

**US Department of Agriculture  
Forest Service**

**Specification 5100-307a**

**Specification for  
Fire Suppressant Foam for Wildland Firefighting  
(Class A Foam)**

**June 1, 2007**

**(Amendments Inserted into the Text, May 17, 2010)**

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Specification 5100-307  
April 2001

**U.S. DEPARTMENT OF AGRICULTURE  
FOREST SERVICE  
SPECIFICATION FOR  
FIRE SUPPRESSANT FOAM FOR WILDLAND FIREFIGHTING  
(CLASS A FOAM)**

**1. GENERAL.**

- 1.1.** **Scope.** The fire suppressant foams described in this specification are for use in wildland fire management. They may be applied from aerial or ground application equipment, directly to the fire area to slow or stop combustion.

Fire suppressant foams depend on the water that they contain to be effective and when that water has evaporated, they are no longer effective.

The foam concentrate shall be added to water to create a foam solution which can be used as a wetting agent or when aerated creates foam. The foam bubbles and the solution draining from them attach to and penetrate ordinary combustible materials, such as wood, due to the reduced surface tension of the water contained in the foam solution. The bubbles hold moisture and release it as the foam breaks down, prolonging the time the moisture may be absorbed by the fuels. The foam tends to cling to horizontal and vertical fuels excluding air from the fuel, enveloping the volatile combustible vapor and the fuel interface when applied in adequate quantities, and resisting disruption due to wind, heat, and flame.

Higher amounts of concentrate in the foam solution produce drier, slow draining foam for exposure (vertical surface) protection. Moderate amounts produce wetting, fast draining foam for vegetation (horizontal surface) application. Low amounts can be used to make wet water having enhanced penetration for mop up.

A wide range of foam characteristics can be prepared from the same concentrate by changing the mix ratio and adjusting the foam generation and application method used.

- 1.1.1.** All Class A fire suppressant foams and wetting agents are covered by this specification. Wetting agents that do not produce foam do not meet the requirements of this specification.
- 1.1.2.** All foam concentrates shall be wet concentrates.
- 1.1.3.** Products shall be one component, i.e., foam solutions shall be prepared by blending a single concentrate with water.
- 1.1.4.** For use during fire management operations, the foam concentrates shall be added to water to make 0.1-percent to 1.0-percent solutions and aerated to produce foam.

**2. SUBMISSION AND EVALUATION.**

**2.1. Wildland Fire Chemical Product Qualification Testing.** Qualification testing for wildland fire chemical products shall be performed prior to use (Forest Service Manual (FSM) 5100, Chapter 5160, Section 5162).

Testing shall include a laboratory evaluation and may include a field evaluation during firefighting operations.

**2.2. Unacceptable ingredients.** In addition to the ingredients identified in 2.4.1 as not meeting Forest Service direction the following ingredients shall not be accepted.

- Sodium ferrocyanide (Yellow Prussiate of Soda or YPS)
- Dichromates
- Thiourea
- Borate or other boron-containing compounds
- Polychlorinated biphenols (PCB) [Amendment 1 adds additional ingredients to list.]
- Polybrominated diphenyl ethers (PBDE) [Amendment 1 adds additional ingredients to list.]

**2.3. Manufacturer Submission Process.** The submitter (manufacturer, distributor, or supplier) shall make a request for evaluation to the USDA Forest Service, Branch Chief for Fire Equipment and Chemicals.

**2.3.1.** The following documents describing the submission procedures, evaluation process, and the required performance for acceptable products are available on the internet at [www.fs.fed.us/rm/fire/wfcs/foam-fir.htm](http://www.fs.fed.us/rm/fire/wfcs/foam-fir.htm):

- The Manufacturers Submission Procedures for Qualification Testing of Class A Foam Products.
- This Specification and current amendments
- Standard Test Procedures for the Evaluation of Wildland Fire Chemical Products.

**2.3.1.1.** Paper copies of these documents can be obtained from the Program Leader or Project Leader, Wildland Fire Chemical Systems (WFCS), 5785 Highway 10 West, Missoula, MT, 59808, if web access is unavailable.

**2.3.1.2. Terms and Definitions.** A list of terms used in this specification and their definitions can be found in Section 6.

**2.3.1.3. Sources of Reference Materials.** A list of sources for obtaining all referenced standards and test methods in this specification can be found in Section 7.

**2.3.2. Classification.** The submitter shall specify the Application Methods of the wildland fire chemical product, according to Section 2.3.2.1, for which qualification is sought.

The evaluation shall be conducted following the test methods and requirements contained in this specification, based on the classifications requested by the submitter.

**2.3.2.1. Application Methods.** Each mixed product shall be classified based on the listed application methods.

HF	Helicopters having a fixed tank, either internal or external in direct contact with the helicopter.
FW/Multi-Engine	Fixed-wing (all delivery systems) land-based, multi-engine aircraft having a tank and delivery system for aerial application of wildland fire chemicals.

FW/Single-Engine	Fixed-wing (all delivery systems) land-based, single-engine (SEAT) aircraft having a tank and delivery system for aerial application of wildland fire chemicals.
FW/WS	Fixed-wing (all delivery systems) water-scooping aircraft having a tank and delivery system for aerial application of wildland fire chemicals.
HB/G	Helicopters having a bucket suspended below the helicopter such that no chemical is likely to contact the helicopter during normal fire operations and all ground-based application equipment, such as wildland engines, portable pumps, and other such devices.

- 2.3.3. Collection Agreement and Test Fee.** A Collection Agreement between the Forest Service, Missoula Technology and Development Center (MTDC)-WFCS and the submitter shall be prepared. This document describes the roles and responsibilities of the Forest Service, WFCS laboratory personnel, and the submitter.

Specific information in the agreement includes a list of authorized contacts for the Forest Service and for the submitter, as well as an estimate of the cost and time required for the evaluation.

- 2.3.4. Product Information.** All product information described below shall be provided to the Forest Service and reviewed by the designated agency representative, as summarized in 2.4 and described in “Manufacturer Submission Procedures for Qualification Testing of Class A Foam Products,” prior to acceptance of samples for testing.

- 2.3.4.1. Proprietary Information.** The formulation disclosure and other product information provided to the Forest Service as a part of the submission process shall be maintained within the WFCS Program for use during the evaluation process.

All proprietary or sensitive information is kept in a locked file accessible only to the Program Leader and Project Leader of WFCS.

Occasionally information will be provided in response to direct questions from the Director of Fire and Aviation, the Branch Chief for Equipment and Chemicals or their staffs.

- 2.3.4.2. Access to Information Under the Freedom of Information Act.** Information provided to the Forest Service as part of the product submission is subject to the Freedom of Information Act (FOIA), 5 U.S.C., Section 552.

Confidential and trade secret information shall not be disclosed if determined to be exempt under FOIA.

The results of the testing performed by the Forest Service may be disclosed under some circumstances.

- 2.3.4.3. Formulation Disclosure Sheet.** The submitter shall submit a Formulation Disclosure Sheet (Table 1 of Manufacturer Submission Procedures) that includes the required information on all ingredients contained in the formulation.

Full disclosure of the types and amounts of each chemical in the product, the Chemical Abstract Services (CAS) number, quality or grade, and manufacturer shall be included for each ingredient.

The manufacturing process, manufacturing site, and other information that the supplier considers significant about each ingredient should also be provided. [Amendment 2 adds manufacturing site to the list of information to be provided.]

- 2.3.4.4. Mix Ratio Range.** The Class A foam product shall be evaluated over the range of mix ratios from 0.1 percent to 1.0 percent, by volume.

- 2.3.4.5. Health and Safety Information.** The submitter shall provide the following safety information to the Forest Service for review, prior to shipping the product:
- a. Mandatory: Material Safety Data Sheet (MSDS) for the proposed product.
  - b. Mandatory: MSDS for each ingredient of the proposed product.
  - c. Optional: Summary of any toxicity or related safety test results conducted by or for the manufacturer prior to submission to the Forest Service.
- 2.3.4.6. Technical Data Sheet.** The submitter shall provide a completed Technical Data Sheet (Table 2 of Manufacturer Submission Procedures) giving all required information on the physical properties and characteristics of the water enhancer. A description of the field mixing and handling requirements shall be included.
- 2.3.4.7. Other Technical Information.** The submitter shall provide information regarding laboratory mixing, field mixing and handling, and any special cleanup procedures that may be of use to the laboratory personnel at WFCS.
- 2.3.4.8. Patents.** Copies of patents covering any aspect of the formulation or its application in wildland fire operations should be included in the submission documentation.
- 2.4. Review Prior to Product Submittal (STP-1.1).** The Project Leader, WFCS shall review the documentation package for completeness and consistency. Any questions that may arise shall be resolved at that time.
- 2.4.1. Chemicals of Concern.** A review of environmental regulations as they apply to the formulation and the ingredients of the formulation shall be completed at the same time. Specifically, the status of each chemical with regard to the regulatory lists shown below shall be determined.
- a. 40 Code of Federal Regulations (CFR) 355 Appendix A. – Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), List of Extremely Hazardous Substances and Their threshold Planning Quantities.
  - b. National Toxicology Program’s Annual Report on Carcinogens
  - c. International Agency for Research on Cancer (IARC) Monographs for Potential Carcinogens
  - d. 40 CFR 302.4. – CERCLA, List of Hazardous Substances and Reportable Quantities
  - e. 40 CFR 261.33. – Resources Conservation and Recovery Act (RCRA), Acutely Hazardous and Toxic Wastes
  - f. 40 CFR 372. – Superfund Amendment and Reauthorization Act (SARA) Title III, sec 313, Emergency Planning and Community Right to Know (EPCRA), Toxic Release Inventory (TRI)

- 2.4.2. Chemical Profile and/or Risk Assessment.** If any of the ingredients trigger concern, a basic chemical profile and/or a risk assessment may be required before further action is taken on the formulation evaluation.

The Forest Service shall make a written notification to the submitter of these concerns and include the acceptable remedies and the associated costs. The submitter has the choice to continue or not at this point, and shall be asked to notify the Forest Service in writing of that decision.

If required, this risk assessment shall be performed by the Forest Service or an approved third-party selected by the Forest Service, using accepted methodology. All costs associated with the additional work shall be the responsibility of the submitter.

- 2.5. Submission of Samples for Laboratory Evaluation.** When requested, and at no cost to the Forest Service, the submitter shall provide the required amount of concentrate for use in the laboratory evaluation tests.

- 2.5.1. Packaging.** The packaging of all wildland fire chemicals submitted for evaluation shall conform to regulations governing the ground and air transport of materials.

The concentrates, in the quantities shown, shall be packaged as specified in Table 1.

<b>Table 1. Test sample quantity and packaging.</b>		
<u>Product Type</u>	<u>Packaging</u>	<u>Quantity</u>
Wet concentrate	5-gallon (18.9 liters) plastic pails	50 gallons (189 liters) ≤ 50 lbs (22.7 kg) per pail

- 2.5.2. Marking.** Individual containers of products submitted for evaluation shall be legibly marked in accordance with Federal Standard 123.

Labeling shall comply with Department of Transportation, Occupational Safety and Health Administration, and applicable State and Local requirements and in addition shall include the following:

- a. Manufacturer's name or trademark.
- b. Product identification including formulation codes and production information codes.
- c. Volume of concentrate per container.
- d. Month and year of submission.

- 2.5.3. Shipping.** The laboratory test sample shall be shipped at the submitter's expense to WFCS at MTDC in Missoula, Montana.

The complete address shall be provided as part of the shipping instructions when the product is requested.

An MSDS for the product shall accompany the shipment.

If the product is imported, the supplier shall be responsible for the entire process necessary to deliver the product to the test laboratory. [Amendment 2 adds this clarification of responsibility.]

### **3. REQUIREMENTS.**

**3.1. Mix Ratio Range.** The evaluation shall be conducted on the concentrate, on the foam solution over a range of mix ratios from 0.1 percent to 1.0 percent, and foam produced from these solutions.

**3.2. Performance Information.** The properties and characteristics of the concentrates and mixed products may vary over a wide range of values.

For some tests, a specific result is not required for qualification.

All listed tests, including those for which no required performance level is given, shall be performed and reported for information.

The performance information developed will be provided to user agencies as input to their procurement and decision-making processes.

**3.2.1. Modifications and Changes to Requirements.** At a later date some or all of the requirements may be amended to include limits to the performance values.

**3.3. Determination of Laboratory Mixing Procedures.** In accordance with 4.2, a suitable set of conditions and methods for preparing laboratory samples of the mixed product shall be determined.

All dilutions shall be prepared with deionized water unless otherwise specified.

This procedure shall be used to prepare all samples for the laboratory evaluation.

**3.4. Health and Safety.**

**3.4.1. Mammalian Toxicity and Irritation Tests.** As required by 3.4.1.1 and 3.4.1.2, the mammalian toxicity and irritation performance of the concentrate and mixed product shall be determined in accordance with 4.3.

The results will be made available to users as performance information.

**3.4.1.1. Concentrate.** The toxicity of the concentrate shall meet the requirements in Table 2 when tested in accordance with 4.3.

<b>Table 2. Toxicity and Irritation Requirements for Concentrate</b>	
<u>Test</u>	<u>Requirement</u>
Acute oral toxicity	LD <sub>50</sub> > 500 mg/kg.
Acute dermal toxicity	LD <sub>50</sub> > 2000 mg/kg.
Primary eye irritation for washed and unwashed eyes	Mildly irritating or less. If more irritating, recommend protective gear and safe handling procedures.
Primary dermal irritation	Primary irritation index < 5.0. If more irritating, recommend protective gear and safe handling procedures.

- 3.4.1.1.1. Review of Mammalian Toxicity and Irritation Test Results.** When the test results for a concentrate indicate that protective gear and safe handling procedures are needed, the manufacturer shall make recommendations to be added to the product label and the Material Safety Data Sheet (MSDS).

In accordance with 4.3.2, the results and related recommendations shall be reviewed by the Program Leader and Project Leader, WFCS, and approved as appropriate.

For unusual situations, the Safety and Health Branch of the Forest Service, Washington Office will be contacted for technical assistance.

- 3.4.1.2. Mixed Product.** The toxicity of a 1.0-percent foam solution shall meet the requirements in Table 3 when tested in accordance with 4.3.

<b>Table 3. Toxicity and Irritation Requirements for Foam Solutions</b>	
<u>Test</u>	<u>Requirement</u>
Acute oral toxicity	LD <sub>50</sub> > 5000 mg/kg.
Acute dermal toxicity	LD <sub>50</sub> > 2000 mg/kg.
Primary eye irritation for washed and unwashed eyes	Mildly irritating or less.
Primary Dermal Irritation	Primary irritation index < 5.0.

- 3.4.2. Fish Toxicity.** The LC<sub>50</sub> for rainbow trout exposed to the concentrate shall be greater than 10 mg/L when tested in accordance with 4.4.

The results will be made available to users as performance information.

- 3.4.3. Biodegradability.** When tested in accordance with 4.5, the concentrate shall be either readily biodegradable or biodegradable.

The results will be made available to users as performance information.

- 3.4.4. Open Cup Flash Point and Fire Point.** As required by 3.4.4.1 and 3.4.4.2, the open cup flash point and fire point of the foam concentrate shall be determined.

- 3.4.4.1. Open Cup Flash Point.** When tested in accordance with 4.6, the open cup flash point of the concentrate shall not be less than 140 °F (60 °C).

The results will be made available to users as performance information.

- 3.4.4.2. Open Cup Fire Point.** The open cup fire point of the concentrate shall be determined in accordance with 4.6.

The results will be made available to users as performance information.

- 3.5. Exposure Protection Effectiveness.** In accordance with 4.7, the mixed product shall be tested for exposure protection effectiveness using the Lateral Ignition and Flame Spread Test (LIFT).

The results will be made available to users as performance information.

- 3.6. Physical Properties.** As required in 3.6.1 and 3.6.2, the physical properties of the foam concentrate and foam solution shall be determined in accordance with 4.8.

These test results shall define the standard characteristics for the submitted product and be used to address quality issues.

The results will be made available to users as performance information.



- 3.6.1. Physical Properties of the Foam Concentrate.** In accordance with 4.8, the density, viscosity, pH, and fluidity of the foam concentrate shall be determined.  
The values determined shall be used as baseline values for stability tests as required in 3.9.1.1.  
The results will be made available to users as performance information.
- 3.6.1.1. Density of Foam Concentrates.** In accordance with 4.8.1, the density of the foam concentrate shall be determined.  
The density of the concentrate shall not exceed 1.15 grams/milliliter.  
The values determined shall be used as baseline values for stability tests as required in 3.9.1.1.  
The results will be made available to users as performance information.
- 3.6.1.2. Viscosity of Foam Concentrates.** In accordance with 4.8.2, the viscosity of the room temperature foam concentrate shall be determined and shall not exceed 150 centipoise (cP). [Amendment 2 adds a maximum viscosity requirement.]  
The values determined shall be used as baseline values for stability tests as required in 3.9.1.1.  
The results will be made available to users as performance information.
- 3.6.1.2.1. Viscosity of Foam Concentrates for Application from Water-Scooping Aircraft.** In accordance with 4.8.2, the viscosity of the foam concentrate shall be determined.  
The viscosity of the foam concentrate for applications from water-scooping aircraft shall not exceed 75 centipoise (cP).
- 3.6.1.3. pH of Foam Concentrates.** In accordance with 4.8.3, the pH of the foam concentrate shall be determined.  
The values determined shall be used as baseline values for stability tests as required in 3.9.1.1.  
The results will be made available to users as performance information.
- 3.6.1.4. Concentrate Fluidity.** In accordance with 4.8.4, the fluidity of foam concentrate shall be determined as a function of temperature.  
The foam concentrate shall maintain fluidity at 35 °F.  
The results at all temperatures will be made available to users as performance information.
- 3.6.2. Physical Properties of the Foam Solution.** In accordance with 4.8, the density, pH, and surface tension of 0.1-percent, 0.3-percent, 0.6-percent, and 1.0-percent foam solutions shall be determined.  
The values determined shall be used as baseline values for stability tests as required in 3.9.1.2.  
The results will be made available to users as performance information.
- 3.6.2.1. Density of the Foam Solution.** In accordance with 4.8.1, the density of 0.1-percent, 0.3-percent, 0.6-percent, and 1.0-percent foam solutions shall be determined.  
The values determined shall be used as baseline values for stability tests.  
The results will be made available to users as performance information.
- 3.6.2.2. pH of the Foam Solution.** In accordance with 4.8.3, the pH of 0.1-percent, 0.3-percent, 0.6-percent, and 1.0-percent foam solutions shall be determined.  
The values determined shall be used as baseline values for stability tests.  
The results will be made available to users as performance information.

**3.6.2.3. Surface Tension of Foam Solutions.** In accordance with 4.8.5, the surface tension of 0.1-percent, 0.3-percent, 0.6-percent, and 1.0-percent foam solutions shall be determined.

The results shall be used as the baseline for stability tests as required in 3.9.1.2.

The results will be made available to users as performance information.

**3.7. Effectiveness Characteristics.** As required by 3.7.1 through 3.7.6, the foam concentrate and its solutions shall be tested to determine the effects of water quality (type) and temperature on performance.

**3.7.1. Foam Rating, Categories, Types.** Reserved.

A rating/categorization scheme, based on foam expansion and drain time test results using 0.3-percent solution prepared with deionized water and aerated with generator setting 20-60-90, is being developed.

<u>Rating</u>	<u>Descriptive</u>	<u>Status</u>
Level 1	Non foaming, wetting agent	Not acceptable
Level 2	Wetter foam, faster draining	Acceptable
Level 3	Drier foam, slower draining	Acceptable

**3.7.2. Foam Expansion.** In accordance with 4.9.2, the expansion of 0.1-percent, 0.3-percent, 0.6-percent, and 1.0-percent foam solutions prepared using several water qualities (types) and temperatures shall be determined.

The results will be made available to users as performance information.

**3.7.2.1. Expansion of Foam Solution Prepared with Deionized Water at 70 °F.** In accordance with 4.9.2.1, the expansion of foam solution prepared using deionized water at 70 °F shall be determined.

The results shall be used as the baseline for stability tests as required in 4.8.

The results will be made available to users as performance information.

**3.7.2.2. Expansion of Foam Solution Prepared with Fresh Water at 70 °F.** In accordance with 4.9.2.2, the expansion of foam solution prepared using fresh water at 70 °F shall be determined.

The results will be made available to users as performance information.

**3.7.2.3. Expansion of Foam Solution Prepared with Artificial Sea Water at 70 °F.** In accordance with 4.9.2.3, the expansion of foam solution prepared using artificial sea water at 70 °F shall be determined.

The results will be made available to users as performance information.

**3.7.2.4. Expansion of Foam Solution Prepared with Fresh Water at 40 °F.** In accordance with 4.9.2.4, the expansion of foam solution prepared using fresh water at 40 °F shall be determined.

The results will be made available to users as performance information.

**3.7.2.5. Expansion of Foam Solution Prepared with Fresh Water at 100 °F.** In accordance with 4.9.2.5, the expansion of foam solution prepared using fresh water at 100 °F shall be determined.

The results will be made available to users as performance information.

- 3.7.2.6. Expansion of Foam Solution Prepared with Artificial Sea Water at 40 °F.** In accordance with 4.9.2.6, the expansion of foam solution prepared using artificial sea water at 40 °F shall be determined.  
The results will be made available to users as performance information.
- 3.7.3. Foam Drain Time.** In accordance with 4.9.3, the drain time of the foam solutions prepared as required in 3.7.2 shall be determined.  
The results will be made available to users as performance information.
- 3.7.3.1. Drain Time of Foam Solution Prepared with Deionized Water at 70 °F.** In accordance with 4.9.3.1, the drain time of foam solution prepared using deionized water at 70 °F shall be determined.  
The results shall be used as the baseline for stability tests as required in 3.9.1.2.  
The results will be made available to users as performance information.
- 3.7.3.2. Drain Time of Foam Solution Prepared with Fresh Water at 70 °F.** In accordance with 4.9.3.2, the drain time of foam solution prepared using fresh water at 70 °F shall be determined.  
The results will be made available to users as performance information.
- 3.7.3.3. Drain Time of Foam Solution Prepared with Artificial Sea Water at 70 °F.** In accordance with 4.9.3.3, the drain time of foam solution prepared using artificial sea water at 70 °F shall be determined.  
The results will be made available to users as performance information.
- 3.7.3.4. Drain Time of Foam Solution Prepared with Fresh Water at 40 °F.** In accordance with 4.9.3.4, the drain time of foam solution prepared using fresh water at 40 °F shall be determined.  
The results will be made available to users as performance information.
- 3.7.3.5. Drain Time of Foam Solution Prepared with Fresh Water at 100 °F.** In accordance with 4.9.3.5, the drain time of foam solution prepared using fresh water at 100 °F shall be determined.  
The results will be made available to users as performance information.
- 3.7.3.6. Drain Time of Foam Solution Prepared with Artificial Sea Water at 40 °F.** In accordance with 4.9.3.6, the drain time of foam solution prepared using artificial sea water at 40 °F shall be determined.  
The results will be made available to users as performance information.
- 3.7.4. Wetting Ability of Foam Solution.** The wetting ability of foam solutions prepared as required in 3.7.4.1 through 3.7.4.3 shall be determined in accordance with 4.9.4.  
The results will be made available to users as performance information.
- 3.7.4.1. Wetting Ability of Foam Solution Prepared with Deionized Water.** The wetting ability of 0.1-percent, 0.3-percent, 0.6-percent, and 1.0-percent foam solutions prepared with deionized water at 70 °F shall be determined in accordance with 4.9.4.1.  
A sink time of 20 sec or less for the 1.0-percent solution shall be acceptable.  
The results shall be used as the baseline for stability tests as required in 3.9.1.2.  
The results for all solutions will be made available to users as performance information.

- 3.7.4.2. Wetting Ability of Foam Solution Prepared with Fresh Water.** The wetting ability of the solutions prepared with fresh water at 70 °F shall be determined in accordance with 4.9.4.2. The results will be made available to users as performance information.
- 3.7.4.3. Wetting Ability of Foam Solution Prepared with Artificial Sea Water.** The wetting ability of the solutions prepared with artificial sea water at 70 °F shall be determined in accordance with 4.9.4.3. The results will be made available to users as performance information.
- 3.7.5. Miscibility of Foam Concentrate.** In accordance with 4.9.5, the foam concentrate shall be tested to determine its ability to mix with water at several temperatures and qualities. The results will be made available to users as performance information.
- 3.7.5.1. Miscibility of Concentrates in Deionized Water.** When tested in accordance with 4.9.5.1, the foam concentrate at 70 °F shall be miscible in deionized water at 70 °F. The results for all combinations will be made available to users as performance information.
- 3.7.5.2. Miscibility of Concentrates in Fresh Water.** In accordance with 4.9.5.2, the miscibility of the foam concentrate in fresh water shall be determined. The results will be made available to users as performance information.
- 3.7.5.3. Miscibility of Concentrates in Artificial Sea Water.** When tested in accordance with 4.9.5.3, the miscibility of the foam concentrate in artificial sea water shall be determined. The results will be made available to users as performance information.
- 3.7.5.4. Miscibility of Concentrates for Application from Water-Scooping Aircraft.** When tested as required in 3.7.5.3, the foam concentrate at 70 °F shall be miscible in 40 °F artificial sea water.
- 3.7.6. Foaming Ability.** In accordance with 4.9.6, the foaming ability of a 1.0-percent solution of concentrate in deionized water shall be determined. The results shall be the basis for a field quality control test. The results will be made available as performance information.
- 3.8. Material Effects.** As required by 3.8.1 through 3.8.3, the effects of the foam concentrate and solutions on metallic and non-metallic materials shall be determined in accordance with 4.10. The results will be made available as performance information.
- 3.8.1. Uniform Corrosion.** When tested in accordance with 4.10.1, the foam concentrate, 0.1-percent foam solution, and 1.0-percent foam solution shall not have corrosion rates exceeding those shown in Table 4 for the alloys listed.
- 3.8.2 Intergranular Corrosion.** When tested in accordance with 4.10.2, the alloys as specified in 3.8.2.1 through 3.8.2.4 shall show no evidence of intergranular corrosion.
- 3.8.2.1. Helicopter Fixed Tank.** When tested in accordance with 4.10.2, coupons made of alloy 2024-T3 aluminum and Az-31B magnesium shall not exhibit intergranular corrosion following exposure to foam solution during the uniform corrosion tests.
- 3.8.2.2. Multi-Engine, Fixed-Wing Air Tanker.** When tested in accordance with 4.10.2, coupons made of alloy 2024-T3 aluminum shall not exhibit intergranular corrosion following exposure to foam solution during the uniform corrosion tests.

**Table 4. Maximum Allowable Corrosion Rates (mils-per-year) for Wildland Fire Chemical Products.<sup>1</sup>**

Temperature: °F	2024-T3 Aluminum				4130 Steel				Yellow Brass	Az31B Magnesium			
	Total		Partial		Total		Partial		Partial	Total		Partial	
	70	120	70	120	70	120	70	120	120	70	120	70	120
-----mils-per-year-----													
<b>Concentrates</b>													
Wet concentrates for fixed-tank helicopters	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Wet concentrates <sup>2</sup> except fixed-tank helicopters	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0				
<b>Mixed Products</b>													
Fixed-tank helicopters <sup>3</sup>	2.0	2.0	2.0	2.0	5.0	5.0	5.0	5.0	5.0	4.0	4.0	4.0	4.0
Fixed-wing air tankers <sup>4</sup>	2.0	2.0	2.0	2.0	5.0	5.0	5.0	5.0	5.0				
Helicopter bucket and <sup>2</sup> Ground-based application	2.0	2.0	2.0	2.0	5.0	5.0	5.0	5.0	5.0				

<sup>1</sup> All uniform corrosion rates shall be determined by 90-day weight loss tests. All uniform corrosion rates are the maximum allowable average of all replicates.

<sup>2</sup> Magnesium uniform corrosion tests shall be performed for performance information. Intergranular corrosion tests are not required on aluminum or magnesium.

<sup>3</sup> Intergranular corrosion tests shall be performed on aluminum and magnesium coupons; no intergranular corrosion is allowed.

<sup>4</sup> Intergranular corrosion tests shall be performed on aluminum coupons; no intergranular corrosion is allowed. Magnesium uniform corrosion tests shall be performed for performance information. Intergranular corrosion tests are not required on magnesium.

- 3.8.2.3. **Single-Engine, Fixed-Wing Air Tanker.** When tested in accordance with 4.10.2, coupons made of alloy 2024-T3 aluminum shall not exhibit intergranular corrosion following exposure to foam solution during the uniform corrosion tests.
- 3.8.2.4. **Helicopter Bucket and Ground Based Application Equipment.** There are no intergranular corrosion requirements for ground-based application equipment.
- 3.8.3 **Effect of Foam Concentrate and Foam Solution on Non-Metallic Materials.** In accordance with 4.10.3, the foam concentrates and foam solutions shall be tested to determine their effect on the non-metallic materials listed in Table 5 and their ability to meet the requirements of 3.8.3.1 and 3.8.3.2.

<b>Table 5. Materials To Be Tested To Determine The Effect Of Exposure To Foam Concentrate And Foam Solutions.</b>	
<u>Material</u>	<u>Material Specification</u>
<b>- - Shall Be Tested And Performance Provided To User Agencies. - -</b>	
Chloroprene rubber	AMS 3208M
PVC Plastic, Flexible	MIL A-A-55859A
Sealant	AMS S-8802
Fiberglass/Epoxy Resin	AMS C-9084
High-Density Polyethylene	ASTM D 4976
Low-Density Polyethylene	ASTM D 4976
Sealant	MIL PRF-81733D
Flexible Cross-Linked Polyolefin	AMS DTL-23053/5

- 3.8.3.1. **Effect of Exposure to Foam Concentrate and Solution on the Hardness and Volume of Non-Metallic Materials.** When tested as required in 3.8.3, the changes in hardness and volume of each of the materials listed in Table 5 shall be determined.

All results will be reported to user agencies as performance information.

<u>Characteristics</u>	<u>Reportable Change</u>
Hardness	≤ 10-percent decrease
Hardness	≤ 20-percent increase
Volume	≤ 0.5 mL from initial

- 3.8.3.2. **Effect of Exposure to Foam Concentrate and Solution on the Hardness and Volume of Non-Metallic Materials for Use in Water-Scooping Aircraft.** When tested as required in 3.8.3, the changes in hardness and volume of each of the materials listed in Table 5 shall be determined.

In addition to the reportable changes required in 3.8.3.1, the hardness and volume changes for chloroprene rubber, flexible PVC plastic, S-8802 sealant, and epoxy-resin-coated fiberglass shall meet the requirements for acceptable change as shown in the table below.

<u>Characteristics</u>	<u>Acceptable Change</u>
Hardness	≤ 10-percent decrease
Hardness	≤ 20-percent increase
Volume	≤ 0.5 mL from initial

**3.9. Product Stability.** When tested in accordance with 4.11, the foam concentrate and the foam solution shall meet all applicable requirements of 3.9.1 through 3.9.4

**3.9.1. Outdoor Storage.** When tested in accordance with 4.11.1, the foam concentrate and foam solution prepared from that concentrate shall meet all applicable requirements of 3.9.1.1 through 3.9.1.3.

**3.9.1.1. Foam Concentrate.** When tested in accordance with 4.11.1.1, the foam concentrate shall meet the following requirements.

The stored concentrate shall have no separation resulting in particles larger than 0.25-inch (0.635 cm) sieve size.

The stored concentrate shall be tested to determine the following properties:

- a. Viscosity, in accordance with 4.8.2,
- b. Density, in accordance with 4.8.1, and
- c. pH, in accordance with 4.8.3.

The values for the viscosity, density, and pH shall be within the allowable variation, shown in Table 6, from the original values determined in 3.6.1.

The stored concentrate shall be used to prepare foam solution as required in 3.9.1.2 and 3.9.1.3.

The results will be made available to users as performance information.

<b>Table 6. Allowable Variation Of Physical Properties Of Stored Foam Concentrate From Fresh Concentrate.</b>	
<u>Property</u>	<u>Allowable Variation from Initial Value</u>
Density	± 1 percent
Viscosity	± 15 percent
pH	± 1 unit

**3.9.1.2. Foam Solution from Stored Concentrate.** As required by 3.9.1.1 and in accordance with 4.11.1.2, a 0.3-percent foam solution prepared from stored concentrate and deionized water shall be tested to determine the following properties:

- a. Foam expansion, in accordance with 4.9.2,
- b. Foam drain time, in accordance with 4.9.3,
- c. Wetting ability, in accordance with 4.9.4, and
- d. Surface tension, in accordance with 4.8.5.

Changes in these properties, from the values determined in 3.6.2, shall be calculated.

The results will be made available to users as performance information.

**3.9.1.3. Corrosivity of Foam Solution from Stored Concentrate.** As required by 3.9.1.1 and in accordance with 4.11.1.3, 0.1-percent and 1.0-percent solutions of the stored concentrate in fresh water shall be tested for uniform and intergranular corrosion and shall meet the uniform and intergranular corrosion requirements of 3.8.1 and 3.8.2.

**3.9.2. Effect of Temperature Cycling on Concentrate.** In accordance with 4.11.2, the foam concentrate shall be subjected to temperature cycling.

The density, viscosity, and pH of the concentrate shall be determined and the results made available to users as performance information.

The concentrate shall be used to prepare foam solutions which shall be tested as required in 3.9.2.1.

**3.9.2.1. Foam Solutions Prepared from Temperature-Cycled Concentrate.** In accordance with 4.11.3, as required by 3.9.2, a 0.3-percent foam solution prepared from temperature-cycled concentrate and deionized water shall be tested to determine the following properties:

- a. Foam expansion, in accordance with 4.9.2,
- b. Foam drain time, in accordance with 4.9.3,
- c. Wetting ability, in accordance with 4.9.4, and
- d. Surface tension, in accordance with 4.8.5.

Changes in these properties shall be calculated.

The results will be made available to users as performance information.

**3.9.3. Resistance of Foam Solution to Microbial Growth.** In accordance with 4.11.4, after 14 days in storage the foam solution shall show no visible sign of microbial contamination, including growths on the surface or within the fluid, significant discoloration, or other change in appearance.

**3.9.4. Effect of Temperature on Viscosity of the Foam Concentrate.** In accordance with 4.11.5, the viscosity of the concentrate shall be determined over a range of temperatures.

The results will be made available to users as performance information.

**4. TEST PROCEDURES.** Detailed test methods are described in Standard Test Procedures for the Evaluation of Wildland Fire Chemical Products (STP). The web and postal addresses are given in 7.2.2.

**4.1. Simplification of Terms.** Specifying temperatures, sample containers, and coupons dimensions is cumbersome and leads to confusion regarding the required test.

The full description of these terms is provided as definitions in Section 6 and a simplified version is used throughout the remainder of this specification.

**Evaluation and Exposure Temperatures.** Frequently used exposure temperatures – including allowable ranges and conversions to Celsius are described in detail in Section 6.

Other temperature and range requirements are shown in detail within the applicable section of the specification.

**Sample Containers.** Two types of sample containers are used throughout the evaluation process. They are defined in Section 6 and referred to throughout the specification as a large sample container and a small sample container.

**Coupons.** Three types of coupons are used throughout the evaluation. They may be made of different alloys, but the dimensions in English and metric units are provided in Section 6 and referred to throughout the specification as a large stability coupon, a small stability coupon, and a corrosion coupon.



- 4.2. **Determination of Laboratory Mixing Procedures (STP-3.2).** As required by 3.3, procedures for the optimum mixing of the concentrate and water shall be determined, in order to obtain maximum stability and performance characteristics.

All dilutions shall be prepared with deionized water unless otherwise specified.

- 4.3. **Mammalian Toxicity and Irritation Tests (STP-1.3).** As required by 3.4.1.1 and 3.4.1.2, mammalian toxicity and irritation testing on foam concentrate and 1.0-percent foam solution shall be conducted by an independent biological testing laboratory approved by the Forest Service.

All testing shall be conducted in compliance with 40 CFR 160 and 792 Good Laboratory Practice Standards, in accordance with EPA/OPPTS Health Effects Test Guidelines, series 870 and shall include:

- a. OPPTS 870.1100, Acute Oral Toxicity;
- b. OPPTS 870.1200, Acute Dermal Toxicity;
- c. OPPTS 870.2400; Primary Eye Irritation; in addition to the standard test, a test shall be performed with washed eyes.

In the test with washed eyes, three test animals shall be exposed to the test product for 30 seconds. The exposed eyes shall then be washed with room temperature, deionized water for 1 minute. Examinations, schedules, and ratings shall be the same as for the standard test.

- d. OPPTS 870.2500; Primary Dermal Irritation.

- 4.3.1. **Report of Test Results.** The results of the mammalian toxicity and irritation testing shall be certified by the testing laboratory and submitted directly to the Project Leader, WFCS-MTDC, in Missoula, Montana for review and recommendations.

- 4.3.2. **Review of Mammalian Toxicity and Irritation Test Results.** When required in accordance with 3.4.1.1.1, the Project Leader, WFCS shall review the results of the testing and the submitter's recommended protective gear and safe handling procedures to ensure adequate protection for workers and the general public who may come into contact with the product. Recommendations shall be reviewed by the Program Leader prior to final approval.

For unusual situations, the Safety and Health Branch of the Forest Service, Washington Office will be contacted for technical assistance.

- 4.4. **Fish Toxicity (STP-1.5).** As required by 3.4.2, the fish toxicity of the foam concentrate to rainbow trout (*Oncorhynchus mykiss*) shall be determined in accordance with OPPTS 850.1075, Ecological Effects Test Guidelines, Fish Acute Toxicity Test, Freshwater and Marine.

Static test conditions in ASTM soft water (described in ASTM E 729) at  $54 \pm 2^\circ\text{F}$  ( $12 \pm 1^\circ\text{C}$ ) shall be maintained throughout the 96-hour test period.

All fish shall be  $60 \pm 15$  days post hatch.

- 4.5. **Biodegradability (STP-1.4).** As required by 3.4.3, the biodegradability of the foam concentrate shall be determined in accordance with OPPTS 835, Section M, Fate, Transport and Transformation Test Guidelines, CO<sub>2</sub> evolution (modified Sturm Test).

If biodegradation has not reached 60 percent at 28 days, biodegradation shall be allowed to continue for up to 42 days.

A commercial inoculum may be used rather than activated sewage sludge.

- 4.6. Open Cup Flash and Fire Point (STP-1.6).** As required in 3.4.4, the open cup flash point and the fire point of the foam concentrate shall be determined in accordance with ASTM D 92, Standard Test Method for Flash Point and Fire Point by Cleveland Open Cup.
- 4.7. Exposure Protection Effectiveness Test (STP-2.2).** As required by 3.5, the concentrate shall be tested for exposure protection effectiveness using the vertical LIFT apparatus and general method in ASTM E 1321 Standard Test Method for Determining Material Ignition and Flame Spread Properties as summarized below.
- Foam solutions (0.4-percent and 1.0-percent) shall be prepared, aerated, and applied to a substrate of T1-11 siding that was conditioned at 70 °F and 50-percent relative humidity.
- The sample with the 1.0-percent concentration shall be drained and exposed to the radiant panel immediately. The sample with the 0.4-percent concentration shall sit undisturbed for 5 minutes, then drained and exposed to the radiant panel.
- Treated and untreated T1-11 siding, in a vertical orientation, shall be exposed to a 40 kW/m<sup>2</sup> radiant panel and the time to ignition determined.
- The time for the treated siding to ignite shall be compared to the time for untreated siding to ignite.
- 4.8. Physical Properties.** As required by 3.6.1 and 3.6.2, the foam concentrate and solution shall be tested to determine the physical properties.
- 4.8.1. Density Test (STP-4.3).** As required by 3.6.1.1 and 3.6.2.1, the density of the foam concentrate and foam solution shall be determined to the nearest 0.001 g/mL using fluid displacement or an electronic density meter.
- 4.8.2. Viscosity (STP-4.5).** As required by 3.6.1.2, the viscosity at 70 °F of the foam concentrate shall be determined.
- A Brookfield Viscometer model LVF, or equal, set at 60 rpm with the number 2 spindle shall be used to measure the viscosity.
- 4.8.3. pH Value Test (STP-4.4).** As required by 3.6.1.3 and 3.6.2.2, the pH of the foam concentrate and foam solution shall be determined with a full range pH meter readable to 0.1 pH unit.
- 4.8.4. Concentrate Fluidity Test (STP-4.7).** As required by 3.6.1.4, the ability of the foam concentrate to flow shall be determined following the general method found in ASTM D 97.
- A small beaker of the concentrate shall be cooled to the test temperature, without being disturbed. Sufficient time shall be allowed for the entire contents of the beaker to reach the test temperature.
- The beaker shall be tilted slightly and the behavior of the concentrate observed.
- A fresh sample of the concentrate shall be cooled to the next lower temperature.
- The process shall be repeated with fresh concentrate cooled to successively lower temperatures until the concentrate does not flow.

Concentrate Fluidity Test Temperatures

Fahrenheit:	40 °F ± 2 °F	35 °F ± 2 °F	5 °F ± 2 °F
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**4.8.5. Surface Tension Test (STP-8.1).** As required by 3.6.2.3, the surface tension of foam solutions at 70 °F shall be determined in accordance with ASTM D 1331.

Each foam concentrate shall be diluted with deionized water to prepare 0.1-percent, 0.3-percent, 0.6-percent, and 1.0-percent foam solutions.

Reported values shall be corrected for the diameter of the platinum-iridium wire and the diameter of the formed ring.

**4.9. Effectiveness Characteristics Tests.** As required by 3.7, the foam concentrate, foam solution, and foam prepared from the solution shall be tested in accordance with 4.9.1 through 4.9.6 to determine their ability to perform over a range of operational conditions.

**4.9.1. Foam Rating, Categories.** Reserved.

**4.9.2. Foam Expansion Test.** As required by 3.7.2., 0.1-percent, 0.3-percent, 0.6-percent, and 1.0-percent foam solutions shall be prepared and converted to foam under controlled conditions using standard settings of the foam generator shown in Figure 1.

The test method is summarized below.

For each of the four standard settings, the foam shall be allowed to flow into a 4600-mL capacity, shallow container, with drain holes in one corner of the bottom.

The excess foam shall be removed from the surface of the foam and from the exterior of the container and the filled container weighed.

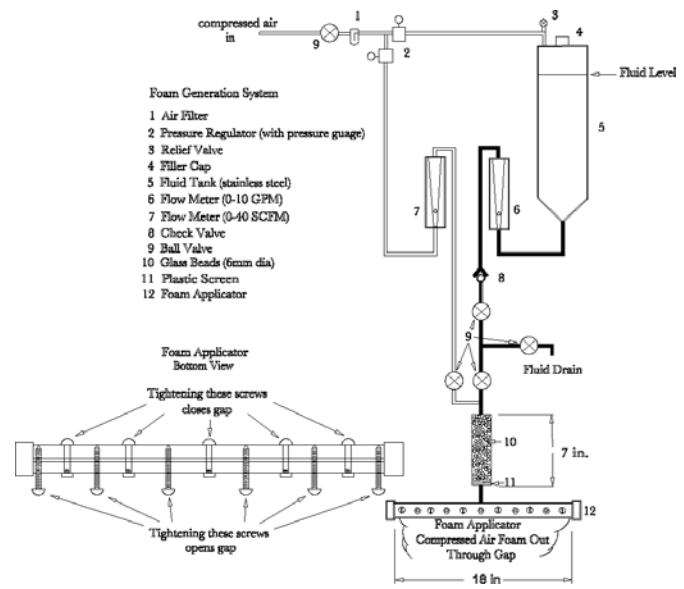


Figure 1.--Foam Generator.

The expansion shall be calculated by the following:

$$\text{Expansion} = \frac{\text{Volume of foam (mL)}}{\text{Weight of foam solution (g)/Density of foam solution (g/mL)}}$$

**4.9.2.1. Expansion of Foam Solution Prepared with Deionized Water at 70 °F.** As required by 3.7.2.1, the expansion tests shall be performed using foam solutions prepared using deionized water at 70 °F.

**4.9.2.2. Expansion of Foam Solution Prepared with Fresh Water at 70 °F.** As required by 3.7.2.2, the expansion tests shall be repeated using foam solutions prepared using fresh water at 70 °F.

**4.9.2.3. Expansion of Foam Solution Prepared with Artificial Sea Water at 70 °F.** As required by 3.7.2.3, the expansion tests shall be repeated using foam solutions prepared using artificial sea water at 70 °F.

- 4.9.2.4. Expansion of Foam Solution Prepared with Fresh Water at 40 °F.** As required by 3.7.2.4, the expansion tests shall be repeated using foam solutions prepared using fresh water at 40 °F.
- 4.9.2.5. Expansion of Foam Solution Prepared with Fresh Water at 100 °F.** As required by 3.7.2.5, the expansion tests shall be repeated using foam solutions prepared using fresh water at 100 °F.
- 4.9.2.6. Expansion of Foam Solution Prepared with Artificial Sea Water at 40 °F.** As required by 3.7.2.6, the expansion tests shall be repeated using foam solutions prepared using artificial sea water at 70 °F.
- 4.9.3. Foam Drain Time Test.** As required by 3.7.3, the foam drain time shall be determined. The test method is summarized below.
- A container filled with foam generated in 4.9.2, shall be placed on a balance in such a manner as to allow fluid draining from the foam to flow from the holes in one corner of the container.
- The weight loss shall be recorded as a function of time for a 60-minute period and a curve prepared showing Percent of Initial Weight Remaining versus Time.
- From the graph, the percent of fluid drained after 5 and 10 minutes shall be determined along with the time for 25 percent of the fluid to drain from the container.
- 4.9.3.1. Drain Time for Foam Prepared with Deionized Water at 70 °F.** As required by 3.7.3.1, the drain time shall be determined using foam solutions prepared using deionized water at 70 °F.
- 4.9.3.2. Drain Time for Foam Prepared with Fresh Water at 70 °F.** As required by 3.7.3.2, the drain time shall be determined using foam solutions prepared using fresh water at 70 °F.
- 4.9.3.3. Drain Time for Foam Prepared with Artificial Sea Water at 70 °F.** As required by 3.7.3.3, the drain time shall be determined using foam solutions prepared using artificial sea water at 70 °F.
- 4.9.3.4. Drain Time for Foam Prepared with Fresh Water at 40 °F.** As required by 3.7.3.4, the drain time shall be determined using foam solutions prepared using fresh water at 40 °F.
- 4.9.3.5. Drain Time for Foam Prepared with Fresh Water at 100 °F.** As required by 3.7.3.5, the drain time shall be determined using foam solutions prepared using fresh water at 100 °F.
- 4.9.3.6. Drain Time for Foam Prepared with Artificial Sea Water at 40 °F.** As required by 3.7.3.6, the drain time shall be determined using foam solutions prepared using artificial sea water at 40 °F.
- 4.9.4. Wetting Ability Test (STP-8.2).** As required by 3.7.4, the wetting ability of 0.1-percent, 0.3-percent, 0.6-percent, and 1.0-percent solutions prepared using the foam concentrate and 70 °F water as specified in each subsection shall be determined. The test method is summarized below.
- A cotton skein, weighing 5.00 g, shall be attached to a hook weighing 1.5 g.
- The time for the skein to sink when immersed in the test solution shall be measured.
- The test shall be repeated at least twice more using a fresh skein and fresh solution for each test, and the results averaged.
- 4.9.4.1. Wetting Ability of Foam Solution Prepared with Deionized Water.** As required by 3.7.4.1, the wetting ability of solutions prepared using deionized water at 70 °F shall be determined.

- 4.9.4.2. **Wetting Ability of Foam Solution Prepared with Fresh Water.** As required by 3.7.4.2, the wetting ability test shall be repeated, using foam solutions prepared with fresh water at 70 °F.
- 4.9.4.3. **Wetting Ability of Foam Solution Prepared with Artificial Sea Water.** As required by 3.7.4.3, the wetting ability test shall be repeated using foam solutions prepared with artificial seawater at 70 °F.
- 4.9.5. **Miscibility Test (STP-8.6).** As required by 3.7.5, the ease of mixing concentrate with water at temperatures shown in the table shall be determined as summarized below.

**Tests Conditions for Miscibility of Foam Concentrate**

<u>Water Temperature</u>	<u>Concentrate Temperature</u>
70 °F	70 °F
70 °F	40 °F
40 °F	70 °F
40 °F	40 °F

An offset stirring attachment, Figure 2, shall be attached to a variable speed stirring motor and inserted in 500 milliliters of water as specified in 4.9.5.1 through 4.9.5.3 at the specified temperature.

The stirrer speed shall be adjusted to 60±10 rpm.  
5 milliliters of concentrate shall be quickly added, with stirring.

After 10 revolutions, the stirred shall be stopped and the fluid observed.

The solution shall be considered to be homogeneous if it is:

- Uniform throughout,
- Has no visible striations or phases
- Uniformly clear, cloudy or milky

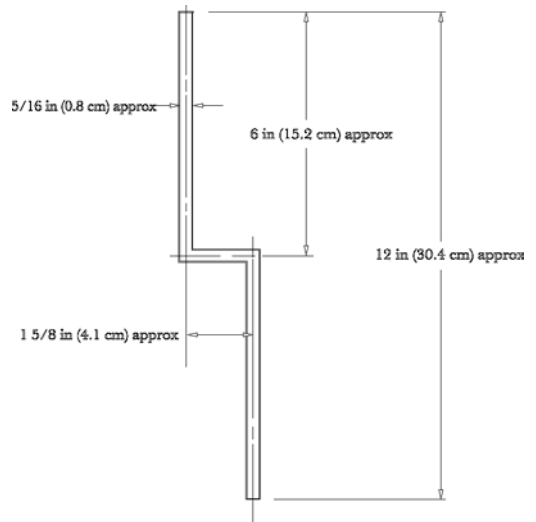
If the sample is not homogeneous, it shall be stirred for an additional 10 revolutions, the stirrer stopped and the appearance of the solution again observed.

The sequence shall be repeated until the sample is homogenous or a maximum of 100 revolutions is reached.

A sample shall be considered to be miscible if it is homogeneous with 100 revolutions or less.

A sample shall be considered to be not miscible if it is not homogeneous after 100 revolutions.

- 4.9.5.1. **Miscibility of Concentrate in Deionized Water.** As required by 3.7.5.1, the miscibility of foam concentrate in deionized water shall be determined.
- 4.9.5.2. **Miscibility of Concentrate in Fresh Water.** As required by 3.7.5.2, the miscibility tests shall be repeated using fresh water.



**Figure 2. Stirring Shaft for miscibility tests.**

**4.9.5.3. Miscibility of Concentrate in Artificial Sea Water.** As required by 3.7.5.3, the miscibility tests shall be repeated using artificial seawater.

**4.9.6. Foaming Ability Test (STP-8.3).** As required by 3.7.6, the ability of a 1.0-percent foam solution to foam shall be determined.

10 milliliters of foam solution prepared with deionized water shall be placed in a 100-milliliter, stoppered graduated cylinder.

The cylinder shall be agitated by shaking forcefully for 10 seconds. It shall be noted immediately whether any solution remains. If solution remains, the cylinder shall be shaken an additional 10 seconds.

The volume of foam in the cylinder shall be noted and recorded immediately. The volume of solution drained from the foam shall be noted and recorded at 1-minute intervals for 5 min. Additional measurements shall be made and recorded at 10 min and 15 min.

The test shall be repeated to obtain at least three data sets. Results of all replicates and the average shall be reported.

**4.10. Material Effects Tests.** In accordance with 4.10.1 through 4.10.3, the effects of foam concentrates and solutions on metallic and non-metallic materials shall be determined.

**4.10.1. Uniform Corrosion (STP-5.1).** As required by 3.8.1, the uniform corrosion caused by the foam concentrate and the 0.1-percent and 1.0-percent foam solutions, prepared with fresh water, shall be determined as summarized below.

Test coupons of 2024-T3 aluminum, 4130 steel, UNS C27000 yellow brass, and Az31B magnesium shall be engraved with a unique identification number, measured, cleaned, dried, and weighed.

Each coupon shall be immersed in the test solution and allowed to remain undisturbed at the required conditions for 90 days.

At the end of the test duration, each coupon shall be cleaned, dried, and weighed, and the corrosion rate calculated.

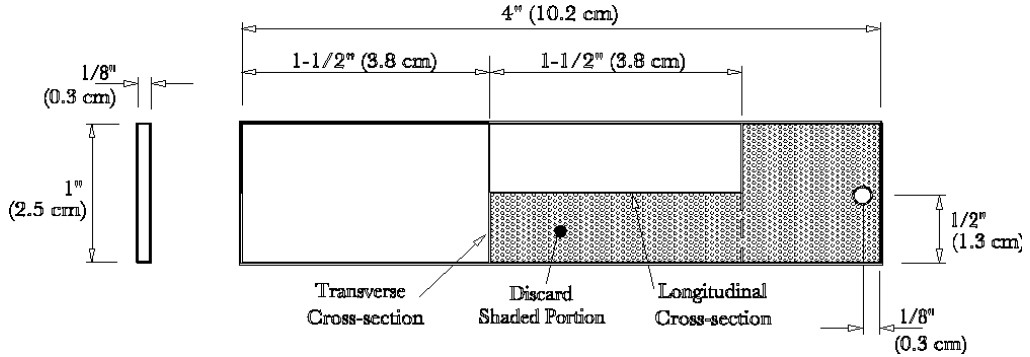
All corrosion rates for the same product, alloy, immersion condition and temperature shall be averaged.

**4.10.2. Intergranular Corrosion Test (STP-5.2).** As required by 3.8.2, foam solution shall be tested for intergranular corrosion as summarized below.

At least one coupon from each exposure and temperature from the uniform corrosion tests on the specified alloys shall be sliced as shown in Figure 3.

The coupon shall be mounted, polished to 0.3 micron alumina finish, and etched using Keller's reagent for aluminum coupons and Nital reagent for magnesium coupons.

The etched coupons shall be examined microscopically with a magnification of 500X.



**Figure 3. Diagram for cutting and examining coupons for intergranular corrosion.**

**4.10.3. Effects of Foam Concentrates and Foam Solutions on Non-Metallic Materials (STP-5.3).** In accordance with 3.8.3, the foam concentrate and solutions shall be tested to determine their effect on non-metallic materials as summarized below.

Prior to exposure of the non-metallic materials, the hardness and volume of each non-metallic sample shall be determined. A hand-held durometer, of the prescribed type, shall be used to measure the hardness and either fluid displacement or dimensional analysis shall be used to determine the volume.

The test pieces of each non-metallic material shall be exposed for 20 cycles. Each cycle shall consist of the material being immersed in the fluid at night and on weekends and in the air during the work day.

At the end of the test period, each test piece shall be rinsed, wiped with a disposable tissue, allowed to air dry, and the hardness and volume of each piece determined on the same day as the exposure ends.

The change in hardness and volume from the initial value of each shall be calculated.

If the result of either exceeds the allowable maximum, the measurements shall be repeated the next day and the calculation of change calculated. No additional measurements shall be allowed.

The results of the last set of measurements taken shall be used to determine if performance is acceptable.

**4.11. Product Stability (STP-4).** As required by 3.9, the foam concentrate and the foam solution shall be tested for product stability in accordance with 4.11.1 through 4.11.4.

**4.11.1. Outdoor Storage Test.** As required by 3.9.1 and in accordance with 4.11.1.1 through 4.11.1.3, the foam concentrate shall be tested to determine the effects of storage in outdoor conditions.

**4.11.1.1. Foam Concentrates.** As required by 3.9.1.1, each foam concentrate shall be evaluated for outdoor stability.

To document the initial condition of the product, the fresh concentrate shall be examined visually to determine the general condition of the concentrate, including the presence or absence of crystals or other solids greater than 0.25 inch (0.635 cm).

The fresh concentrate shall then be stored in large sample containers, outdoors at MTDC-WFCS and SDTDC for 52 weeks.

At the end of the 52-week storage period, the sample shall be inspected visually to determine if there are changes in the general condition of the concentrate (crystals or other solids greater than 0.25 inch [0.635 cm]) from the original samples.

The samples shall be recirculated for 1 minute with low shear (1800 rpm with 2-bladed propeller-type stirrer), tested to determine viscosity, density, and pH, and then used to prepare foam solutions.

In accordance with 4.11.1.2 and 4.11.1.3, the foam solutions from stored concentrate shall be prepared and tested as required by 3.9.1.2 and 3.9.1.3.

**4.11.1.2. Solution from Stored Concentrate.** As required by 3.9.1.2, a 0.3-percent foam solution of the stored concentrate in deionized water shall be prepared and tested as shown below.

The surface tension of the foam solution shall be determined in accordance with 4.8.5.

The foam expansion, foam drain time, and wetting ability shall be determined in accordance with 4.9.2 through 4.9.4.

**4.11.1.3. Corrosivity of Solution from Stored Concentrate.** As required by 3.9.1.3 and in accordance with 4.11.1.1, 0.1-percent and 1.0-percent foam solutions of the stored concentrate in fresh water shall be tested to determine the uniform and intergranular corrosion in accordance with 4.10.1 and 4.10.2.

**4.11.2. Temperature Cycling Test.** As required by 3.9.2, small sample containers containing 800-mL samples of the foam concentrate shall be tested as described below.

At the beginning of the test, the physical appearance of each sample shall be described. The presence of growths on the surface or within the fluid, significant discoloration or other changes in odor or appearance which might be related to microbial degradation shall be noted.

The samples shall then be exposed to temperature cycling as described in 4.11.2.1 through 4.11.2.4.

Each cycle shall consist of 1 day (8 to 10 hours) and the following night (or weekend).

Following each prescribed exposure, the samples shall sit for 24 hours at 70 °F to come to room temperature.

Each sample shall again be examined visually and any changes from the initial appearance noted.

The density, viscosity, and pH of the concentrate shall be determined in accordance with 4.8.1 through 4.8.3.

The foam concentrate shall be used to prepare and test foam solution in accordance with 4.11.3.

**4.11.2.1. Exposure 1:** The sample shall be stored for 30 cycles. Each cycle shall consist of 1 day at 70 °F and 1 night (or weekend) at 120 °F.



- 4.11.2.2. Exposure 2:** The sample shall be stored for 30 cycles. Each cycle shall consist of 1 day at 70 °F and 1 night (or weekend) at 15 °F.
- 4.11.2.3. Exposure 3:** The sample shall be stored for a total of 60 cycles. The first 30 cycles shall consist of 1 day at 70 °F and 1 night (or weekend) at 120 °F. The last 30 cycles of 1 day at 70 °F and 1 night (or weekend) at 15 °F.
- 4.11.2.4. Exposure 4:** The sample shall be stored for a total of 60 cycles. The first 30 cycles shall consist of 1 day at 70 °F and 1 night (or weekend) at 15 °F. The last 30 cycles of 1 day at 70 °F and 1 night (or weekend) at 120 °F.
- 4.11.3. Performance of Foam Solutions Prepared from Temperature-Cycled Concentrate.** The foam concentrate shall be used to prepare a 0.3-percent solution in deionized water.  
The surface tension of the foam solution shall be determined in accordance with 4.8.5.  
The foam expansion, foam drain time, and wetting ability of the foam solution shall be determined in accordance with 4.9.2 through 4.9.4.
- 4.11.4. Resistance to Microbial Growth Test (STP-6.4).** As required by 3.9.3, the foam solution shall be tested, observed, and assessed for microbial contamination.  
A small sample container containing 800 mL of a 1.0-percent foam solution and a 2024-T3 aluminum, small stability coupon, shall be capped tightly to prevent evaporation, and allowed to sit undisturbed at 70 °F for 14 days.  
The physical appearance, including growths on the surface or within the fluid, significant discoloration, or other changes shall be described and recorded at the initiation of the test and on days 1, 2, 7, and 14.
- 4.11.5. Effect of Concentrate Temperature on Viscosity of the Foam Concentrate.** As required by 3.9.4, individual 800-mL samples of the concentrate shall be stored at 35 °F, 40 °F, 70 °F, and 100 °F until the concentrate is at the required temperature.  
The viscosity of the concentrate shall be determined in accordance with 4.8.2.
- 5. Qualification.**
- 5.1. Qualification Tests.** The samples submitted shall be subjected to the applicable tests listed in section 4 to determine if they meet the applicable requirements of Section 3 and classifications as indicated in 2.3.2.  
These tests shall be performed at Forest Service-WFCS laboratory or in third-party laboratories approved by WFCS on samples provided by WFCS. All reports of third-party testing shall be submitted directly to WFCS.
- 5.1.1. Additional Testing at the Discretion of the Forest Service.** Additional tests not specified in this document may be required at the discretion of the Forest Service when information provided in the product information or otherwise known to the Forest Service suggests a need.  
The submitter shall be informed, before any additional testing is performed, of the specific tests to be performed, the reason for the tests, and the cost of the tests.  
All costs of the additional testing shall be borne by the submitter.

- 5.1.2. Waiver of Testing at the Discretion of the Forest Service.** At the discretion of the Forest Service, the requirement for the performance of specific tests may be waived.
- When a test is waived, a written notice of the decision will be prepared by Forest Service WFCS and provided to the submitter.
- 5.2. Notice of Qualification.** When the information submitted in accordance with 2.3.4 has been approved and the product is tested and found to meet all requirements of section 3, the products will be added to the Forest Service Qualified Products List (QPL) and an informal notification made to the supplier.
- A formal Notice of Product Qualification shall be issued in writing by the National Director, Fire and Aviation Management, USDA Forest Service.
- 5.2.1. Use of the Forest Service Shield or Implied Endorsement by the Forest Service.** No use of the Forest Service shield is permitted. The logo is a protected image under Title 36, Code of Federal Regulations, Part 264. Use includes but is not limited to portrayal on product brochures, advertising, presentations, web sites, or other promotional items.
- No statements implying endorsement by the Forest Service are permitted.
- Following the laboratory evaluation of a product and listing on the QPL, the following statement may be used on product brochures or other similar informational material.
- “This product has been evaluated by the USDA Forest Service and meets the requirements of Forest Service Specification 5100-306a for applications as determined during the product evaluation and shown on the QPL.”
- [Amendment 2 adds restrictions on the use of the Forest Service shield and certain language relating to product qualification.]
- 5.2.2. Ownership of Evaluation Results.** The entity submitting the product and paying the costs of the evaluation is the only entity that may benefit directly from the results of the evaluation.
- Information developed during the course of the evaluation will not be transferred to other parties except at the direct request of the submitter. The Forest Service will not acknowledge that a submitted formulation is similar to or the same as a product submitted by another. Testing of each product will proceed independently of products submitted by any other company.
- The submitting entity may transfer the rights to the evaluation and listing on the qualified products list at its discretion; however, the Forest Service must be notified of such transfer to assure legitimate access to information on file.
- 5.2.3. Access to Product Information and Test Results.** When a product is added to the Forest Service Qualified Products List (QPL), the product name, mix ratio, and classification shall be available to the public as part of the QPL. The results of all tests performed by the Forest Service will be summarized and made available to agency personnel and others upon request.
- The performance information developed will be provided to user agencies as input to their procurement and decision-making processes.
- 5.3. Notice of Failure to Qualify.** The submitter shall be notified in writing within 45 days following completion of testing if qualification cannot be granted.
- Written notification shall include all test results and identify unacceptable performance.

- 5.4. **Qualification of Changed or Modified Product.** The Forest Service Branch Chief, Fire Equipment and Chemicals shall be notified of planned formulation changes. Any change to the formulation, including but not limited to changes in the type, quantity, quality, processing, supplier, manufacturer, or manufacturing site of individual ingredients shall be considered a formulation change.
- Qualification testing may be required for any formulation change deemed significant by the Forest Service.
- 5.5. **Acceptance Inspection and Quality Assurance Tests.** During qualification testing, the Forest Service test facility shall establish requirements and procedures for lot acceptance and quality assurance of field shipments of product.
- 5.6. **Other Tests.** The Forest Service reserves the right to perform any other tests it deems necessary at agency expense.

6. **DEFINITIONS.**

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

The following three terms are used to describe the extent to which a product is biodegradable.

- **Readily Biodegradable.** A product which is  $\geq 60$ -percent biodegraded within 28 days is considered to be readily biodegradable.
- **Biodegradable.** A product which is not  $\geq 60$ -percent biodegraded within 28 days but which is  $\geq 60$ -percent biodegraded by 42 days is considered to be biodegradable.
- **Not Biodegradable.** A product which is not  $\geq 60$ -percent biodegraded by 42 days is considered to be not biodegradable.

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

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

**Component.** Each combination of ingredients, packaged together by the manufacturer for use in preparation of the mixed product by the user.

**Coupon, Large Stability.** A metal sample, approximately 2 in x 12 in x 1/8 in (5 cm x 30 cm x 0.3 cm), made of mild steel or 2024-T3 aluminum for use in outdoor stability testing.

**Coupon, Small Stability.** A metal sample, approximately, 1 in x 1 in x 1/8 in (2.5 cm x 2.5 cm x 0.3 cm), made of mild steel or 2024-T3 aluminum for use in indoor stability testing.

**Coupon, Corrosion.** A metal test specimen, approximately 1 in x 4 in x 1/8 in (2.5cm x 10.2 cm x 0.3 cm), made of 2024-T3 aluminum, mild steel, yellow brass, or Az31B magnesium for use in uniform corrosion testing.

**Density.** The weight in grams of 1 milliliter (mL) of product.

**Drain Time.** The time that it takes for a specified portion of the total solution 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.

**Exposure Cycle.** Each exposure cycle shall consist of 1 day (8 to 10 hours) and the following night or weekend.

**Fire Point.** The lowest temperature at which a liquid will ignite and achieve sustained burning when exposed to a test flame.

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

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

The product is not effective once the water it originally contained has evaporated.

**Foam Concentrate.** The foaming and wetting agents, and other ingredients, as received from the supplier that, when mixed with water, becomes foam solution.

**Foam Solution.** The combination of water and foam concentrate (0.1 percent to 1.0 percent, by volume) which is aerated to produce the foam used for actual fire suppression.

The addition of foam concentrate to water produces a solution with reduced surface tension which enhanced the wetting ability of the water.

**Forest Service.** The term Forest Service as used throughout this document refers to the U.S. Department of Agriculture, Forest Service.

**Ingredient.** Each single chemical used by the manufacturer in the formulation of the product.

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

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

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

**Miscibility.** The ability of concentrate to mix with water under specified conditions.

**Mixed Product.** The combination of a wet or dry concentrate and water at the qualified mix ratio for use in fire management activities.

**Mix Ratio.** The proportion of concentrate and water in the mixed product.

The mix ratio can be expressed in several ways:

- Pounds of dry concentrate added to a gallon of water
- Gallons of wet concentrate to be added to a gallon of water
- Volume percentage of concentrate and water – typical for foams and wet concentrate water enhancers

**pH.** A measure of the acidity or alkalinity of a solution, represented on a numeric scale with 7 representing neutral solutions. Higher numbers represent alkaline solutions and lower numbers represent acidic solutions.

**Sample Container, large.** A 5.5-gallon (20 liter), low-density polyethylene carboy without spigot. Carboy shall be closed with a size 13.5 rubber stopper secured by a polypropylene screw cap.

**Sample Container, small.** A straight-sided, wide-mouth, glass jar having a capacity of approximately 1 quart (946 mL) with non-metallic, screw cap, 89 mm diameter with a vinyl or vinyl-backed fiber liner.

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

**Temperature.** Each temperature included in the specification consists of a Fahrenheit temperature and allowable variation from that temperature and the Celsius equivalents for the temperature and range.

Commonly used temperatures and variations are shown in the first section below and included in the specification requirements and test descriptions by listing a simple Fahrenheit temperature.

Other temperatures are described in detail in the second section. Sufficient information is provided within the individual specification requirements and test descriptions to determine the proper choice of conditions.

<u>Fahrenheit</u>	<u>Variation</u>	<u>Celsius</u>	<u>Variation</u>
15 °F	± 5 °F	-9.4 °C	± 2.8 °C
35 °F	± 2 °F	1.7 °C	± 1.1 °C
40 °F	± 5 °F	4.4 °C	± 2.8 °C
70 °F	± 5 °F	21.1 °C	± 2.8 °C
100 °F	± 5 °F	37.8 °C	± 2.8 °C
120 °F	± 5 °F	48.9 °C	± 2.8 °C
5 °F	± 2 °F	-15 °C	± 1 °C
35 °F	± 2 °F	2 °C	± 1 °C
40 °F	± 2 °F	4 °C	± 1 °C

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

**Viscosity.** A measure of the resistance of a liquid to flow, expressed in centipoise (cP).

**Water, Artificial Sea.** A solution of chemicals in deionized water in the prescribed percentages to approximate natural seawater. All percentages are expressed as weight of chemical to total weight of solution.

**Water, Deionized.** Water treated by distillation, ion exchange, reverse osmosis, or a combination of these methods to remove most salts in conformance to ASTM D-1193 Type IV reagent water.

All dilutions shall be made with deionized water unless otherwise specified.

**Water, Fresh.** Tap water with a hardness of 120 to 140 ppm of calcium carbonate. A mixture of 3 volumes of ASTM hard water and 1 volume of ASTM soft water as defined in ASTM E-729 may be substituted for the fresh water.

**Wet Concentrate.** A liquid, single component which is added to water to prepare the mixed product.

**Wetting Ability.** The ability of a solution to spread and penetrate fuel, char, and ash.

**7. APPLICABLE DOCUMENTS.**

**7.1. Order of Precedence.** In the event of conflict between the text of this document and the references cited herein, the text of this document takes precedence.

Nothing in this document, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

**7.2. United States Government Documents.** The specifications, standards, and handbooks referenced form a part of this document to the extent specified herein.

Unless otherwise specified, the issues of these documents in effect on the date of the invitation for bids or request for proposals shall apply.

**7.2.1. Code of Federal Regulations (CFR).** The text of the Codes of Federal Regulations are available at <http://www.gpoaccess.gov/cfr/index.html>

**7.2.2. U.S. Department of Agriculture, Forest Service.** The following Forest Service documents are available on the internet at [www.fs.fed.us/rm/fire/wfcs/foam-fir.htm](http://www.fs.fed.us/rm/fire/wfcs/foam-fir.htm) unless otherwise noted.

Paper copies of these documents can be obtained from the Program Leader or Project Leader, WFCS, 5785 Highway 10 West, Missoula, MT, 59808, if web access is unavailable.

- Manufacturer Submission Procedure for Qualification Testing of Class A Foam Products.
- Standard Test Procedures for the Evaluation of Wildland Fire Chemical Products, version in effect on the date of submission for evaluation.
- USDA Forest Service Manual (FSM) 5160, Section 5162 – Fire Management Chemicals. Available at <http://www.fs.fed.us/im/directives>

**7.2.3. U.S. Department of Agriculture and U.S. Department of Interior; Interagency Standards.** Interagency Standards for Fire and Fire Aviation Operation. Department of Agriculture, Forest Service, and Department of the Interior Agencies: Bureau of Land Management, National Park Service and U.S. Fish and Wildlife Service.

Available at <http://www.fire.blm.gov/Standards/redbook.htm>

**7.2.4. U.S Environmental Protection Agency (EPA), Office of Prevention, Pesticides, and Toxic Substances (OPPTS).** EPA documents can be obtained from the web site at <http://www.epa.gov/opptsfrs/home/guidelin.htm> or by mail from U.S. Environmental Protection Agency, National Service Center for Environmental Publication (NSCEP), P.O. Box 42419, Cincinnati, OH 45242.

**7.2.5. United States Department of Health and Human Services,** National Toxicology Program: Report on Carcinogens is available at <http://ntp-server.niehs.nih.gov/>

**7.2.6. International Agency for Research on Cancer (IARC).** IARC Monographs of Carcinogens are available at <http://www-cie.iarc.fr/monoeval/grlist.html>

**7.2.7. Federal Standards.** Federal Standards can be obtained from <http://dsp.dla.mil/onlinedocs-dsp.htm>

**7.2.8. Military Specification.** Military Specifications can be obtained from <http://dsp.dla.mil/onlinedocs-dsp.htm>

- 7.2.9. **Freedom of Information Act (FOIA)**. The Forest Service FOIA information can be found at <http://www.fs.fed.us/im/foia/>
- 7.3. **Other Publications**. The following publications of the issue in effect on the date of invitation for bids form a part of this specification.
  - 7.3.1. **American Society for Testing and Materials (ASTM)**. Copies of ASTM publications can be obtained on the web at <http://www.astm.org> or by mail from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.
  - 7.3.2. **National Association of Corrosion Engineers International (NACE)**. Copies of NACE publications can be obtained on the web at <http://www.nace.org> or by mail from NACE International, 1440 South Creek Drive, Houston, TX 77084.
  - 7.3.3. **Society of Automotive Engineers, Inc. (SAE)**. Copies of SAE publications can be obtained on the web at <http://sae.org> or by mail from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001.