

**US Department of Agriculture
Forest Service**

Specification 5100-306a

**Specification for
Water Enhancers (Gels) for Wildland Firefighting**

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SPECIFICATION FOR

WATER ENHANCERS (GELS) FOR WILDLAND FIREFIGHTING

1. GENERAL.

- 1.1.** **Scope.** The water enhancers described in this specification are for use in wildland and wildland-urban interface fire management. They may be applied from ground or aerial application equipment, directly to the fire area to slow or stop combustion, and for exposure protection.

Enhanced water mixtures depend on the water that they contain to be effective and when that water has evaporated, they are no longer effective. They contain thickeners which improve aerial application, minimize drift, and aid in adherence to fuels.

The concentrate (wet or dry) shall be added to water to create an enhanced water mixture. The higher concentrations may be more appropriate for exposure (vertical surface) protection while lower concentrations may be more appropriate for vegetation (horizontal surface) application.

- 1.1.1.** All Class A water enhancers, except Class A Foams and wetting agents, are covered by this specification.

- 1.1.2.** Water enhancer concentrates may be wet or dry.

- 1.1.3.** Uncolored products shall be one component, i.e., enhanced water mixture shall be prepared by blending a single concentrate with water.

Colored products may be either one component or a two component prepared by blending a qualified uncolored product with a qualified colorant at the time of preparing the enhanced water mixture.

Suppliers are responsible for providing information relative to the equipment needs associated with the mixing and loading of their product at permanent or portable sites. They are responsible for demonstrating acceptable performance of their systems with their product.

- 1.1.4.** The highest mix ratio of the uncolored product shall be no greater than 3.0 percent weight/weight (for dry concentrates) or volume/volume (for wet concentrates).

The submitter shall specify the use range for which qualification is requested.

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

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/water-en.htm:

- The Manufacturers Submission Procedures for Qualification Testing of Water Enhancer 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 classifications of the wildland fire chemical product, according to Sections 2.3.2.1 through 2.3.2.4, 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.

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.

2.3.2.2. Form of Concentrate. Each concentrate shall be classified as wet or dry.

Dry Concentrate A single, dry component which is mixed with water to prepare the uncolored enhanced water mixture.

Wet Concentrate A single, wet component which is mixed with water to prepare the uncolored enhanced water mixture.

2.3.2.3. Storability. All concentrates shall be classified and evaluated as storable products.

All mixed products shall be classified and evaluated as not storable.

Storable Concentrate is stable for at least 52 weeks.
Products may be recirculated in storage and recirculation may be required to obtain a homogeneous and usable product.

Not Storable Mixed product is stable for at least 14 days.
Products are mixed or blended during transfer to aircraft or other application devices. Minimal additional mixing or recirculation is necessary.
These products are not routinely stored in the mixed form except in application equipment where recirculation is not available.

2.3.2.4. Color. Each mixed product shall be classified as uncolored or fugitive colored.

Uncolored A mixed product that contains no ingredients that impart color.
The product in the container may have some earth-tone color; however it is not visible when applied to natural fuels.

Fugitive Colored A mixed product that contains one or more ingredients that impart a high degree of visibility from the air when first applied to wildland fuels but will lose visibility gradually over several months.
A color component may be included as part of the single, wet component or added as a single, additional component during blending.
The color of mixed product preferably will be easily recognized as different from that of long-term retardant.

2.3.2.5. Base Type. The evaluation shall be conducted following the test methods and requirements contained in this specification, based on the classifications shown above.

Approvals for use from specific base types shall be determined by product performance and mixing and storage needs.

Permanent Storable mixed products or not storable mixed products made from wet concentrates are suitable.
Recirculation is possible, large/long-term storage capability, and auxiliary equipment are readily available.

Temporary/Mobile Not storable mixed products are suitable; storable products may be suitable.

Small volumes of mixed product storage capability and limited auxiliary equipment, including recirculation, are available.

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 Water Enhancer 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 will 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 inquiries 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 and other information that the supplier considers significant about each ingredient should also be provided.

2.3.4.4. Mix Ratio Range. The submitter shall specify the range of mix ratios over which the product is designed and for which qualification is being sought.

The maximum use level of the uncolored product shall be no greater than 3.0 percent weight/weight (for dry concentrates) or volume/volume (for wet concentrates).

2.3.4.5. Health and Safety Information. The submitter shall submit to the Forest Service the following safety information 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 (Tables 2 and 3 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.

Table 1. Test sample quantity and packaging.		
<u>Product Type</u>	<u>Packaging</u>	<u>Quantity</u>
Dry concentrate	5-gallon (18.9 liter) Plastic Pails with Removable Lids	10 Pails – Each containing ≤ 50 lbs (22.7 kg) per pail
Wet concentrate	5-gallon (18.9 liter) Plastic Pails with Removable Lids	50 gallons (189 liters) – ≤ 50 lbs (22.7 kg) per pail
Note: Based on specific product information, the Project Leader may specify a different amount of product than shown here.		

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 (weight in the case of a dry 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.

3. REQUIREMENTS.

3.1. Mix Ratio Range. The evaluation shall be conducted on the concentrate and on the mixed product prepared using the manufacturer's recommended range of mix ratios.

The highest mix ratio of the uncolored product shall be no greater than 3.0 percent weight/weight (for dry concentrates) or volume/volume (for wet concentrates).

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 these 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 wet or dry concentrate shall meet the requirements in Table 2 when tested in accordance with 4.3.

Table 2. Toxicity and irritation requirements for wet or dry concentrate.	
<u>Test</u>	<u>Requirement</u>
Acute oral toxicity	LD ₅₀ > 500 mg/kg.
Acute dermal toxicity	LD ₅₀ > 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 the mixed product at the greatest recommended mix ratio shall meet the requirements in Table 3 when tested in accordance with 4.3.

Table 3. Toxicity and irritation requirements for mixed product.	
<u>Test</u>	<u>Requirement</u>
Acute oral toxicity	LD ₅₀ > 5000 mg/kg.
Acute dermal toxicity	LD ₅₀ > 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 LC₅₀ 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. Product Degradation.** Each concentrate and mixed product shall be evaluated to determine biodegradability or light degradation as required below.
The results will be made available to users as performance information.
- 3.4.3.1. Biodegradability.** The biodegradability of the concentrate shall be determined in accordance with 4.5.1.
The results shall be made available to users as performance information.
- 3.4.3.2. Degradation of Enhanced Water Mixtures by Light.** The effect of light exposure on the mixed product shall be determined in accordance with 4.5.2.
The results shall 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 water enhancer 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 below 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 enhanced water mixture shall be tested for exposure protection effectiveness using the Lateral Ignition and Flame Spread Test (LIFT) and a performance rating determined.
The performance rating scale based on the increased time to ignite compared to a water-treated substrate is being developed.
The results will be made available to users as performance information.
- 3.6. Physical Properties.** In accordance with 4.8, the physical properties of the wet concentrate and enhanced water mixtures of all the concentrate shall be determined as required in 3.6.1 and 3.6.2.
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 Wet Concentrate.** In accordance with 4.8, the density, viscosity, pH, and fluidity of the wet concentrates shall be determined.
The values determined shall be used as baseline values for stability tests as required in 3.9.1.1.2
The results will be made available to users as performance information.

- 3.6.1.1. Density of Wet Concentrate.** In accordance with 4.8.1, the density of the wet concentrate shall be determined.
The values determined shall be used as baseline values for stability tests as required in 3.9.1.1.
The values determined will be made available to users as performance information.
- 3.6.1.2. Viscosity of Wet Concentrate.** In accordance with 4.8.2, the viscosity of the wet concentrate shall be determined.
The values determined shall be used as baseline values for stability tests as required in 3.9.1.1.
The values determined will be made available to users as performance information.
- 3.6.1.3. pH of Wet Concentrate.** In accordance with 4.8.3, the pH of the wet concentrate shall be determined.
The values determined shall be used as baseline values for stability tests as required in 3.9.1.1.
The values determined will be made available to users as performance information.
- 3.6.1.4. Concentrate Fluidity.** In accordance with 4.8.4, the fluidity of wet concentrate shall be determined as a function of temperature.
The wet 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 Enhanced Water Mixtures.** In accordance with 4.8, the steady state viscosity, density, and pH of the enhanced water mixtures over the entire mix ratio range shall be determined.
The results will be made available to users as performance information.
- 3.6.2.1. Density of the Enhanced Water Mixtures.** In accordance with 4.8.1, the density the enhanced water mixtures shall be determined.
The values determined for enhanced water mixtures prepared with fresh water shall be used as baseline values for stability tests as required in 3.9.1.1.1
The results will be made available to users as performance information.
- 3.6.2.2. Steady State Viscosity of the Enhanced Water Mixture.** In accordance with 4.8.2.1, the steady state viscosity of the enhanced water mixtures shall be determined.
No viscosity less than 200 centipoise shall be acceptable.
The values determined for enhanced water mixtures prepared with fresh water shall be used as baseline values for stability tests as required in 3.9.1.1.1
The results will be made available to users as performance information.
- 3.6.2.3. pH of the Enhanced Water Mixture.** In accordance with 4.8.3, the pH of the enhanced water mixtures shall be determined.
The values determined for enhanced water mixtures prepared with fresh water shall be used as baseline values for stability tests as required in 3.9.1.1.1
The results will be made available to users as performance information.
- 3.7. Effectiveness Characteristics.** As required by 3.7.1 through 3.7.5, the concentrate and enhanced water mixtures shall be tested in accordance with 4.9 to determine the effects of concentration and water quality (type) and temperature on performance.

- 3.7.1. Miscibility of Concentrate.** As required by 3.7.1.1 through 3.7.1.3, the concentrate shall be tested in accordance with 4.9.1 to determine its ability to mix with water of different qualities (types) and temperatures.
The results will be made available to users as performance information.
- 3.7.1.1. Miscibility of Concentrate in Deionized Water.** In accordance with 4.9.1.1, the concentrate shall be tested to determine its ability to mix with deionized water.
The results will be made available to users as performance information.
- 3.7.1.2. Miscibility of Concentrate in Fresh Water.** In accordance with 4.9.1.2, the concentrate shall be tested to determine its ability to mix with fresh water.
The results will be made available to users as performance information.
- 3.7.1.3. Miscibility of Concentrate in Artificial Sea Water.** In accordance with 4.9.1.3, the concentrate shall be tested to determine its ability to mix with artificial sea water
The results will be made available to users as performance information.
- 3.7.2. Retention on Fuel of Enhanced Water Mixtures.** As required by 3.7.2.1 through 3.7.2.6, the enhanced water mixtures shall be tested in accordance with 4.9.2 in to determine their ability to remain on vertical and horizontal surfaces as a function of concentration, water quality (types) and water temperature.
The results will be made available to users as performance information.
- 3.7.2.1. Retention on Fuel of Enhanced Water Mixture Prepared with 70 °F Deionized Water.** In accordance with 4.9.2.1, the enhanced water mixtures prepared with 70 °F, deionized water shall be tested to determine their ability to remain on vertical and horizontal surfaces.
The results will be made available to users as performance information.
- 3.7.2.2. Retention on Fuel of Enhanced Water Mixture Prepared with 70 °F Fresh Water.** In accordance with 4.9.2.2, the enhanced water mixtures prepared with 70 °F, fresh water shall be tested to determine their ability to remain on vertical and horizontal surfaces.
The results will be made available to users as performance information.
- 3.7.2.3. Retention on Fuel of Enhanced Water Mixture Prepared with 70 °F Artificial Sea Water.** In accordance with 4.9.2.3, the enhanced water mixtures prepared with 70 °F, artificial sea water shall be tested to determine their ability to remain on vertical and horizontal surfaces.
The results will be made available to users as performance information.
- 3.7.2.4. Retention on Fuel of Enhanced Water Mixture Prepared with 40 °F Fresh Water.** In accordance with 4.9.2.4, the enhanced water mixtures prepared with 40 °F, fresh water shall be tested to determine their ability to remain on vertical and horizontal surfaces.
The results will be made available to users as performance information.
- 3.7.2.5. Retention on Fuel of Enhanced Water Mixture Prepared with 100 °F Fresh Water.** In accordance with 4.9.2.5, the enhanced water mixtures prepared with 100 °F, fresh water shall be tested to determine their ability to remain on vertical and horizontal surfaces.
The results will be made available to users as performance information.

- 3.7.2.6. Retention on Fuel of Enhanced Water Mixture Prepared with 40 °F Artificial Sea Water.**
In accordance with 4.9.2.6, the enhanced water mixtures prepared with 40 °F, artificial sea water shall be tested to determine their ability to remain on vertical and horizontal surfaces.
The results will be made available to users as performance information.
- 3.7.3. Evaporation Rate of Enhanced Water Mixtures.** As required by 3.7.3.1 through 3.7.3.3, the enhanced water mixtures shall be tested in accordance with 4.9.3 to determine their rate of evaporation under controlled conditions as a function of concentration, water quality (type), and depth of the enhanced water mixtures.
The results will be made available to users as performance information.
- 3.7.3.1. Evaporation Rate of Enhanced Water Mixtures Prepared with 70 °F Deionized Water.** In accordance with 4.9.3.1, the enhanced water mixtures prepared with 70 °F, deionized water shall be tested to determine their rate of evaporation under controlled conditions as a function of concentration, water quality (type), and depth of the enhanced water mixtures.
The results will be made available to users as performance information.
- 3.7.3.2. Evaporation Rate of Enhanced Water Mixtures Prepared with 70 °F Fresh Water.** In accordance with 4.9.3.2, the enhanced water mixtures prepared with 70 °F, fresh water shall be tested to determine their rate of evaporation under controlled conditions as a function of concentration, water quality (type), and depth of the enhanced water mixtures.
The results will be made available to users as performance information.
- 3.7.3.3. Evaporation Rate of Enhanced Water Mixtures Prepared with 70 °F Artificial Sea Water.**
In accordance with 4.9.3.3, the enhanced water mixtures prepared with 70 °F, artificial sea water shall be tested to determine their rate of evaporation under controlled conditions as a function of concentration, water quality (type), and depth of the enhanced water mixtures.
The results will be made available to users as performance information.
- 3.7.4. Water Retention of Enhanced Water Mixtures.** As required by 3.7.4.1 through 3.7.4.3, the enhanced water mixtures shall be tested in accordance with 4.9.4 to determine their ability to retain the water they originally contained as a function of concentration and water quality (type).
The results will be made available to users as performance information.
- 3.7.4.1. Water Retention of Enhanced Water Mixtures Prepared with 70 °F Deionized Water.** In accordance with 4.9.4.1, the enhanced water mixtures prepared with 70 °F, deionized water shall be tested to determine their ability to retain the water they originally contained.
The results will be made available to users as performance information.
- 3.7.4.2. Water Retention of Enhanced Water Mixtures Prepared with 70 °F Fresh Water.** In accordance with 4.9.4.2, the enhanced water mixtures prepared with 70 °F, fresh water shall be tested to determine their ability to retain the water they originally contained.
The results will be made available to users as performance information.
- 3.7.4.3. Water Retention of Enhanced Water Mixtures Prepared with 70 °F Artificial Sea Water.**
In accordance with 4.9.4.3, the enhanced water mixture prepared with 70 °F, artificial sea water shall be tested to determine their ability to retain the water they originally contained.
The results will be made available to users as performance information.

- 3.7.5. Consistency of Enhanced Water Mixtures.** As required by 3.7.5.1 through 3.7.5.6, the enhanced water mixtures shall be tested in accordance with 4.9.5 to determine their consistency as a function of concentration, water quality (type), and water temperature.
The results will be made available to users as performance information.
- 3.7.5.1. Consistency of Enhanced Water Mixtures Prepared with 70 °F Deionized Water.** In accordance with 4.9.5.1, the enhanced water mixtures prepared with 70 °F, deionized water shall be tested to determine their consistency.
The results will be made available to users as performance information.
- 3.7.5.2. Consistency of Enhanced Water Mixtures Prepared with 70 °F Fresh Water.** In accordance with 4.9.5.1, the enhanced water mixtures prepared with 70 °F, fresh water shall be tested to determine their consistency.
The results will be made available to users as performance information.
- 3.7.5.3. Consistency of Enhanced Water Mixtures Prepared with 70 °F Artificial Sea Water.** In accordance with 4.9.5.1, the enhanced water mixtures prepared with 70 °F, artificial sea water shall be tested to determine their consistency.
The results will be made available to users as performance information.
- 3.7.5.4. Consistency of Enhanced Water Mixtures Prepared with 40 °F Fresh Water.** In accordance with 4.9.5.1, the enhanced water mixtures prepared with 40 °F, fresh water shall be tested to determine their consistency.
The results will be made available to users as performance information.
- 3.7.5.5. Consistency of Enhanced Water Mixtures Prepared with 100 °F Fresh Water.** In accordance with 4.9.5.1, the enhanced water mixtures prepared with 100 °F, fresh water shall be tested to determine their consistency.
The results will be made available to users as performance information.
- 3.7.5.6. Consistency of Enhanced Water Mixtures Prepared with 40 °F Artificial Sea Water.** In accordance with 4.9.5.1, the enhanced water mixtures prepared with 40 °F, artificial sea water shall be tested to determine their consistency.
The results will be made available to users as performance information.
- 3.7.6. Modified Marsh Funnel Flow-Through Time of the Enhanced Water Mixtures.** As required by 3.7.6.1 through 3.7.6.5, the enhanced water mixtures shall be tested in accordance with 4.9.6 to determine their modified Marsh funnel flow-through time as a function of concentration, water quality (type), and water temperature.
The results will be made available to users as performance information.
- 3.7.6.1. Modified Marsh Funnel Flow-Through Time of Enhanced Water Mixtures Prepared with 70 °F Deionized Water.** In accordance with 4.9.6.1, the enhanced water mixtures prepared with 70 °F, deionized water shall be tested to determine their modified Marsh funnel flow-through time.
The results will be made available to users as performance information.
- 3.7.6.2. Modified Marsh Funnel Flow-Through Time of Enhanced Water Mixtures Prepared with 70 °F Fresh Water.** In accordance with 4.9.6.2, the enhanced water mixtures prepared with 70 °F, fresh water shall be tested to determine their modified Marsh funnel flow-through time.
The results will be made available to users as performance information.

- 3.7.6.3. Modified Marsh Funnel Flow-Through Time of Enhanced Water Mixtures Prepared with 70 °F Artificial Sea Water.** In accordance with 4.9.6.3, the enhanced water mixtures prepared with 70 °F, artificial sea water shall be tested to determine their modified Marsh funnel flow-through time.
The results will be made available to users as performance information.
- 3.7.6.4. Modified Marsh Funnel Flow-Through Time of Enhanced Water Mixtures Prepared with 40 °F Fresh Water.** In accordance with 4.9.6.4, the enhanced water mixtures prepared with 40 °F, fresh water shall be tested to determine their modified Marsh funnel flow-through time.
The results will be made available to users as performance information.
- 3.7.6.5. Modified Marsh Funnel Flow-Through Time of Enhanced Water Mixtures Prepared with 100 °F Fresh Water.** In accordance with 4.9.6.5, the enhanced water mixtures prepared with 100 °F, fresh water shall be tested to determine their modified Marsh funnel flow-through time.
The results will be made available to users as performance information.
- 3.7.6.6. Modified Marsh Funnel Flow-Through Time of Enhanced Water Mixtures Prepared with 40 °F Artificial Sea Water.** In accordance with 4.9.6.6, the enhanced water mixtures prepared with 40 °F, artificial sea water shall be tested to determine their modified Marsh funnel flow-through time.
The results will be made available to users as performance information.
- 3.8. Material Effects.** As required by 3.8.1 through 3.8.3, the effects of the wet concentrate and enhanced water mixtures prepared with fresh water 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, wet concentrate and freshly prepared enhanced water mixtures of all concentrates 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 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 enhanced water mixtures 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 enhanced water mixtures during the uniform corrosion tests.
- 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 enhanced water mixtures during the uniform corrosion tests.
- 3.8.2.4. Helicopter Bucket and Ground Based Application Equipment.** There are no intergranular corrosion requirements for helicopter bucket.

Table 4. Maximum Allowable Corrosion Rates (mils-per-year) for Wildland Fire Chemical Products.¹

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
----- <i>mils-per-year</i> -----													
Concentrates													
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 ² except fixed-tank helicopters	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0				
Mixed Products													
Fixed-tank helicopters ³	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 ⁴	2.0	2.0	2.0	2.0	5.0	5.0	5.0	5.0	5.0				
Helicopter bucket and ² Ground-based application	2.0	2.0	2.0	2.0	5.0	5.0	5.0	5.0	5.0				

¹ 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.

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

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

⁴ 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.

3.8.3. Effect of Wet Concentrate and Enhanced Water Mixtures on Non-Metallic Materials. In accordance with 4.10.3, the wet concentrates and all enhanced water mixtures 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.

Table 5. Materials To Be Tested To Determine The Effect Of Exposure To Wet Concentrate And Enhanced Water Mixtures.	
<u>Material</u>	<u>Materials Specifications</u>
- - Shall Be Tested And Performance Provided To User Agencies. - -	
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 Wet Concentrate and Enhanced Water Mixtures on 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 shall 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

3.9. Product Stability. When tested in accordance with 4.11, concentrates and enhanced water mixtures 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 concentrates and mixed products shall meet all applicable requirements of 3.9.1.1 and 3.9.1.2.

3.9.1.1. Concentrates. All concentrates shall meet the requirements of either 3.9.1.1.1 or 3.9.1.1.2.

3.9.1.1.1. Dry Concentrates. In accordance with 4.11.1.1.1, dry concentrates shall be stored outdoors for 52 weeks.

The stored concentrate shall have no visual separation such as discoloration or caking. Lumps shall fit through a 0.25-inch (0.625 cm) sieve-size.

The stored concentrate shall be used to prepare enhanced water mixture as required in 3.9.1.1.3.

3.9.1.1.2. Wet Concentrates. In accordance with 4.11.1.1.2, wet concentrates shall be stored outdoors for 52 weeks.

There shall be no separation resulting in particles larger than 0.25-inch (0.625 cm) sieve-size.

The stored concentrate shall be tested to determine the viscosity, density, and pH in accordance with 4.8.1 through 4.8.3.

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

The stored concentrate shall be used to prepare enhanced water mixture as required in 3.9.1.1.3.

3.9.1.1.3. Water Mixtures from Stored Concentrate. As required by 3.9.1.1.1 and 3.9.1.1.2, the enhanced water mixtures shall be prepared from the stored concentrate and fresh water and tested as required in 3.9.1.1.4 through 3.9.1.1.5.

Enhanced water mixtures shall be prepared from the stored concentrate and fresh water and tested to determine enhanced water mixture stability as required by 3.9.1.1.6 and corrosion as required in 3.9.1.1.7.

3.9.1.1.4. Physical Properties of Water Mixtures from Stored Concentrate. The enhanced water mixtures prepared as required in 3.9.1.1.3 shall be tested to determine the following properties:

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

These values shall be within the allowable variation, as shown in Table 6, from the original values, determined in 3.6.2, for the enhanced water mixtures prepared from fresh concentrate.

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

Table 6. Allowable Variation of Physical Properties of Enhanced Water Mixtures Prepared from Fresh Concentrates and Concentrates Stored for 52 weeks.	
<u>Property</u>	<u>Allowable Variation from Initial Value</u>
Density	± 1 percent
pH	± 0.75 units
Viscosity	Not determined

3.9.1.1.5. Effectiveness Characteristics of Enhanced Water Mixtures from Stored Concentrate. The enhanced water mixtures prepared as required by 3.9.1.1.3 shall be tested to determine the following effectiveness characteristics:

- a. Fuel retention, in accordance with 4.9.2.2,
- b. Consistency, in accordance with 4.9.5.2, and
- c. Modified Marsh funnel flow-through times, in accordance with 4.9.6.2.

Changes from the value determined in 3.7, shall be calculated.

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

3.9.1.1.6. Stability of Enhanced Water Mixtures from Stored Concentrate. The enhanced water mixtures prepared as required by 3.9.1.1.3 shall be stored outdoors for 14 days, in accordance with 4.11.1.2, for freshly prepared enhanced water mixtures.

The stored enhanced water mixtures shall be tested as required in 3.9.1.1.4 and 3.9.1.1.5.

3.9.1.1.7. Corrosivity of Enhanced Water Mixtures from Stored Concentrate. The enhanced water mixtures prepared as required by 3.9.1.1.3 shall be tested to determine for uniform and intergranular corrosion and shall meet the uniform and intergranular corrosion requirements of 3.8.1 and 3.8.2.

3.9.1.2. Outdoor Stability of Enhanced Water Mixture. In accordance with 4.11.1.2, the enhanced water mixtures shall be stored outdoors for 14 days.

At the end of the storage period, the stored mixture shall be examined visually and shall have no separation resulting in particles larger than 0.25-inch (0.635 cm) sieve size.

The stored enhanced water mixture shall be tested as required in 3.9.1.2.1 and 3.9.1.2.2.

3.9.1.2.1. Physical Properties of Stored Water Mixtures. The stored enhanced water mixtures shall be tested to determine the following properties:

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

These values shall be within the allowable variation, as shown in Table 6, from the original values, determined in 3.6.2, for the enhanced water mixtures prepared from fresh concentrate.

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

3.9.1.2.2. Effectiveness Characteristics of Stored Enhanced Water Mixtures. The enhanced water mixtures shall be tested to determine the following effectiveness characteristics:

- a. Fuel retention, in accordance with 4.9.2.2,
- b. Consistency, in accordance with 4.9.5.2, and
- c. Modified Marsh funnel flow-through times, in accordance with 4.9.6.2.

Changes from the value determined in 3.7, shall be calculated and made available to users as performance information.

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

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

The concentrate shall be used to prepare enhanced water mixtures which shall be tested as required in 3.9.2.1.

3.9.2.1. Enhanced Water Mixtures Prepared from Temperature-Cycled Concentrate. As required by 3.9.2, enhanced water mixtures prepared from temperature-cycled concentrate and deionized water shall be tested in accordance with 4.11.3 to determine the following properties:

- a. Fuel retention of enhanced water mixture, in accordance with 3.7.2.1,
- b. Consistency of enhanced water mixture, in accordance with 3.7.5.1, and
- c. Modified Marsh funnel flow-through time of the enhanced water mixture, in accordance with 3.7.6.1.

Changes in these properties shall be calculated.

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

- 3.9.3. Resistance of Enhanced Water Mixtures to Microbial Growth.** After 14 days in storage in accordance with 4.11.4, enhanced water mixture 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 Wet Concentrate.** In accordance with 4.11.5, the viscosity of the concentrate shall be determined over a range of temperatures.
The results shall be made available to users as performance information.
- 3.10. Color Properties and Visibility.** Enhanced water mixtures shall be evaluated as required in 3.10.1 through 3.10.3 to determine their visibility characteristics.
- 3.10.1. Acceptable Colors.** Color of the enhanced water mixtures shall be easily identifiable as different from that of long-term retardant.
- 3.10.2. Laboratory Evaluation of Fugitive-Colored Enhanced Water Mixtures.** As required by 3.10.2.1 and 3.10.2.2, all fugitive-colored enhanced water mixtures shall be tested to determine the opacity and fading of films applied in accordance with 4.12.1.1 through 4.12.1.4
- 3.10.2.1. Opacity of Fugitive-Colored Enhanced Water Mixtures.** When tested in accordance with 4.12.1.2, all colored enhanced water mixtures shall be tested to determine their opacity on a 20-step black-white opacity chart.
The results shall be made available to users as performance information.
- 3.10.2.2. Fading of Fugitive-Colored Enhanced Water Mixtures.** In accordance with 4.12.1.4, at the end of the exposure period in accordance with 4.12.1.3, the enhanced water mixture with fugitive colorant shall be no more colored than a sample of the uncolored product in water, applied and treated in the same manner as the enhanced water mixture.
- 3.10.3. Field Visibility.** In accordance with 4.12.2, the visibility of each enhanced water mixture shall be determined by an experienced observer team designated by the government and shall meet the requirements in 3.10.3.1.
All costs associated with the field visibility test shall be the responsibility of the submitter.
- 3.10.3.1. Field Visibility of Fugitive-Colored Mixed Products.** In accordance with 4.12.2, all fugitive-colored mixed products for aerial application shall be tested and determined to be acceptably visible immediately after application; and shall be determined to be acceptably not visible 3 months after application.
- 3.11. Air Drop Characteristics.** As deemed necessary by the Forest Service, in accordance with 4.13, the air drop characteristics of the mixed product shall be determined.
All costs associated with the air drop characteristics test shall be the responsibility of the submitter.

- 3.12. Operational Field Evaluation.** In accordance with 4.14, after meeting the requirements of 3.1 through 3.11, an analysis shall be performed to determine the need for an operational field evaluation of the water enhancer.

The analysis shall document the rationale for no field test or provide a summary of the issues and performance to be addressed during the field evaluation.

A copy of the analysis shall be provided to the submitter.

Product for the operational field evaluation shall be purchased by the Forest Service or other cooperating agency according to the classification established during qualification testing. All other costs associated with the operational field evaluation shall be the responsibility of the submitter.

The product shall perform satisfactorily under operational conditions during a fire season. An acceptable test should include fire fighting operations on a variety of fuel types, slopes, aspects, and exposures.

Operations should include both routine and accelerated burning conditions and multiple ignitions over several months.

- 4. TEST PROCEDURES.** Detailed test methods are described in Standard Test Procedures for the Evaluation of Wildland Fire Chemical Products (STP).

- 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-3.3).** 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, mammalian toxicity and irritation test on wet and dry concentrates and the enhanced water mixture having the highest amount of concentrate, 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 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 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 E729) at 54 ± 2 °F (12 ± 1 °C) shall be maintained throughout the 96-hour test period.

All fish shall be 60 ± 15 days post hatch.

- 4.5. Degradation.** As required by 3.4.3 and in accordance with 4.5.1 and 4.5.2, the wet and dry concentrates shall be tested to determine their susceptibility to degradation by light or biological means.

- 4.5.1. Biodegradability (STP-1.4).** As required by 3.4.3.1, the biodegradability of the wet and dry concentrates shall be determined in accordance with OPPTS 835, Section M, Fate, Transport and Transformation Test Guidelines, CO₂ 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.

- 4.5.2. Light Degradation (STP-9.4).** As required in 3.4.3.2, the effect of exposure to light and/or UV radiation on the consistency of the enhanced water mixtures prepared with deionized water shall be determined.
- Samples of enhanced water mixture shall be exposed to a standard light array containing both visible and ultraviolet light for 4-hour and 8-hour periods.
- The consistency of the test sample and a control of the same product shall be measured and the change from the consistency at the beginning of the test shall be determined.
- 4.6. Open Cup Flash and Fire Point (STP-1.7).** As required in 3.4.4, the open cup flash point and the fire point of the wet concentrates 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.
- Enhance water mixtures (covering the requested evaluation range) shall be prepared and applied to a substrate of T1-11 siding that was conditioned at 70 °F and 50-percent relative humidity.
- The samples shall be drained and exposed to the radiant panel immediately.
- Treated and untreated T1-11 siding, in a vertical orientation, shall be exposed to a 40 kW/m² 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 wet concentrate and enhanced water mixtures 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 wet concentrate and enhanced water mixtures shall be determined to the nearest 0.001 g/mL by using fluid displacement or an electronic density meter.
- 4.8.2. Viscosity (STP-4.5).** As required by 3.6.1.2, the wet concentrate shall be tested to determine the viscosity at 70 °F.
- A Brookfield Viscometer model LVF, or equal, set at 60 rpm shall be used to measure the viscosity.
- 4.8.2.1. Steady State Viscosity.** As required by 3.6.2.2, the viscosity of each enhanced water mixture shall be determined in accordance with 4.8.2 at 10 minutes, 20 minutes, 30 minutes, 1 hour, 4 hours, 8 hours, 1 day, and daily for 8 days after mixing.
- Viscosity values shall be graphed against time. The viscosity value corresponding to the plateau of the viscosity curve shall be determined as the steady state viscosity.
- 4.8.3. pH Value Test (STP-4.4).** As required by 3.6.1.3 and 3.6.2.3, the pH of the wet concentrate and enhanced water mixtures of the concentrate shall be determined using 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 wet 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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4.9. Effectiveness Characteristics Tests. As required by 3.7, the concentrates and enhanced water mixtures shall be tested in accordance with 4.9.1 through 4.9.5 to determine their ability to perform over a range of operational conditions.

4.9.1 Miscibility (STP-8.6). As required by 3.7.1, the ease of mixing concentrate with water at temperatures shown in the table shall be determined as summarized below.

The current test method will not work to assess all products. Modifications based on the same concept are in progress.

Tests Conditions for Miscibility of Water Enhancer 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

A prescribed stirring attachment, Figure 1, based on the optimum mixing method shall be inserted in 500 milliliters of water as specified in 4.9.1.1 through 4.1.5.3 at the specified temperature.

The stirrer speed shall be adjusted to the lowest available setting.

The volume of concentrate required to prepare the highest mix ratio in 500 milliliters of water shall be quickly added, with stirring.

After a brief, prescribed, mixing time, the mixer 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 prescribed time, 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.

- 4.9.1.1. Deionized Water at 70 °F.** As required by 3.7.1.1, the miscibility test shall be performed using deionized water at 70 °F.
- 4.9.1.2. Fresh Water at 70°F.** As required by 3.7.1.2, the miscibility test shall be performed using fresh water at 70 °F.
- 4.9.1.3. Artificial Sea Water at 70°F.** As required by 3.7.1.3, the miscibility test shall be performed using artificial sea water at 70 °F.

Figure 1. Stirring attachment for miscibility tests.

- 4.9.2** **Fuel Retention of Enhanced Water Mixtures (STP-9.1).** As required by 3.7.2, the ability of the enhanced water mixtures to remain on horizontal and vertical surfaces shall be determined.
- A simple dowel tree, suspended from a support stand on a balance, shall be arranged so that the tree is suspended beyond the edge of the balance.
- The weight of the tree and support stand shall be recorded.
- The viscosity (or other consistency measure) of the enhanced water mixture shall be measured and recorded.
- The bottom 4 inches (10.2 cm) of the tree shall be immersed in the enhanced water mixture for 60 seconds.
- The tree shall be removed and the weight of the dowel tree, support stand, and retained enhanced water mixture shall be monitored for 60 minutes.
- The test shall be repeated for all mix ratios and graphs of weight retained versus time shall be prepared.
- 4.9.2.1.** **Fuel Retention of Enhanced Water Mixtures Prepared with Deionized Water at 70 °F.** As required by 3.7.2.1, the fuel retention test shall be performed using deionized water at 70 °F.
- 4.9.2.2.** **Fuel Retention of Enhanced Water Mixtures Prepared with Fresh Water at 70 °F.** As required by 3.7.2.2, the fuel retention test shall be performed using fresh water at 70 °F.
- 4.9.2.3.** **Fuel Retention of Enhanced Water Mixtures Prepared with Artificial Sea Water at 70 °F.** As required by 3.7.2.3, the fuel retention test shall be performed using artificial sea water at 70 °F.
- 4.9.2.4.** **Fuel Retention of Enhanced Water Mixtures Prepared with Fresh Water at 40 °F.** As required by 3.7.2.3, the fuel retention test shall be performed using fresh water at 40 °F.
- 4.9.2.5.** **Fuel Retention of Enhanced Water Mixtures Prepared with Fresh Water at 100 °F.** As required by 3.7.2.3, the fuel retention test shall be performed using fresh water at 100 °F.
- 4.9.2.6.** **Fuel Retention of Enhanced Water Mixtures Prepared with Artificial Sea Water at 40 °F.** As required by 3.7.2.3, the fuel retention test shall be performed using artificial sea water at 40 °F.
- 4.9.2.4.** **Fuel Retention of Enhanced Water Mixtures Prepared with Deionized Water at 70 °F.** As required by 3.7.2.1, the fuel retention test shall be performed using deionized water at 70 °F.
- 4.9.3.** **Evaporation Rate of Enhanced Water Mixtures (STP-9.2).** As required by 3.7.3, the time required for the water contained in the enhanced water mixtures to evaporate under controlled conditions shall be determined.
- A shallow, straight-sided glass or heat-resistant plastic container shall be weighed to the nearest 0.001 gram and the weight recorded.
- The enhanced water mixture shall be added to containers to create a layer having depths of 0.1, 0.25, 0.5 inches (0.25, 0.64, and 1.27 cm) and the weight determined.
- Each container shall be placed in the drying oven, adjusted to 100 °F.
- The weight of each container shall be monitored for 8 hours and a graph of weight loss as a function of time shall be prepared for each sample.
- A graph of weight loss as a function of time shall be prepared.

- 4.9.3.1. Evaporation Rate of Enhanced Water Mixtures Prepared with Deionized Water at 70 °F.** As required by 3.7.3.1, the evaporation rate test shall be performed using deionized water at 70 °F.
- 4.9.3.2. Evaporation Rate of Enhanced Water Mixtures Prepared with Fresh Water at 70 °F.** As required by 3.7.3.1, the evaporation rate test shall be performed using fresh water at 70 °F.
- 4.9.3.3. Evaporation Rate of Enhanced Water Mixtures Prepared with Artificial Sea Water at 70 °F.** As required by 3.7.3.1, the evaporation rate test shall be performed using artificial sea water at 70 °F.
- 4.9.4. Water Retention of Enhanced Water Mixtures (STP-9.3).** As required by 3.7.4, the time required for the water contained in the enhanced water mixtures to drain out under controlled conditions shall be determined as summarized below.
- The weight of a shallow pan, approximately 8 in x 10 in (20.3 cm x 25.4 cm), shall be determined and recorded.
- A disposable furnace filter screen shall be placed over the pan and the combined weight of the pan and screen determined and recorded.
- A sample of enhanced water mixture shall be prepared, as established for optimum mixing, with deionized water and used to fill a disposable container, approximately 175 mL, with a hole in the bottom. The hole shall be blocked during filling.
- The container and freshly prepared sample shall be inverted on the screen in one motion and the hole opened.
- The container shall be removed, the weight of pan, screen, and sample noted, and the pile of enhanced water mixture measured to determine height and diameter at the base.
- The total weight of the pan, screen, and sample shall be determined and recorded 5 minutes after mixing the sample.
- The screen shall be lifted and the pan and drained liquid weighed and recorded. Changes in the diameter and height of the pile of enhanced water mixture on the screen shall be noted at the same time.
- The weighing step shall be repeated at prescribed intervals for 4 to 8 hours. Changes in the diameter and height of the pile of enhanced water mixture on the screen shall be noted at the same time.
- 4.9.4.1. Water Retention of Enhanced Water Mixtures Prepared with Deionized Water at 70 °F.** As required by 3.7.4.1, the water retention test shall be performed using deionized water at 70 °F.
- 4.9.4.2. Water Retention of Enhanced Water Mixtures Prepared with Fresh Water at 70 °F.** As required by 3.7.4.2, the water retention test shall be performed using fresh water at 70 °F.
- 4.9.4.3. Water Retention of Enhanced Water Mixtures Prepared with Artificial Sea Water at 70 °F.** As required by 3.7.4.3, the water retention test shall be performed using artificial sea water at 70 °F.

- 4.9.5. Consistency of Enhanced Water Mixtures (STP-).** As required by 3.7.5, the enhanced water mixture, prepared according to the established laboratory mixing procedure, using the waters described in 4.9.5.1 through 4.9.5.6 shall be tested to determine their consistency under controlled conditions as summarized below.
- The gate of the leveled consistometer shall be closed and the reservoir filled with the test material.
- The gate shall be released and the distance the material flows in 10 seconds, 30 seconds, 60 seconds, and 5 minutes shall be determined.
- At least three measurements shall be taken and an average calculated.
- 4.9.5.1. Consistency of Enhanced Water Mixtures Prepared with Deionized Water at 70 °F.** As required by 3.7.5.1, the consistency test shall be performed using deionized water at 70 °F.
- 4.9.5.2. Consistency of Enhanced Water Mixtures Prepared with Fresh Water at 70 °F.** As required by 3.7.5.2, the consistency test shall be performed using fresh water at 70 °F.
- 4.9.5.3. Consistency of Enhanced Water Mixtures Prepared with Artificial Sea Water at 70 °F.** As required by 3.7.5.3, the consistency test shall be performed using artificial sea water at 70 °F.
- 4.9.5.4. Consistency of Enhanced Water Mixtures Prepared with Fresh Water at 40 °F.** As required by 3.7.5.4, the consistency test shall be performed using fresh water at 40 °F.
- 4.9.5.5. Consistency of Enhanced Water Mixtures Prepared with Fresh Water at 100 °F.** As required by 3.7.5.5, the consistency test shall be performed using fresh water at 100 °F.
- 4.9.5.6. Consistency of Enhanced Water Mixtures Prepared with Artificial Sea Water at 40 °F.** As required by 3.7.5.6, the consistency test shall be performed using artificial sea water at 40 °F.
- 4.9.6. Modified Marsh Funnel Flow-Through Time of Enhanced Water Mixtures (STP-4.6).** As required by 3.7.6, the enhanced water mixtures, prepared according to the established laboratory mixing procedure, using the waters described in 4.9.6.1 through 4.9.6.6 shall be tested. to determine the flow-through time, from the modified Marsh Funnel as summarized below.
- The prescribed orifice shall be inserted into the Marsh funnel.
- The orifice shall be covered and the funnel filled to the screen.
- The time for 1 quart (946 mL) of enhanced water mixture to flow through the funnel shall be determined.
- At least three measurements shall be taken and the average calculated.
- 4.9.6.1. Modified Marsh Funnel Flow-Through Time of Enhanced Water Mixtures Prepared with Deionized Water at 70 °F.** As required by 3.7.6.1, the Marsh funnel test shall be performed using deionized water at 70 °F.
- 4.9.6.2. Modified Marsh Funnel Flow-Through Time of Enhanced Water Mixtures Prepared with Fresh Water at 70 °F.** As required by 3.7.6.2, the Marsh funnel test shall be performed using fresh water at 70 °F.
- 4.9.6.3. Modified Marsh Funnel Flow-Through Time of Enhanced Water Mixtures Prepared with Artificial Sea Water at 70 °F.** As required by 3.7.6.3, the Marsh funnel test shall be performed using artificial sea water at 70 °F.

- 4.9.6.4. Modified Marsh Funnel Flow-Through Time of Enhanced Water Mixtures Prepared with Fresh Water at 40 °F.** As required by 3.7.6.4, the Marsh funnel test shall be performed using fresh water at 40 °F.
- 4.9.6.5. Modified Marsh Funnel Flow-Through Time of Enhanced Water Mixtures Prepared with Fresh Water at 100 °F.** As required by 3.7.6.5, the Marsh funnel test shall be performed using fresh water at 100 °F.
- 4.9.6.6. Modified Marsh Funnel Flow-Through Time of Enhanced Water Mixtures Prepared with Artificial Sea Water at 40 °F.** As required by 3.7.6.6, the Marsh funnel test shall be performed using artificial sea water at 40 °F.
- 4.10. Material Effects Tests.** As required by 3.8.1 through 3.8.3, the effects of wet concentrates and enhanced water mixtures on metallic and non-metallic materials shall be determined in accordance with 4.10.1 through 4.10.3.
- 4.10.1. Uniform Corrosion (STP-5.1).** As required by 3.8.1, the wet concentrate and enhanced water mixtures, prepared with fresh water, of all concentrates shall be tested for uniform corrosion 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 (STP-5.2).** As required by 3.8.2, enhanced water mixtures shall be tested for intergranular corrosion as summarized below.
- At least one coupon for each exposure and temperature from the uniform corrosion tests on the specified alloys shall be sliced as shown in Figure 2.
- 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.

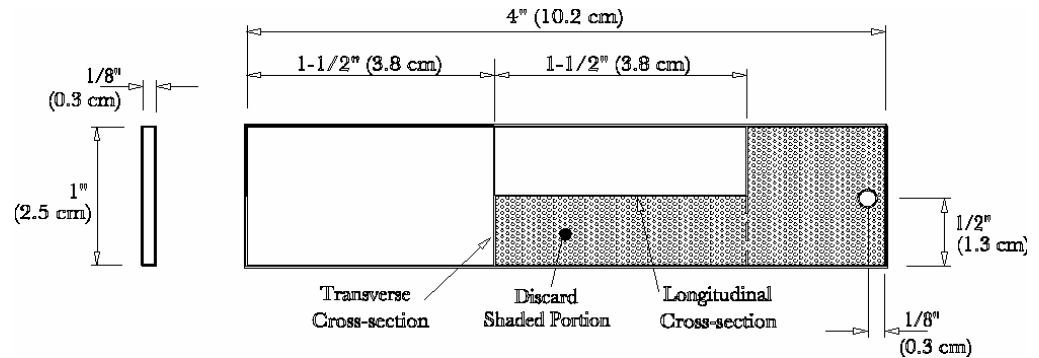


Figure 2. Diagram for cutting and examining coupons for intergranular corrosion.

4.10.3. Effect of Wet Concentrates and Enhanced Water Mixtures on Non-Metallic Materials STP-5.3. In accordance with 3.8.3, the wet concentrate and enhanced water mixtures 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, with the prescribed scale, 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 performance.

4.11. Product Stability Test (STP-6). As required by 3.9, all concentrates and enhanced water mixtures shall be tested for product stability in accordance with 4.11.1 through 4.11.5.

4.11.1. Outdoor Storage Test (STP-6.1). As required by 3.9.1, all concentrates and enhanced water mixtures shall be tested to determine storage characteristics in outdoor weather conditions.

4.11.1.1. Concentrates. Each water enhancer concentrate shall be evaluated to determine outdoor stability in accordance with 4.11.1.1.1 or 4.11.1.1.2.

4.11.1.1.1. Dry Concentrates. As required by 3.9.1.1.1, each dry 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 fluidity, presence or absence of lumps, the ease of crumbling the lumps, or visually separate layers.

The fresh concentrate shall then be stored, shielded from light, in large sample containers outdoors at MTDC-WFCS and San Dimas Technology and Development Center (SDTDC) for 52 weeks.

At the end of the 52 week storage period, the samples shall be examined visually to determine that there are no changes in the general condition, such as fluidity and/or presence of hard lumps, from the original sample.

As required by 3.9.1.1.3, the stored concentrate shall be used to prepare enhanced water mixture in accordance with 4.11.1.1.3.

4.11.1.1.2. Wet Concentrates. As required by 3.9.1.1.2, each wet concentrate shall be evaluated for outdoor stability.

The initial condition of the fresh concentrate shall be documented 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, shielded from light, in a large sample container, outdoors at MTDC-WFCS and SDTDC for 52 weeks.

At the end of the 52 week storage period, the sample shall be inspected to determine that there are no changes in the general condition of the concentrate and then tested as required in 3.9.1.1.2.

As required by 3.9.1.1.3, the stored concentrate shall be circulated and used to prepare enhanced water mixtures in accordance with 4.11.1.1.3.

4.11.1.1.3. Mixed Product from Stored Concentrate. As required by 3.9.1.1.3, the mixed product shall be prepared using the method determined in 4.2.

As required by 3.9.1.1.4 and 3.9.1.1.5, mixed product shall be prepared from stored concentrate and deionized water and tested to determine the physical properties and effectiveness characteristics listed.

Physical properties: density, pH, viscosity

Effectiveness characteristics: fuel retention, consistency, modified Marsh funnel flow-through time

As required by 3.9.1.1.6 and 3.9.1.1.7, mixed product shall be prepared from stored concentrate and fresh water and tested to determine the outdoor stability and corrosivity of the enhanced water mixture from stored concentrate.

- 4.11.1.2. Mixed Products.** As required by 3.9.1.2, the enhanced water mixtures shall be stored, shielded from light, in large sample containers, each containing a large aluminum stability coupon outdoors at MTDC-WFCS and SDTDC.
- During the 14-day storage period, the sample shall be visually inspected at 7 and 14 days and any visual changes noted.
- At the end of the storage period, the carboy shall be opened and the stored product mixed for 1 minute at low shear (1800 rpm with 2-bladed propeller-type stirrer).
- As required by 3.9.1.2.1 and 3.9.1.2.2, the mixed sample shall be tested to determine the physical properties and effectiveness characteristics listed.
- Physical properties: density, pH, viscosity
Effectiveness characteristics: fuel retention, consistency, modified Marsh funnel flow-through time
- 4.11.2. Temperature Cycling Test.** As required by 3.9.2, small sample containers containing 800-mL samples of the wet concentrate shall be examined visually 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 samples shall be determined in accordance with 4.8.1 through 4.8.3.
- As required by 3.8.2.1, the concentrate shall be used to prepare the enhanced water mixture and tested 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 Enhanced Water Mixtures Prepared from Temperature-Cycled Concentrate.** As required by 3.9.2.1, the temperature-cycled, wet concentrate shall be used to prepare enhanced water mixtures in deionized water and tested to determine the physical properties and effectiveness characteristics listed.
Physical properties: density, pH, viscosity
Effectiveness characteristics: fuel retention, consistency, modified Marsh funnel flow-through time
- 4.11.4. Resistance to Microbial Growth Test (STP-6.4).** As required by 3.9.3, the enhanced water mixture shall be tested, observed, and assessed for microbial contamination.
A small sample container containing 800 mL of an enhanced water mixture 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 Temperature on Viscosity of the Wet Concentrate.** As required by 3.9.4, the wet concentrate shall be tested to determine the effect of temperature on the concentrate viscosity.
Small sample container containing 800 mL of wet concentrate shall be stored at 35 °F, 40 °F, 70 °F, and 100 °F until the concentrate is at the required temperature.
Each sample shall be tested to determine the viscosity.
The changes that occur with changes in concentrate temperature shall be determined.
- 4.12. Visibility Tests (STP-10).** As required by 3.10, and at the fire chemical manufacturer's expense, the uncolored and fugitive colored enhanced water mixtures shall be tested to determine the visibility of the mixed products.
- 4.12.1. Laboratory Visibility Test of Fugitive-Colored Enhanced Water Mixtures (STP-10.1).** As required by 3.10.2, the enhanced water mixture shall be tested to determine the opacity and fading characteristics of the fugitive-colored mixture.
- 4.12.1.1. Preparation of the Test Panels.** The fugitive-colored product and the product without color, as a control, shall be used to prepare the test panels.
Five test panels of plate glass shall be treated by applying a 0.064 inch (4 GPC) thick layer of the test product with a Gardner knife or equivalent.
Five control panels shall be treated in the same manner with the uncolored product.
- 4.12.1.2. Opacity of the Enhanced Water Mixture (STP-10.2).** As required by 3.10.2.1, the opacity of the enhanced water mixture film on the glass panel shall be determined immediately after application and again after 24 hours.

- 4.12.1.3. Light Exposure of the Enhanced Water Mixture.** The test and control panels shall be exposed outdoors to natural light at a test facility acceptable to the Forest Service.
- All exposures shall be performed in accordance with ASTM G-24 (Standard Recommended Practice for conducting Natural Light Exposures) until 50,000 Langleys are accumulated.
- Visual observations and photographic records shall be made after each 10,000 Langleys of exposure.
- At the end of the exposure period, the test panels shall be returned to the laboratory for final assessment in accordance with 4.12.1.4.
- 4.12.1.4. Assessment of Fading.** As required by 3.10.2.2, the acceptability of fading of the test panels shall be assessed.
- The outer edges of the film shall not be considered during the assessment. This area, the outer edge of the film, approximately 1 in (2.5 cm), shall be removed or masked.
- Each panel shall be examined and the appearance of the film shall be compared with the appearance of the control panels.
- The appearance of the panels with the test material shall be neutral in color and not significantly different from the appearance of the control material.
- 4.12.2. Field Evaluation of Product Visibility (STP-10.3).** As required by 3.10.3, the uncolored and fugitive colored enhanced water mixtures shall be tested for visibility on a variety of fuel types and conditions (slope, aspect, daylight conditions, and weather).
- An experienced observer team, in the air at 2500 feet (762 meters), directly overhead, and on the ground, shall evaluate the visibility of each product applied by air dropping or ground tanker application depending on manufacturer's designated use.
- 4.13. Air Drop Characteristics (STP-9).** As required by 3.11, and as deemed necessary by the Forest Service, the enhanced water mixture shall be tested to determine the air drop characteristics.
- 4.14. Operational Field Evaluation (STP-12).** As required by 3.12, the Forest Service shall undertake an analysis to address any concerns arising from the nature of the formulations and/or results of the laboratory evaluation.
- The laboratory testing shall be completed prior to conducting an operational field evaluation. When an operational field evaluation is needed, a test plan will be developed.
- The evaluation will be conducted in accordance with the developed test plan. Detailed test methods are described in Standard Test Procedures for the Evaluation of Wildland Fire Chemical Products.
- 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 will 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 shall 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 will be issued in writing by the National Director, Fire and Aviation Management, USDA Forest Service.
- 5.2.1. 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.
- 5.2.2. 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 ≥ 60 -percent biodegraded within 28 days is considered to be readily biodegradable.
- **Biodegradable.** A product which is not ≥ 60 -percent biodegraded within 28 days but which is ≥ 60 -percent biodegraded by 42 days is considered to be biodegradable.
- **Not Biodegradable.** A product which is not ≥ 60 -percent biodegraded by 42 days is considered to be not biodegradable.

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.

Mixed product shall be prepared by mixing a single component with water; except that in the case of enhanced water mixtures colored products may be prepared either by mixing a single component with water or by mixing an uncolored single component and a single color component with water.

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.

Coupon, Large. 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. 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.

Dry Concentrate. A dry, single component which is mixed with water to prepare the mixed product.

Enhanced Water Mixture. A wet or dry water enhancer concentrate, mixed with water at a qualified mix ratio.

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

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.

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

Fugitive Color. A coloring agent which imparts a high degree of visibility to the mixed product when first applied to wildland fuels but will gradually disappear over several months.

Hydration. The action of a combination of concentrate with water required to produce a thickened product.

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.

LC₅₀. 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.

LD₅₀. 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 Bakelite® screw cap, 89 mm diameter with vinyl-backed fiber liner.

Steady State Viscosity. The viscosity after hydration is complete and viscosity is stable,

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 tap water.

Water Enhancer Concentrate. A concentrate that is added to water to enhance one or more of the physical characteristics of water such as changing the viscosity or elasticity of the water or improving the ability to cling to smooth or vertical surfaces.

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

7. **SOURCES FOR OBTAINING 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/water-en.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 Procedures for Qualification Testing of Water Enhancer 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.