required concentration shall be added to the beaker. After 10 revolutions of the stirrer, rotation shall be stopped and the liquid mixture shall be observed. If the solution is not visually homogeneous, it shall be stirred for an additional 10 revolutions. This procedure shall be repeated until the solution is visually homogeneous or the total number of revolutions is equal to 100. The observations made at each 10-revolution interval shall be recorded. The sample shall remain undisturbed for 15 minutes. If the solution is not visually homogeneous after the 15-minute period, the result shall be recorded as "not miscible."

Three miscibility (ease of mixing) tests shall be made using 70°F (21°C) foam concentrate mixed into 40°, 70°, and 100°F (4°, 21°, and 38°C) deionized water in accordance with the above test method.

A second series of three tests shall be conducted using 40°F (4°C) foam concentrate and the same water temperatures specified in the previous paragraph.

3-7 Stability of Concentrate.

3-7.1 Three 19-L (5-gal) samples of foam concentrate from a single production lot shall be stored in sealed containers, of the type used by the manufacturer for shipping and storage, as described in 3-7.1.2 through 3-7.1.4. The samples shall be designated as Samples 1, 2, and 3.

3-7.1.1 Samples shall not be agitated or disturbed in any way or at any time during or between the entire storage periods.

3-7.1.2 Sample 1 shall be stored at 105°F ± 5°F (41°C ± 3°C) for 30 continuous days. At the end of the 30-day period, the sample shall be removed from the 105°-F (41°-C) environment and stored at 70°F ± 4°F (21°C ± 2°C) for 7 days (168 hours). Sample 1 then shall be handled, opened, and inspected in accordance with 3-7.2.

3-7.1.3 Sample 2 shall be stored at 105°F ± 5°F (41°C ± 3°C) for 30 continuous days in a manner identical to Sample 1. Within 12 hours of removal from the 105°-F (41°-C) environment, Sample 2 shall be placed in an environment at a temperature of 14°F ± 2°F (-10°C ± 1°C). It shall be kept in this cold environment for a second continuous 30-day period and then placed in an environment of 70°F ± 4°F (21°C ± 2°C) for 7 days. At the end of this 7-day period (67 days into the test regimen), Sample 2 then shall be handled, opened, and inspected in accordance with 3-7.2.

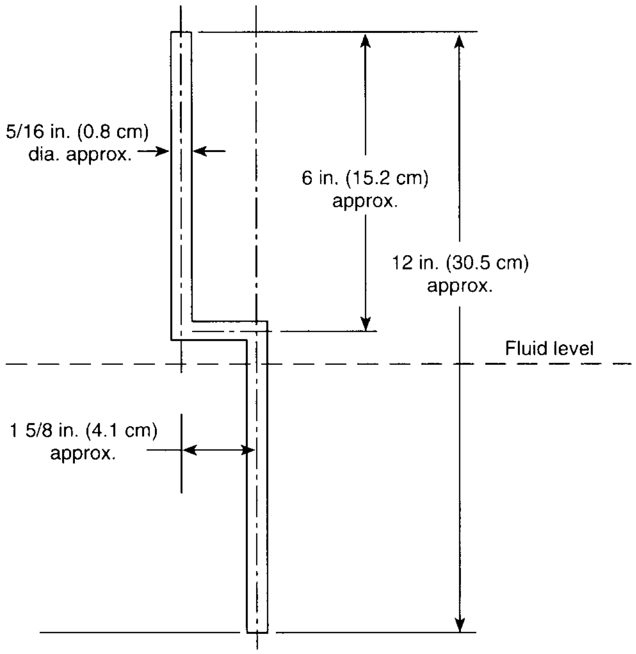

Figure 3-6 Stirrer shaft for miscibility test.

3-7.1.4 Sample 3 shall be stored at 14°F ± 2°F (-10°C ± 1°C) for 30 continuous days, removed and held at a temperature of 70°F ± 4°F (21°C ± 2°C) for 7 days. At the end of this period, Sample 3 shall be handled, opened, and inspected in accordance with 3-7.2.

3-7.2 At the end of the storage periods described in 3-7.1, the sealed sample container shall be inverted four times within a 1-minute period. It then shall be opened and the foam concentrate poured into an open pail and allowed to sit undisturbed for 10 minutes to allow bubbles to rise to the surface. The sample then shall be visually examined for separation, stratification, and crystallization. After thoroughly mixing to achieve homogeneity, the expansion and drain time of the concentrate shall be determined in accordance with the procedure in Section 3-5 and in accordance with 2-1.4.1. The empty container shall be examined, as well, for any evidence of residual sediment or crystals.

3-8 Viscosity. The viscosity of the foam concentrate shall be tested in the following manner as required in 2-1.4.2. A Brookfield viscometer model LVT or LVF, or 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) to measure the viscosity shall be used. A Griffith beaker or other straight-sided container containing approximately 800 ml of the test sample shall be positioned under the viscometer. The spindle shall be immersed to the proper depth in the concentrate. The viscometer then shall be turned on and the spindle allowed to rotate for 1 minute prior to reading the dial. Triplicate measurements shall be made, stirring between each measurement, and the viscosity of the sample calculated in centipoise using the appropriate multiplier (5 for spindle No. 2 and 100 for spindle No. 4).

3-9 Surface Tension. Foam solutions containing 0.1, 0.3, 0.6, and 1.0 g of foam concentrate per 100 g of solution shall be prepared with deionized water preadjusted to 70°F ± 4°F (21°C ± 2°C) and the surface tension of each sample determined according to ISO 304, *Surface Active Agents — Determination of Surface Tension by Drawing Up Liquid Films*, as referenced in 4-1.2.

3-10 Flash Point. As required in 2-1.4.4 the open cup flash point shall be determined in accordance with ASTM D92, *Method of Test for Flash and Fire Points by Cleveland Open Cup.*

Chapter 4 Referenced Publications

4-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

4-1.1 "Pesticide Assessment Guidelines, Subdivision F, Hazard Evaluation: Human and Domestic Animals," U.S. Environmental Protection Agency, Washington, D.C., as found in *Federal Register*, Vol. 43, No. 163.

4-1.2 International Organization for Standardization, ISO 304, *Surface Active Agents — Determination of Surface Tension by Drawing Up Liquid Films*, second edition, 1985-12-15.

4-1.3 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).

4-1.4 Canadian General Standards Board, Standard 28-GP-74M (September 1982).

4-1.5 *Code of Federal Regulations*, 40 CFR, Parts 160, 792, and 796.3100.

4-1.6 "Environmental Protection Series, Biological Test Method: Acute Lethality Test Using Rainbow Trout," Report EPS1/RM/9, July 1990

4-1.7 Federal Test Standard No. 601, Methods 3021 and 3025 (April 12, 1985).

4-1.8 ASTM D92, *Method of Test for Flash and Fire Points by Cleveland Open Cup*, 1990. American Society of Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

4-1.9 Gledhill, W.E. "Screening Test for Assessment of Ultimate Biodegradability: Linear Alkyl Benzene Sulfonate," *Applied Microbiology*, 30:922-929(1975).

4-1.10 Pramer, D., Bartha, R. "Preparation and Processing of Soil Samples for Biodegradation Testing," *Environmental Letters*, 2:217-224 (1972).

Appendix A Explanatory Material

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

A-1-3 Class A Foam. Types of systems for producing Class A fire suppressant foam are as follows:

(a) *Compressed Air Foam System or Water Expansion Pumping System.* The compressed air foam system (CAFS) is a fire-fighting system that expands water from 1 to at least 60 times its original volume and is designed for foam application on Class A fuels.

(b) *Air-aspirating Foam Nozzle.* Foam concentrate is mixed with water and the solution is pumped to the aspirating nozzle where foam is generated.

(c) *Fixed-wing Aircraft.* Solutions mixed at 0.3 to 1.0 percent by volume are dropped from low altitudes to produce expansion up to 15:1 (depending on drop speed, aircraft height, and mix ratio).

(d) *Helicopters.* Foam solutions are dropped from helicopters equipped with fixed tanks or buckets to produce expansion rates of up to 10:1.

Additional information on each of these foam development and application methods is referenced in Appendix B.

A-2-1.1 Corrosion of Metals. Generally, foam solutions have a cleansing action that removes loose grease, oil, scale, and paint from metal surfaces, which normally protect metal from the corrosive attack of water.

A-2-1.1.2 If other nonmetallic materials are to be used with foam concentrate, such materials also should be tested in acordance with 3-1.3.

Foam concentrate or foam solutions might cause corrosion of some metal surfaces. Storage of foam solutions or concentrates for long periods of time in metal tanks should be avoided unless the container is fabricated of corrosion-resistant materials.

Solutions containing foam concentrates that interact with or remove galvanizing or similar coatings should not be used where contact with such coatings is likely.

Points of Inspection. All joints, seams, or connections that conceivably could be subject to leakage should be carefully examined because foam solution is capable of passing through openings too small for water. These include valve packing, retainers, bushings, threaded joints, and screw unions.

A-2-1.2 Personnel 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 wetted with concentrate should be changed and washed. Soiled clothes should be cleaned on a daily basis.

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. Eyes should be washed for 20 minutes. Fresh water should be available on site for this purpose.

Personnel handling foam solutions should wear protective clothing including eye protection and should avoid ingesting solution.

User Responsibility.

(a) Every container in the workplace that contains foam concentrate should be and should remain labeled in the prescribed manner.

(b) Labels and material safety data sheets should be available in English and such other language or languages as are prescribed by the authority having jurisdiction.

(c) Foam concentrate should not be used at a workplace unless a label and material safety data sheet are present and worker instruction and training have been completed.

(d) A material safety data sheet should be made available in the workplace in such a manner as to allow examination by the workers.

(e) Prescribed safe-handling equipment should be present, in proper repair, and in use at the workplace.

A-2-1.3 Recommended Operational Procedures.

Water Source Protection. The following procedures should be used where mixing and applying Class A fire suppressant foams:

(a) *Filling Mobile Water Supply Apparatus.* All pumps used to fill mobile water supply apparatus using foam should have a check valve on the suction side, an internal check valve, or a check valve next to the pump on the discharge side to avoid water source contamination and siphoning of the tank. Tanks should not leak and operators should avoid overflow spills and discharge hose spills.

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

Portable tanks or sumps used to premix solution or fill buckets should be located at least 100 ft (30 m) from fish-bearing streams or streams flowing into fish-bearing waters, and they should be situated on soil as opposed to gravel floodplains. Spills from portable tanks or sumps should be prevented from entering fish-bearing habitat or water that flows into fish-inhabited water.

(c) *Filling Fixed-wing Aircraft and Helicopters with Attached Tanks.* Mixing operations should be set up and executed to avoid spilling concentrate or solution. Spillage should not drain into drainage systems that empty into fish habitat or waterways that flow into fish-inhabited water.

Air drops should be more than 100 ft (30 m) from fish-bearing streams or streams flowing into fish-bearing streams.

For additional information on applications, see Appendix B.

A-2-1.4.1 Foam Concentrate Compatibility. Product brands and types might not be compatible. Users should flush and rinse concentrate holding containers before adding another brand or type of concentrate. Advice from the manufacturer should be obtained before mixing different concentrates.

A-2-2.1.3 If other nonmetallic materials are to be used with foam solutions, such materials also should be tested in accordance with 3-1.3.

Appendix B Referenced Publications

B-1 The following documents or portions thereof are referenced within this standard for informational purposes only and thus are not considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

FOAM VS FIRE, June 1992, National Wildfire Coordinating Group, NFES 2246.

Introduction to Class A Foams and Compressed Air Foam Systems for the Structural Fire Service, John Liebson, International Society of Fire Service Instructors, 0-929662-08-3.

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The NFPA Codes and Standards Development Process

Since 1896, one of the primary purposes of the NFPA has been to develop and update the standards covering all areas of fire safety.

Calls for Proposals

The code adoption process takes place twice each year and begins with a call for proposals from the public to amend existing codes and standards or to develop the content of new fire safety documents.

Report on Proposals

Upon receipt of public proposals, the technical committee members meet to review, consider, and act on the proposals. The public proposals – together with the committee action on each proposal and committee-generated proposals – are published in the NFPA's Report on Proposals (ROP). The ROP is then subject to public review and comment.

Report on Comments

These public comments are considered and acted upon by the appropriate technical committees. All public comments – together with the committee action on each comment – are published as the Committee's supplementary report in the NFPA's Report on Comments (ROC).

The committee's report and supplementary report are then presented for adoption and open debate at either of NFPA's semi-annual meetings held throughout the United States and Canada.

Association Action

The Association meeting may, subject to review and issuance by the NFPA Standards Council, (a) adopt a report as published, (b) adopt a report as amended, contingent upon subsequent approval by the committee, (c) return a report to committee for further study, and (d) return a portion of a report to committee.

Standards Council Action

The Standards Council will make a judgement on whether or not to issue an NFPA document based upon the entire record before the Council, including the vote taken at the Association meeting on the technical committee's report.

Voting Procedures

Voting at an NFPA Annual or Fall Meeting is restricted to members of record for 180 days prior to the opening of the first general session of the meeting, except that individuals who join the Association at an Annual or Fall Meeting are entitled to vote at the next Fall or Annual Meeting.

"Members" are defined by Article 3.2 of the Bylaws as individuals, firms, corporations, trade or professional associations, institutes, fire departments, fire brigades, and other public or private agencies desiring to advance the purposes of the Association. Each member shall have one vote in the affairs of the Association. Under Article 4.5 of the Bylaws, the vote of such a member shall be cast by that member individually or by an employee designated in writing by the member of record who has registered for the meeting. Such a designated person shall not be eligible to represent more than one voting privilege on each issue, nor cast more than one vote on each issue.

Any member who wishes to designate an employee to cast that member's vote at an Association meeting in place of that member must provide that employee with written authorization to represent the member at the meeting. The authorization must be on company letterhead signed by the member of record, with the membership number indicated, and the authorization must be recorded with the President of NFPA or his designee before the start of the opening general session of the Meeting. That employee, irrespective of his or her own personal membership status, shall be privileged to cast only one vote on each issue before the Association.

Sequence of Events Leading to Publication of an NFPA Committee Document

Call for proposals to amend existing document or for recommendations on new document.

▼

Committee meets to act on proposals, to develop its own proposals, and to prepare its report.

▼

Committee votes on proposals by letter ballot. If two-thirds approve, report goes forward. Lacking two-thirds approval, report returns to committee.

▼

Report is published for public review and comment. (Report on Proposals - ROP)

▼

Committee meets to act on each public comment received.

▼

Committee votes on comments by letter ballot. If two-thirds approve, supplementary report goes forward. Lacking two-thirds approval, supplementary report returns to committee.

▼

Supplementary report is published for public review. (Report on Comments - ROC).

▼

NFPA membership meets (Annual or Fall Meeting) and acts on committee report (ROP and ROC).

▼

Committee votes on any amendments to report approved at NFPA Annual or Fall Meeting.

▼

Complaints to Standards Council on Association action must be filed within 20 days of the NFPA Annual or Fall Meeting.

▼

Standards Council decides, based on all evidence, whether or not to issue standard or to take other action, including hearing any complaints.

▼

Appeals to Board of Directors on Standards Council action must be filed within 20 days of Council action.