NFPA® 18A

Standard on Water Additives for Fire Control and Vapor Mitigation

2011 Edition

NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
An International Codes and Standards Organization

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NFPA® 18A

Standard on

Water Additives for Fire Control and Vapor Mitigation

2011 Edition

This edition of NFPA 18A, *Standard on Water Additives for Fire Control and Vapor Mitigation,* was prepared by the Technical Committee on Water Additives for Fire Control and Vapor Mitigation. It was issued by the Standards Council on December 14, 2010, with an effective date of January 3, 2011, and supersedes all previous editions.

This edition of NFPA 18A was approved as an American National Standard on January 3, 2011.

Origin and Development of NFPA 18A

In 1998, the NFPA Standards Council approved the formation of the Technical Committee on Water Additives for Fire Control and Vapor Mitigation. The committee was tasked with having primary responsibility for documents on the manufacture, testing, application, and use of water additives for the control and/or suppression of fire and flammable vapor mitigation, including water additives used to prevent or reduce the spread of fire and the use of water additives in fixed, semi-fixed, mobile, and portable fire suppression systems. The standard they were given was NFPA 18, *Wetting Agents*.

Initially, the committee proposed to combine wetting agents and water additives under one standard. This effort was returned to the committee by Association action in June 2003. As a result, the committee decided to divide this work into two subject areas and standards, retaining and revising NFPA 18 and creating a new standard addressing water additives, NFPA 18A, the first edition of which was issued in 2007.

Changes in the 2011 edition include a reorganization of Chapters 5 and 6, clarification of test procedures and criteria, and the removal of secondary (U.S.) units throughout much of the text.

Technical Committee on Water Additives for Fire Control and Vapor Mitigation

Armand V. Brandao, *Chair*
FM Approvals, MA [I]

Michael T. Greiner, *Secretary*
Hazard Control Technologies, Inc., GA [M]

Dominic J. Colletti, Hale Products, Inc., PA [M]
Rep. Fire Apparatus Manufacturers Association
James M. Figueira, Environmental Chemical Solutions, CA [M]
Charles W. George, IFSC Consultants, MT [SE]
Cecilia W. Johnson, U.S.D.A. Forest Service, MT [RT]
Blake M. Shugarman, Underwriters Laboratories Inc., IL [RT]
Stanley R. Tarnowski, FIRESAFE Consulting Group, GA [SE]
Robert E. Tinsley, Jr., Pyrocool Technologies, Inc., VA [M]
Larry Vandersall, Lawdon Fire Services, Inc., CA [SE]
Rep. TC on Forest and Rural Fire Protection

Alternates

Bob R. Carter, Hazard Control Technologies Canada, Canada [M]
(Alt. to M. T. Greiner)
Gerald J. Halpin III, CET Fire Pumps Manufacturing, Canada [M]
(Alt. to D. J. Colletti)
George Unger, Underwriters' Laboratories of Canada, Canada [RT]
(Alt. to B. M. Shugarman)
Bennie Vincent, FM Global, MA [I]
(Alt. to A. V. Brandao)

Richard P. Bielen, NFPA Staff Liaison

This list represents the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.

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

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

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex E. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Changes other than editorial are indicated by a vertical rule beside the paragraph, table, or figure in which the change occurred. These rules are included as an aid to the user in identifying changes from the previous edition. Where one or more complete paragraphs have been deleted, the deletion is indicated by a bullet (•) between the paragraphs that remain.

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

Chapter 1 Administration

1.1 Scope. This standard provides the minimum requirements for water additives used for the control and/or suppression of Class A and Class B fires and the mitigation of flammable vapors.

1.2 Purpose. This standard is intended for the use and guidance of those responsible for purchasing, testing, listing, and using water additives for use on fires in Class A and Class B fuels.

1.3* Application. This standard applies to water additives utilized in preventing or reducing the spread of fire in Class A and Class B fuels.

1.4 Retroactivity. The provisions of this standard reflect a consensus of what is necessary to provide an acceptable degree of protection from the hazards addressed in this standard at the time the standard was issued.

1.4.1 Unless otherwise specified, the provisions of this standard shall not apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the standard. Where specified, the provisions of this standard shall be retroactive.

1.4.2 In those cases where the authority having jurisdiction determines that the existing situation presents an unacceptable degree of risk, the authority having jurisdiction shall be permitted to apply retroactively any portions of this standard deemed appropriate.

1.4.3 The retroactive requirements of this standard shall be permitted to be modified if their application clearly would be impractical in the judgment of the authority having jurisdiction and only where it is clearly evident that a reasonable degree of safety is provided.

1.5 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard.

1.5.1 Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1.5.2 The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

1.6 Units and Formulas. The primary system of measurement for this standard is the International System of Units (SI). Inch-pound units are provided where necessary and applicable.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

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

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2010 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 2010 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 2007 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 2011 edition.

NFPA 1901, *Standard for Automotive Fire Apparatus,* 2009 edition.

2.3 Other Publications.

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

ASTM D 92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester,* 2005a.

ASTM D 97, *Standard Test Method for Pour Point of Petroleum Products*, 2002.

ASTM D 1293, *Standard Test Methods for pH of Water*, 1999 (2005).

ASTM D 2196, *Standard Test Methods for Rheological Properties of Non-Newtonian Materials by Rotational (Brookfield type) Viscometer*, 2010.

ASTM D 2240, *Standard Test Method for Rubber Property — Durometer Hardness*, 2005.

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

ASTM G 1, *Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens,* 2003.

ASTM G 31, *Standard Practice for Laboratory Immersion Corrosion Testing of Metals,* 1972 (2004).

2.3.2 ISO Publications. International Organization for Standardization, 1 rue de Varembé, Case postale 56, CH-1211, Genève 20, Switzerland.

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories,* 2005.

2.3.3 NACE Publications. NACE International, 1440 South Creek Drive, Houston, TX 77084-4906.

NACE TM0169, *Standard Test Method — Laboratory Corrosion Testing of Metals*, 2000.

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

UL 162, *Foam Equipment and Liquid Concentrates*, 1994, revised 1999.

ANSI/UL 711/CAN/ULC S508, *Rating and Fire Testing of Fire Extinguishers*, 2004, revised 2009.

2.3.5 ULC Publications. Underwriters' Laboratories of Canada, 7 Underwriters Road, Toronto ON M1R 3B4.

CAN/ULC S560, *Category 3 Aqueous Film-Forming Foam (AFFF) Liquid Concentrates*, 2006.

2.3.6 U.S. EPA Publications. Environmental Protection Agency, National Service Center for Environmental Publications (NSCEP), P.O. Box 42419, Cincinnati, OH 45242.

OPPTS 835.3110, *Ready Biodegradability*, Section M, CO_2 *Evolution (Modified Sturm) Test,* Fate, Transport and Transformation Test Guidelines, January 1998.

OPPTS 850.1075, *Fish Acute Toxicity Test, Freshwater and Marine,* Ecological Effects Test Guidelines, 1996.

OPPTS 870.1100, *Acute Oral Toxicity,* Health Effects Test Guidelines, 1998.

OPPTS 870.1200, *Acute Dermal Toxicity,* Health Effects Test Guidelines, 1998.

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

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

2.3.7 U.S. Government Publications. U.S. Government Printing Office, Washington, DC 20402.

Title 40, Code of Federal Regulations, Part 86.113-94, Air Programs, "Fuel Specifications."

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

Title 40, Code of Federal Regulations, Part 792, Toxic Substances Control Act, "Good Laboratory Practice."

● **2.3.8 Other Publications.**

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

2.4 References for Extracts in Mandatory Sections.

NFPA 10, *Standard for Portable Fire Extinguishers,* 2010 edition.

NFPA 36, *Standard for Solvent Extraction Plants,* 2009 edition.

NFPA 1145, *Guide for the Use of Class A Foams in Manual Structural Fire Fighting,* 2011 edition.

NFPA 1150, *Standard on Foam Chemicals for Fires in Class A Fuels,* 2010 edition.

Chapter 3 Definitions

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

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

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

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

3.2.5 Shall. Indicates a mandatory requirement.

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

3.3 General Definitions.

3.3.1 Application Rate. Amount of water additive solution applied over a specified period of time.

3.3.2 Biodegradability. A measure of the decomposition of organic matter through the action of microorganisms. [**1150**, 2010]

3.3.3 Class A Fire. A fire in ordinary combustible materials, such as wood, cloth, paper, rubber, and many plastics. [**10**, 2010]

3.3.4* Class B Fire. A fire in flammable liquids, combustible liquids, petroleum greases, tars, oils, oil-based paints, solvents, lacquers, alcohols, and flammable gases. [**10**, 2010]

3.3.5 Combustible Liquid. Any liquid that has a closed-cup flash point at or above 37.8°C.

3.3.6* Concentration. The percent of water additive concentrate contained in a water additive solution.

3.3.7* Demulsification. A process either physical or chemical by which an emulsion is broken down to its original constituents.

3.3.8* Discharge Device. A device designed to discharge water or foam–water solution or water additive solution in a predetermined, fixed, or adjustable pattern.

3.3.9 Eductor (Inductor). A device that uses the Venturi principle to introduce a proportionate quantity of water additive concentrate into a water stream; the pressure at the throat is below atmospheric pressure and will draw in liquid from atmospheric storage.

3.3.10 Emulsification. The process of forming an emulsion. *(See also 3.3.12, Emulsion.)*

3.3.11 Emulsifier. A chemical or mixture of chemicals that along with some energy input promotes the formation of an emulsion.

3.3.12* Emulsion. A heterogeneous system, consisting of at least one immiscible liquid dispersed in another in the form of droplets.

3.3.13* Fixed Monitor (Cannon). A device that delivers a large water additive solution stream and is mounted on a stationary support that either is elevated or is at grade.

3.3.14 Flammable Liquid. A liquid that has a closed-cup flash point that is below 37.8°C and a maximum vapor pressure of 2068 mm Hg at 37.8°C.

3.3.15* Handline. A hose and nozzle that can be held and directed by hand.

3.3.16 Hydrocarbon. A chemical substance consisting of only hydrogen and carbon atoms. [**36**, 2009]

3.3.17 Indirect Attack. Fire-fighting operations involving the application of extinguishing agents to reduce the buildup of heat released from a fire without applying the agent directly onto the burning fuel. [**1145**, 2011]

3.3.18 LC_{50} (Lethal Concentration$_{50}$). The concentration of agent in water, usually expressed as milligrams of agent in a liter or solution, that results in the death of 50 percent of the aquatic test specimens within a specified time frame. [**1150**, 2010]

3.3.19 LD_{50} (Lethal Dosage$_{50}$). The dosage of a chemical, usually expressed as milligrams of the chemical per kilogram of body weight of the test animal, at which 50 percent of the test animals die within a specified time frame. [**1150**, 2010]

3.3.20* Micelle. The basic building unit of an emulsion.

3.3.21 Miscibility. The property of being capable of mixing in any ratio without separation into phases. [**1150**, 2010]

3.3.22 Portable Monitor (Cannon). A device that delivers a large water additive solution stream and is mounted on a movable support or wheels so it can be transported to the fire scene.

3.3.23 Proportioning. The introduction of water additive concentrate at the recommended ratio into the water stream to form a water additive solution.

3.3.24 Surface Active Agent (Surfactant). A chemical agent that materially reduces the surface tension of water.

3.3.25 Surface Tension. The elastic-like force at the surface of a liquid, which tends to minimize the surface area, causing drops to form. [**1150**, 2010]

3.3.26 Synthetic or Artificial Sea Water. A solution consisting of 1.10 percent magnesium chloride hexahydrate, 0.16 percent calcium chloride dihydrate, 0.40 percent anhydrous sodium sulfate, 2.50 percent sodium chloride, and 95.84 percent deionized or distilled water.

3.3.27 Three-Dimensional Fire. A liquid fuel fire that flows freely from a vertical height, falling on associated equipment or structure down to a static pooled surface fire.

3.3.28* Water Additive. An agent that, when added to water in proper quantities, suppresses, cools, mitigates fire and/or vapors, and/or provides insulating properties for fuels exposed to radiant heat or direct flame impingement.

3.3.29* Water Additive Concentrate. The chemical or chemical composition as received from the manufacturer.

3.3.30* Water Additive Solution. A homogeneous mixture of water and water additive concentrate.

Chapter 4 Uses and Limitations

4.1 General.

4.1.1 Water additive concentrate for fire fighting shall be listed and approved by the authority having jurisdiction.

4.1.2 Water additive concentrate shall be mixed only with water.

4.2 Limitations.

4.2.1 General. The use of water additive solution shall be limited to those applications identified by the manufacturer's listing and Section 4.2.

4.2.2 Water-Reactive Chemicals. Water additive solution shall have the same limitations as water with respect to extinguishing fires involving chemicals that react with water to create additional hazards.

4.2.3 Class B Fires.

4.2.3.1 The use of water additive solution for the extinguishment of fires involving Class B flammable or combustible liquids shall be limited to those fuels not soluble in water.

4.2.3.2* The use of fire extinguishers and fixed fire-extinguishing systems using water additive solution shall not be permitted for the extinguishment of fires in commercial cooking equipment that involve combustible cooking media (vegetable or animal oils and fats) unless specifically listed for this hazard.

4.2.4* Class C Fires. Water additive solution shall have the same limitations as water with respect to extinguishing fires involving energized electrical equipment.

4.2.5* Class D Fires. Water additive solution shall not be used on Class D fires unless specifically listed for that purpose.

4.3* Compatibility of Water Additive Concentrate and Solutions.

4.3.1 Water additive concentrate of different brands and other types of concentrate intended for fire prevention, control, suppression, extinguishment, or vapor mitigation shall not be mixed.

4.3.2 Premixed solution prepared with water additive concentrate of different brands and premixed solution prepared with other types of concentrate intended for fire prevention, control, suppression, extinguishment, or vapor mitigation shall not be mixed within the same storage container.

4.3.3 Solution generated separately with water additive concentrate of different brands shall be permitted to be applied to a fire in sequence or simultaneously.

4.3.4 Solution generated with water additive concentrate and solution generated with other types of concentrate intended for fire prevention, control, suppression, extinguishment, or vapor mitigation shall be permitted to be applied to a fire in sequence or simultaneously if approved by the authority having jurisdiction.

4.4 Concentrations. Water additive solution shall be used only in concentrations specified by their listing.

Chapter 5 Properties and General Test Protocols for Evaluation of Water Additive Concentrate and Solution

5.1 General.

5.1.1 Water additive concentrate and water additive solution prepared at the concentrations specified for use by the manufacturer shall be subjected to the tests in this chapter.

5.1.2 The tests detailed in this chapter shall be conducted by an approved independent laboratory using laboratory practices in accordance with 40 CFR 160 and 40 CFR 792 and calibration competency in accordance with ISO/IEC 17025, or equivalent as applicable.

5.1.3 The information developed in response to the requirements of this chapter shall be reported on the manufacturer's technical data sheet and made available to potential users.

5.2 Toxicity and Environmental Tests.

5.2.1 Mammalian Toxicity.

5.2.1.1 Water additive concentrates and water additive solution prepared at the maximum concentration specified for use by the manufacturer shall be tested in accordance with the following U.S. EPA OPPTS tests or an equivalent test procedure that is recognized by the authority having jurisdiction where the water additive is to be used:

(1) OPPTS 870.1100, for acute oral toxicity
(2) OPPTS 870.1200, for acute dermal toxicity
(3) OPPTS 870.2400, for acute eye irritation
(4) OPPTS 870.2500, for acute dermal irritation

5.2.1.2* The water additive concentrate and water additive solution prepared at the maximum concentration specified for use by the manufacturer shall not exceed the toxicity limits acceptable to the authority having jurisdiction.

5.2.2 Aquatic Toxicity.

5.2.2.1 Water additive concentrates and water additive solution prepared at the maximum concentration specified for use by the manufacturer shall be tested, using *Oncorhynchus mykiss* (rainbow trout), in accordance with U.S. EPA OPPTS 850.1075, ASTM E 729, or an equivalent test procedure that is recognized by the authority having jurisdiction where the water additive is to be used.

5.2.2.2 In accordance with ASTM E 729, 10 fish that are 60 days ± 15 days posthatch shall be exposed under static conditions to each level of a water additive solution in soft water as defined in ASTM E 729 for 96 hours at 12°C ± 1°C.

5.2.2.3* The water additive concentrate shall have an LC_{50} acceptable to the authority having jurisdiction when tested in accordance with ASTM E 729 and when measured after 96 hours of static exposure.

5.2.3 Biodegradability.

5.2.3.1* The concentrate shall be readily biodegradable or biodegradable when tested in accordance with 5.2.3.2 through 5.2.3.5.

5.2.3.2 The biodegradability of the concentrate shall be determined in accordance with EPA OPPTS 835.3110 Section M, CO_2 evolution test (modified Sturm test) or equivalent test recognized by the authority having jurisdiction.

5.2.3.3 Testing shall be conducted for a minimum of 28 days and shall be continued until an oxygen depletion plateau is reached.

5.2.3.4 Testing shall be discontinued at the end of 42 days, even if the plateau has not been reached.

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

5.3 Physical Properties.

5.3.1 Concentrate Pour Point. The concentrate pour point shall be determined in accordance with ASTM D 97.

5.3.2 Concentrate Miscibility.

5.3.2.1 The concentrate shall be miscible in water and result in a homogenous solution at the concentrations specified for use by the manufacturer. Opalescence shall be considered equivalent to homogeneity.

5.3.2.2 The concentrate miscibility shall be determined in accordance with 5.3.2.2.1 through 5.3.2.2.9.

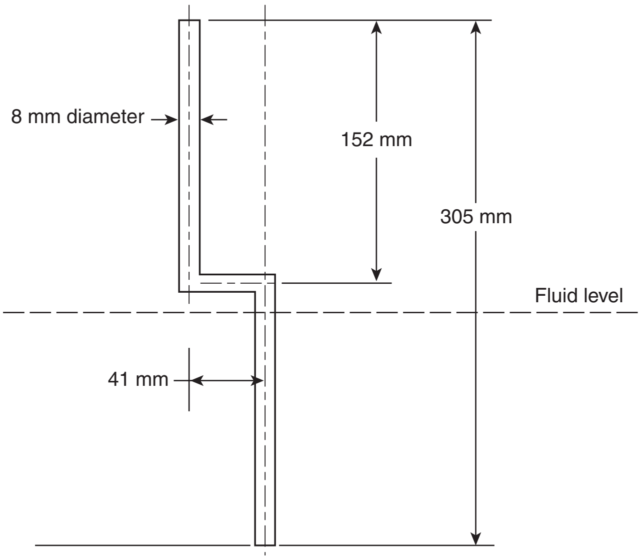
5.3.2.2.1 The water and the concentrate shall be conditioned to each of the temperature combinations shown in Table 5.3.2.2.1.

Table 5.3.2.2.1 Temperature Combinations of Water Additive Concentrates and Water for Miscibility Testing

Water Additive Temperature	Water Temperature
°C	°C
4 ± 1	21 ± 1
21 ± 1	21 ± 1
4 ± 1	4 ± 1
21 ± 1	4 ± 1

5.3.2.2.2 Five hundred milliliters of deionized water conditioned to the test temperature shall be added to a 1 L glass beaker.

5.3.2.2.3 A stirrer, as illustrated in Figure 5.3.2.2.3, shall be inserted into the water to the depth shown in the figure.



Note: All measurements are approximate.

FIGURE 5.3.2.2.3 Stirrer Shaft for Miscibility Test.

5.3.2.2.4 The stirrer motor shall be adjusted to 60 rpm ± 10 rpm.

5.3.2.2.5 The required amount of concentrate conditioned to the test temperature shall be added to the beaker of water within 2 seconds.

5.3.2.2.6 After 10 revolutions of the stirrer, rotation shall be stopped and the liquid shall be visually examined. If the solution is visually homogeneous, the number of revolutions shall be recorded and the result recorded as miscible.

5.3.2.2.7 If the solution is not visually homogeneous, it shall be stirred for an additional 10 revolutions.

5.3.2.2.8 The procedure described in 5.3.2.2.6 and 5.3.2.2.7 shall be repeated until the total number of revolutions is 100 or the solution is visually homogeneous.

5.3.2.2.9 If the solution is not visually homogeneous immediately following 100 revolutions, the results shall be recorded as not miscible.

5.3.3 Concentrate pH. The pH of the concentrate at 18°C ± 2.7°C shall be between 6 and 9 when tested in accordance with ASTM D 1293.

5.3.4 Concentrate Viscosity.

5.3.4.1 The concentrate viscosity shall be determined and reported in terms of absolute viscosity (centipoise).

5.3.4.2 Two samples of concentrate shall be conditioned to temperatures of 2°C, 21°C, and 49°C prior to measuring the viscosity.

5.3.4.3* A viscometer rotating at 60 rpm with the appropriate spindle shall be used to measure the viscosity in accordance with ASTM D 2196.

5.3.4.4 Triplicate measurements of the viscosity of each sample shall be made, with the sample being stirred gently between measurements.

5.3.4.5 The three viscosity measurements for each sample shall be averaged.

5.3.5 Concentrate Flash Point. The open cup flash point of the concentrate shall be determined in accordance with ASTM D 92.

5.4 Stability.

5.4.1 Concentrate Stability.

5.4.1.1 Three 19 L samples of water additive concentrate from a single production lot shall be stored in sealed containers as described in 5.4.1.4, 5.4.1.5, and 5.4.1.6.

5.4.1.2 The samples shall be designated as Sample 1, Sample 2, and Sample 3.

5.4.1.3* Samples shall not be agitated at any time during or between storage periods.

5.4.1.4 Sample 1.

5.4.1.4.1 Sample 1 shall be stored at 41°C ± 3°C for 30 continuous days.

5.4.1.4.2 At the end of 30 days, Sample 1 shall be removed from the 41°C ± 3°C environment and immediately stored at 21°C ± 2°C for 168 hours.

5.4.1.4.3 Sample 1 shall be handled, opened, and inspected in accordance with 5.4.1.7.

5.4.1.5 Sample 2.

5.4.1.5.1 Sample 2 shall be stored at 41°C ± 3°C for 30 continuous days in a manner identical to that for Sample 1.

5.4.1.5.2 At the end of the 30 days, Sample 2 shall be placed immediately in an environment at a temperature of −10°C ± 1°C.

5.4.1.5.3 Sample 2 shall be kept in this cold environment for a continuous 30-day period.

5.4.1.5.4 At the end of the second 30 days, Sample 2 shall be removed from the −10°C ± 1°C environment and then placed immediately in an environment of 21°C ± 2°C for 168 hours.

5.4.1.5.5 Sample 2 then shall be handled, opened, and inspected in accordance with 5.4.1.7.

5.4.1.6 Sample 3.

5.4.1.6.1 Sample 3 shall be stored at −10°C ± 1°C for 30 continuous days.

5.4.1.6.2 At the end of the 30 days, Sample 3 shall be removed from the −10°C ± 1°C environment and immediately placed at a temperature of 21°C ± 2°C for 168 hours.

5.4.1.6.3 Sample 3 shall then be handled, opened, and inspected in accordance with 5.4.1.7.

5.4.1.7 Concentrate Handling, Opening, and Inspection.

5.4.1.7.1 At the end of the storage periods described in 5.4.1.4 through 5.4.1.6, each sealed sample container shall be inverted four times within a 1-minute period.

5.4.1.7.2 Each sample shall be opened and the water additive concentrate poured into an open pail and allowed to sit undisturbed for 10 minutes to allow bubbles to rise to the surface.

5.4.1.7.3 Each sample then shall be visually examined for separation, stratification, and crystallization.

5.4.1.7.4 Each empty container shall be examined as well for any evidence of residual sediment or crystals.

5.4.1.7.5 The water additive concentrate shall not be stratified, crystallized, or otherwise separated at the end of any test outlined in 5.4.1.

5.4.2 Solution Separation on Standing.

5.4.2.1* If the water additive solution is to be stored for more than 30 days, the water additive solution, in concentrations specified for use by the manufacturer, shall display no tendency to stratify or otherwise separate when stored undisturbed for 30 days in a closed container at the minimum and maximum concentrations and at 21°C ± 3°C.

5.4.2.2 The formation of two or more distinct layers or the presence of precipitate occurring during the course of the test shall be considered as separation.

5.5 Uniform Corrosion.

5.5.1 The water additive and its solutions shall not have corrosion rates exceeding those shown in Table 5.5.1 when tested in accordance with Section 5.5.

5.5.2* The concentrate and its solutions at the maximum and minimum use concentrations specified for use by the manufacturer shall be tested to determine the corrosivity to 4130 mild steel, 2024-T3 aluminum, UNS C27000 yellow brass (65 percent copper, 35 percent zinc), and magnesium AZ31B.

5.5.3 Testing of the corrosive effects of water additive concentrate and its solutions prepared at the minimum and maximum concentrations specified for use by the manufacturer shall be conducted in accordance either with NACE Standard Test Method TM0169 or with ASTM G 1 and ASTM G 31 and in accordance with 5.5.4 through 5.5.9.

5.5.4 Test Coupons.

5.5.4.1* Marking and Measurement. Each coupon, 25 mm × 102.6 mm × 3.2 mm, shall be marked by a vibrating engraver with a unique identification code, drilled in the upper center to insert the braided polyester string used to suspend it, and then measured to the nearest 0.01 mm for length, width, and thickness.

5.5.4.2* A minimum of three test coupons of each alloy shall be exposed to each test liquid (the concentrate and its solutions at the maximum and minimum use concentrations specified for use by the manufacturer) and shall be tested at each of the following test conditions:

(1) Total immersion at 21°C ± 2°C
(2) Total immersion at 49°C ± 2°C
(3) Partial immersion at 21°C ± 2°C
(4) Partial immersion at 49°C ± 2°C

Table 5.5.1 Maximum Allowable Corrosion Rates (mils per year) for Wildland Fire Chemical Products

	2024-T3 Aluminum				4130 Steel				Yellow Brass	AZ31B Magnesium			
	Total		Partial		Total		Partial		Partial	Total		Partial	
Temperature (°F)	**70**	**120**	**70**	**120**	**70**	**120**	**70**	**120**	**120**	**70**	**120**	**70**	**120**
	mils per year												
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[1] except 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
Mixed products													
Fixed-tank helicopters[2]	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[3]	2.0	2.0	2.0	2.0	5.0	5.0	5.0	5.0	5.0				
Helicopter bucket and[1] ground-based application	2.0	2.0	2.0	2.0	5.0	5.0	5.0	5.0	5.0				

Note: 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.

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

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

[3] 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.

5.5.5 Cleaning and Drying.

5.5.5.1 Degreased coupons shall not be touched with a bare hand, to prevent contamination by skin oils.

5.5.5.2* Each coupon shall be degreased, rinsed in tap water, and then cleaned chemically as described in Table 5.5.5.2, rinsed in deionized water, wiped to remove the water film, and dried at 50°C to 55°C for 15 to 30 minutes.

5.5.5.3 The coupons shall be cooled to room temperature, weighed to 0.1 mg and the weight recorded, and exposed to the test solution.

5.5.6 Test Set-Up.

5.5.6.1 One coupon shall be suspended by a length of braided Dacron fishing line in a 0.95 L glass jar in such a way that the coupon does not touch the sides or the bottom of the jar.

5.5.6.2 Each jar shall contain 0.8 L of liquid for total immersion tests or 0.4 L of liquid for partial immersion tests.

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

5.5.6.4 For partial immersion tests, the coupon shall be suspended so that 50 percent ± 2.5 mm of its length is exposed to the vapor.

5.5.6.5* Each jar shall be firmly closed with a screw cap, labeled with coupon identification and starting date, and put in an incubator at 21°C or 49°C, depending on the desired test condition.

5.5.7 Test Duration and Completion.

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

5.5.7.2 At the end of the 90-day test period, the coupons shall be removed from the liquid and rinsed under running water to remove loosely attached corrosion products.

5.5.7.3 The coupons shall be lightly scrubbed with a toothbrush or other nonmetallic brush to aid in removal of scale.

5.5.7.4 The coupons shall be cleaned chemically using the same procedures that were used initially in accordance with Table 5.5.5.2.

5.5.7.5 A clean, unused coupon shall be cleaned in the same manner at the same time to serve as a control for weight lost during the cleaning process. The final weight of each coupon shall be determined to 0.1 mg.

5.5.8 Corrosion Rate.

5.5.8.1 The corrosion rate (*Cr*) in mils per year (mpy) shall be calculated for each sample as follows:

$$Cr = 534\frac{Wt_i - Wt_f - Wt_c}{Atp}$$

where:
Cr = corrosion rate (mpy)
Wt_i = initial coupon weight (mg)
Wt_f = final coupon weight (mg)
Wt_c = weight loss of the control (mg)
A = area of the coupon (in.^{2})
t = exposure (hours)
p = density of the alloy [g/cm^3 (lb/in.^{3})] as follows: 4130 steel = 7.86 g/cm^3 (0.28 lb/in.^{3}); yellow brass = 8.53 g/cm^3 (0.3 lb/in.^{3}); 2024-T3 aluminum = 2.77 g/cm^3 (0.1 lb/in.^{3})

5.5.9 Results. Results of replicate tests shall be averaged and rounded to the nearest 0.1 mpy.

5.6 Intergranular Corrosion Test.

5.6.1* There shall be no intergranular corrosion on aluminum 2024-T3 when tested in accordance with 5.6.2 through 5.6.5 if the solution is recommended for application by fixed-wing aircraft and magnesium AZ31B for rotary-wing aircraft.

Table 5.5.5.2 Procedures for Cleaning Corrosion Coupons

Alloy	Cleaning Solution*	Immersion Time (minutes)	Solution Temperature	Remarks
Aluminum	70% HNO_3	2–3	Room temperature	Lightly scrub using nonmetallic brush or scrub pad after immersion. If corrosion film resists cleaning with the HNO_3, alternate with 10-minute immersion in a solution of 2 g CrO_3 and 5 g H_3PO_4 in 93 mL of 80°C to 85°C deionized or distilled water.
Brass	15–20% HCl	2–3	Room temperature	Lightly scrub using nonmetallic brush or scrub pad after immersion. A rubber stopper, Scotch Brite®, or equivalent nonmetallic scourer or scrubber can be used to scrub coupons with hard or severe coating.
Steel	50 g SnCl + 20 g $SbCl_3$ in 1 L conc HCl	3–5	Ice bath	

*Discard cleaning solutions when changing from one product to another and when the cleaning solutions become discolored. Use fresh chemical to clean each magnesium coupon. Exercise care to prevent cross-contamination.
Source: NACE TM0169.

5.6.2 At least one aluminum 2024-T3 coupon for each exposure and temperature condition from the uniform corrosion tests shall be tested for intergranular corrosion.

5.6.3 Each coupon shall be sliced as shown in Figure 5.6.3, mounted, and polished to 0.3 micron alumina finish to make a test specimen.

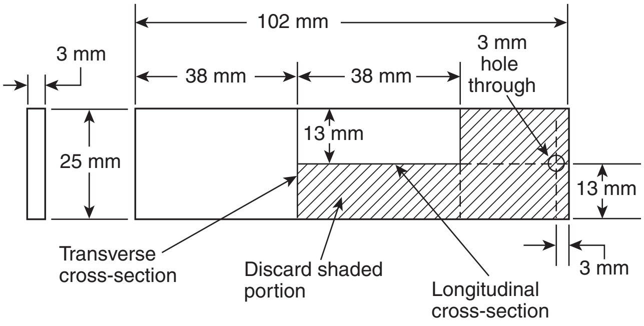


FIGURE 5.6.3 Intergranular Corrosion Test.

5.6.4 Polished aluminum test specimens shall be etched with Keller's reagent, and polished magnesium test specimens shall be etched with Nital reagent using standard metallurgical techniques.

5.6.5 The prepared test specimens shall be examined at a magnification of 500× on the transverse and longitudinal cross-sections.

5.7 Compatibility with Nonmetallic Materials.

5.7.1 General.

5.7.1.1 The effect of water additive concentrate and its solutions on the hardness and volume of the following nonmetallic materials shall be determined in accordance with the following procedure:

(1) PVC plastic CID A-A-55859A Type 1
(2) SAE Aerospace Materials Specification (AMS) S-8802 sealant
(3) MIL-PRF-81733D sealant
(4) Chloroprene rubber SAE AMS, 3208M
(5) SAE AMS C-9084 fiberglass with epoxy resin
(6) High-density polyethylene ASTM D 4976-04
(7) Flexible polyolefin SAE AMS DTL-23053/5

5.7.1.2 The degree of change in hardness and volume of the test piece shall be reported in accordance with Section 5.1.

5.7.2 Sample Exposure Tests.

5.7.2.1 Samples of each test material not previously exposed shall be measured to determine volume and hardness as described in 5.7.3 and 5.7.4 before and after exposure to the water additive concentrate and its solutions as described in 5.7.2.2 through 5.7.2.13.

5.7.2.2 The solutions shall be prepared in accordance with the manufacturer's recommendations.

5.7.2.3 A wide-mouth bottle of nominal 125 mL volume, sealable with a nonmetallic screw cap, shall be used as the test container.

5.7.2.4 A sample of the nonmetallic material having a volume of 10 cm^3 to 20 cm^3 shall be prepared with dimensions chosen so that it can be placed in the test container.

5.7.2.5 The sample shall be placed in the container and the container filled with the test concentrate or solution so that the sample is totally immersed.

5.7.2.6 The test container shall be covered loosely and maintained at 21°C during the test.

5.7.2.7 The sample shall be removed from the concentrate or solution without being wiped, rinsed, or dried and placed on top of the container lid for 8 consecutive hours during each 24-hour period for 5 consecutive days.

5.7.2.8 The container shall be closed during atmospheric exposure of the sample.

5.7.2.9 At the end of each atmospheric exposure period, the sample shall be returned to the test container.

5.7.2.10 At the end of five 24-hour test periods, the sample shall remain in the solution for 48 to 63 hours.

5.7.2.11 This cycle shall be repeated until the sample has been subjected to four cycles at the conditions described in 5.7.2.10.

5.7.2.12 Any lost concentrate or solution shall be replenished during the test period so that the sample is totally immersed when in the test solution.

5.7.2.13 At the end of the test period, the sample shall be removed from the liquid, rinsed with distilled water, and air-dried.

5.7.3 Volume Test.

5.7.3.1 The volume of the sample shall be measured to within 1 cm^3 by liquid displacement before and after exposure to the water additive concentrate and its solutions as described in 5.7.2.

5.7.3.2 Volumes shall be recorded.

5.7.3.3 The change in volume shall be calculated and reported as a percentage of the initial volume.

5.7.3.4 The average of triplicate results shall be reported on the manufacturer's product data sheet.

5.7.4 Hardness Test.

5.7.4.1 The hardness of the samples shall be determined following ASTM D 2240 prior to and following the procedure described in 5.7.2.

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

5.7.4.3 A Shore A2 gauge shall be used for all materials other than fiberglass and high-density polyethylene.

5.7.4.4 The hardness of each sample shall be recorded.

5.7.4.5 The change in hardness shall be calculated and reported on the product data sheet as a percentage of initial hardness.

5.7.4.6 The average of the triplicate results shall be reported.

Chapter 6 Class A Fire Test Methods

6.1 General. Water additive solutions for Class A fuels shall be tested and listed in accordance with all of the following fire test procedures:

(1) Wood panel fire test
(2) Wood crib fire test

6.2 Wood Panel Fire Test.

6.2.1 The ability of water additive solutions to extinguish wood panel fires shall be determined with solution prepared at the minimum concentration specified for use by the manufacturer according to the procedures detailed in this section and in ANSI/UL 711/CAN/ULC S508 for Class A fires utilizing a 4-A wood panel.

6.2.2 The solution shall be applied with a nozzle acceptable to the listing agency at a rate of 19 L/min for 30 seconds, by which time extinguishment shall have been achieved.

6.2.3 Observations shall be continued for 15 minutes following the end of discharge, during which time re-ignition shall not occur.

6.3 Wood Crib Fire Test.

6.3.1 The ability of water additive solution to extinguish wood crib fires shall be determined with solution prepared at the minimum concentration specified for use by the manufacturer according to the procedures detailed in this section and in ANSI/UL 711/CAN/ULC S508 for Class A fires utilizing a 4-A wood crib.

6.3.2 The solution shall be applied with a nozzle acceptable to the listing agency at a rate of 19 L/min for 30 seconds, by which time extinguishment shall have been achieved.

6.3.3 Observations shall be continued for 15 minutes following the end of discharge, during which time re-ignition shall not occur.

Chapter 7 Class B Fire Test Methods

7.1 General. Water additive solutions for Class B fuels shall be tested and listed in accordance with one or more of the following test procedures:

(1) Spill fire test
(2) Pool fire test
(3) Three-dimensional fuel fire test
(4) Polar solvent fire test
(5) Emulsification test
(6) Fuel in depth fire test

7.2* Spill Fire Test.

7.2.1 When tested as described in this section, a water additive prepared at the minimum concentration specified for use by the manufacturer solution shall achieve 100 percent extinguishment in an average of not more than 60 seconds.

7.2.2 The burnback resistance shall be confined to an area of 1.15 m^2 or 25 percent for an average of 180 seconds.

7.2.3 Test Site.

7.2.3.1 The 4.6 m^2 fire test shall be conducted indoors in a level 2.43 m inside diameter pan fabricated from 6 mm thick steel having sides 125 mm high.

7.2.3.2 The pan shall contain 38 L heptane on a substrate of water.

7.2.3.3 The water shall be used only to ensure complete coverage of the pan and shall not exceed 5 mm in depth at the shallowest point of the pan.

7.2.3.4 All fire tests shall be conducted on a surface that is flushed free of fuel and water additive solution from previous tests.

7.2.3.5 The fire test pan shall be cool to the touch before retesting.

7.2.4 Test Equipment.

7.2.4.1 The air-aspirated or non-air-aspirated nozzle or compressed air system, as specified by the manufacturer, shall have a flow rate of 18.9 L/min.

7.2.4.2 When an air-aspirated nozzle or compressed air system is used, foam quality tests shall be conducted and reported in accordance with CAN/ULC S560.

7.2.5 Test Conditions.

7.2.5.1 The temperature of the solution shall be 20°C ± 3°C.

7.2.5.2 The amount of 38 L of commercial grade heptane conforming to UL 162 shall be used.

7.2.5.3 Fuel temperature shall not be less than 10°C.

7.2.5.4 Tests shall be conducted only when the ambient temperature is above 5°C.

7.2.6 Test Procedures.

7.2.6.1 For air-aspirated nozzles and compressed air systems, expansion and drainage testing as described in CAN/ULC S560 shall be conducted prior to initiation of fire testing to confirm equipment functionality.

7.2.6.2 Tests shall be conducted and reported using a solution of water additive liquid concentrate, as received, in freshwater and in synthetic seawater.

7.2.7 Number of Tests.

7.2.7.1 Two sets of two tests, one set with freshwater and one set with synthetic seawater, shall be conducted to derive average extinguishment and burnback times.

7.2.7.2 In the event that either of the averages after the two tests does not meet the requirements of this standard, one more test shall be conducted, with the results of all three tests being averaged.

7.2.7.3 No further testing shall be conducted if either of the averages fails to meet the requirements following the third test.

7.2.8 Test Method.

7.2.8.1 The complete fuel charge shall be emptied into the pan.

7.2.8.2 The fuel shall be ignited within 60 seconds after completion of fueling and shall be permitted to burn freely for 15 seconds before application of the water additive solution.

7.2.8.3 The water additive solution shall be applied for a period of 90 seconds, and the fire shall be extinguished in accordance with the manufacturer's application instructions.

7.2.8.4 The nozzle shall be permitted to be moved throughout the duration of the solution application or fixed in position for part or all of the solution application, but at no time shall the nozzle tip extend beyond the plane of the edge of the pan.

7.2.8.5 The operator shall be permitted to move around the entire area of the pan.

7.2.9* Burnback.

7.2.9.1 A weighted 300 mm diameter pan having 50 mm side walls and charged with 1.1 L of heptane shall be placed in the center of the test area.

7.2.9.2 An eyebolt with a 20 mm shaft attached to the center of the pan and a 3 m pole with a hook on the end shall facilitate the placement of the pan.

7.2.9.3 The fuel shall be ignited, and the burnback pan shall be placed in the 4.6 m^2 fire test pan within 15 seconds after solution application is terminated.

7.2.9.4 Burnback time shall commence at the time of placement of the burnback pan and shall terminate when 25 percent of the fire test pan area is aflame.

7.2.9.5 The burnback pan shall be left in the fire test pan until 25 percent burnback has been achieved.

7.2.10 Data. The following data shall be recorded for each test:

(1) Time for extinguishment (seconds)
(2) Time for 25 percent burnback (seconds)
(3) Ambient temperature
(4) Expansion and drainage (for air-aspirated nozzles or compressed air systems)

7.2.11 Application Rate. The listed application rate shall be 6.89 L/min/m^2.

7.3* Pool Fire Test.

7.3.1 General. Water additive solution prepared at the minimum concentration specified for use by the manufacturer shall be tested in accordance with this section for use on fuels pooled to a depth of 50.8 mm or less.

7.3.1.1 A water additive in combination with an 18.9 L/min nozzle shall be tested in accordance with this section and shall comply with the specified requirements.

7.3.1.2 When an air-aspirated nozzle or compressed air system is used, foam quality tests shall be conducted and reported in accordance with CAN/ULC S560.

7.3.2 Performance. The water additive solution discharged onto flammable liquid test fires shall comply with 7.3.2.1 through 7.3.2.4.

7.3.2.1 The fire shall be completely extinguished during or at the end of discharge.

7.3.2.2 The test fuel surface shall not re-ignite when a lighted torch is moved over all areas of the surface.

7.3.2.3 Candling, flaming, or flashover that self-extinguishes shall be permitted provided that the phenomenon does not remain in one area for more than 30 seconds.

7.3.2.4 When the stovepipe is removed, the liquid surface shall react in either of the following ways:

(1) Restrict the spread of fire at any time during the 3-minute duration to a total area of not more than 0.92 m^2
(2) Flow over and extinguish the burning area

7.3.3 Pretest Storage. Each water additive concentrate to be tested shall be taken from its container as received from the manufacturer, following storage at room temperature for at least 24 hours.

7.3.4 Arrangement of Test.

7.3.4.1 The test fuel of commercial grade heptane conforming to UL 162 shall be placed in a 4.6 m^2 fire test pan constructed in accordance with UL 162.

7.3.4.2 The pan shall be located on the floor.

7.3.4.3 A fuel layer at least 50.8 mm deep shall be added to the pan.

7.3.4.4 The fuel depth shall be adjusted to provide a distance from the top of the pan to the surface of the liquid of not less than 202 mm.

7.3.4.5 Fuel temperature shall not be less than 10°C.

7.3.5 Nozzle Position and Spray Direction.

7.3.5.1 The nozzle shall be positioned in front of and above the test pan.

7.3.5.2 The nozzle shall be permitted to be moved throughout the duration of water additive solution application or fixed in position for part of or all of the application.

7.3.5.3 Until at least 90 percent flame reduction is attained, all water additive solution application shall be from behind one side of the test pan and discharged directly onto the fuel surface.

7.3.5.4 After at least 90 percent flame reduction is attained, water additive solution application shall be permitted to be from the front and one adjacent side and shall be permitted to be directed onto the inside of the test pan.

7.3.5.5 The nozzle shall be permitted to be moved beyond the adjacent side extensions.

7.3.5.6 The nozzle shall not be permitted to extend over any part of the test pan.

7.3.6 Preburn. After the fuel has been added to the test pan and the nozzle has been arranged, the fuel shall be ignited and the resulting fire allowed to burn freely for a 60-second preburn.

7.3.7 Discharge.

7.3.7.1 At the end of the 60-second preburn, the water additive solution shall be discharged for 5 minutes.

7.3.7.2 The fire shall be completely extinguished at or before the end of discharge.

7.3.7.3 After all discharge is complete, the test fuel with water additive solution shall be left undisturbed for 5 minutes.

7.3.8 Re-ignition.

7.3.8.1 During the time the water additive solution with test fuel is left undisturbed, a lighted torch constructed as described in UL 162 shall be passed approximately 25 mm above the entire liquid surface, including corners, in an attempt to re-ignite the fuel.

7.3.8.2 The torch test shall be conducted once during this period and shall commence 2 minutes after the end of agent discharge and prior to the ignition of the 300 mm diameter stovepipe.

7.3.8.3 The torch test shall be conducted for not less than 1 minute.

7.3.8.4 The fuel shall not re-ignite while the torch is being passed over the fuel.

7.3.8.5 Candling, flaming, or flashover that self-extinguishes shall be permitted provided that the phenomenon does not remain in one area for more than 30 seconds.

7.3.9 Burnback.

7.3.9.1 After completion of the attempt to re-ignite the fuel with the lighted torch, a stovepipe constructed as described in UL 162 shall be lowered into the liquid.

7.3.9.2 The stovepipe shall be placed approximately 0.76 m from each of two adjacent sides of the test pan in the corner considered to cause the most severe burnback condition and lowered in such a manner that the liquid surface is not disturbed.

7.3.9.3 The portion of the foam blanket that is enclosed by the stovepipe shall be removed with as little disturbance as possible of the foam blanket outside the stovepipe.

7.3.9.4 If no foam blanket is present, 1 L of heptane shall be poured into the stovepipe.

7.3.9.5 The fuel cleared or placed inside the stovepipe shall be ignited 5 minutes after the end of agent discharge and allowed to burn for 1 minute.

7.3.9.6 The stovepipe then shall be slowly removed from the pan while the fuel continues to burn.

7.3.9.7 When the stovepipe is removed, the liquid surface shall react in either of the following ways:

(1) Restrict the spread of fire at any time during a 3-minute duration to a total area of not more than 0.92 m^2
(2) Flow over and extinguish the burning area

7.3.9.7.1 The spread of fire caused by candling, ghosting, or flashover, in which the flame height exceeds 0.6 m but then self-extinguishes, shall be considered unacceptable if the total area involved in flame exceeds 0.92 m^2 at any time during the 3-minute duration per 7.3.9.7(1).

7.3.10 Application Rate. The listed application rate shall be 10.19 L/min/m^2.

7.4 Three-Dimensional Fuel Fire Test.

7.4.1 General.

7.4.1.1 Water additive concentrates shall be evaluated for aviation applications or industrial applications, or both, and shall be listed only for those applications for which they have been successfully tested.

7.4.1.2 To be listed for the extinguishment of three-dimensional fires, water additive solutions prepared at the minimum concentration specified for use by the manufacturer shall be tested and listed as described in this section. *(See Annex D.)*

7.4.2 Fuel.

7.4.2.1 Water additives shall be tested against a free-flowing running fuel fire.

7.4.2.2 For aviation (*A*) applications, the fuel shall be jet petroleum Grade A.

7.4.2.3 For industrial (*I*) applications, the fuel shall be commercial heptane.

7.4.3* Flow Adjustments. For the purpose of this fire test, fuel shall be adjusted to flow slowly down both sides of the vertical cascade at a total fuel flow rate of 13.25 L/min ± 1.9 L/min.

7.4.4 Wind Speed. Maximum wind speed for this test sequence shall be less than 8 kph.

7.4.5 Water.

7.4.5.1 The lower collection basin of the tower system shall be charged with 101 mm of freshwater at less than 38°C.

7.4.5.2 The vertical tower column shall have water free flowing through the tower cooling system, and the vertical tower temperature prior to the test shall be below 38°C.

7.4.6 Preburn.

7.4.6.1 The basin area shall contain 18.9 L of fuel prior to ignition.

7.4.6.2 The fuel shall be ignited and allowed to preburn for a minimum of 45 seconds.

7.4.6.3 In the event both faces of the test apparatus are not fully involved after 45 seconds, the preburn time shall be extended until full involvement is achieved.

7.4.7 Application of Water Additive.

7.4.7.1 Water additive solution shall be applied with a non-air-aspirated nozzle, an air-aspirated nozzle, or a compressed air–foam system.

7.4.7.2 When an air-aspirated nozzle or compressed air system is used, foam quality tests shall be conducted and reported in accordance with CAN/ULC S560.

7.4.7.3 For aviation fuel, the water additive solution application rate shall be a maximum of 151 L/min, and extinguishment shall occur in 20 seconds or less.

7.4.7.4 For industrial applications, the water additive solution application rate shall be a maximum of 227 L/min, and extinguishment shall occur in 45 seconds or less.

7.4.8 Distance to Fire.

7.4.8.1 At the start of application, fire fighters shall position themselves at the front of the cascade system at least 6.1 m from the closest corner of the cascade fuel basin.

7.4.8.2 At no time shall a fire fighter get closer than 3 m to accomplish the extinguishing process.

7.4.8.3 Fire fighters shall remain within an arc of no more than 1.52 m left or right of the closest corner starting point of the collection basin.

7.4.9 Performance. For each application (aviation or industrial) to be listed, three fires in a maximum of six total trials shall meet the performance requirements of 7.4.7.3 or 7.4.7.4.

7.5* Polar Solvents Fire Test. (Reserved)

7.6 Emulsification Test.

7.6.1* General. This section shall cover test procedures to evaluate the ability of a water additive solution to render a hydrocarbon fuel nonflammable through emulsification.

7.6.2 Test Materials.

7.6.2.1 The following materials shall be provided for the test:

(1) 6.35 mm thick steel pan measuring 1.2 m × 1.2 m × 202 mm
(2) Amount of water additive concentrate as specified by the manufacturer for the fuel being tested
(3) Types of fuels as specified in 7.6.2.2
(4) Amount of water needed to meet the manufacturer's specified concentration ratio
(5) Ignition source consisting of a propane torch producing a minimum 25 mm flame

7.6.2.2 The following fuels shall be tested:

(1) Heptane
(2) Gasoline as defined in 40 CFR 86.113-94
(3) Gasoline with 10 percent ethanol
(4) Gasoline with 18 percent methyl tertiary butyl ether (MTBE)
(5) No. 2 diesel
(6) Jet A

7.6.3* Test Set-Up. The emulsification test shall be set up as follows:

(1) The steel pan shall be thoroughly washed with clean water and dried.
(2) The full amount of fuel shall be poured into the pan.
(3) The full amount of water additive concentrate shall be mixed into the fuel within 1 minute.
(4) The full amount of water shall be added within 1 minute in a manner to agitate the resulting mixture. Following addition of the water, agitation is to be stopped.

7.6.4 Test Procedures.

7.6.4.1 General. Ignition tests for each fuel in 7.6.2.2 shall be conducted in accordance with 7.6.4.2 and 7.6.4.3.

7.6.4.2 One-Minute Ignition Test.

7.6.4.2.1 One minute after completion of agitation, the ignition torch described in 7.6.2.1(5) shall be passed over the entire liquid surface, including corners, with the tip of the flame impinging on the surface, in an attempt to re-ignite the fuel.

7.6.4.2.2 The fuel shall not re-ignite while the torch is being passed over the fuel.

7.6.4.3 Two-Hour Ignition Test.

7.6.4.3.1 Two hours after completion of agitation, the ignition torch described in 7.6.2.1(5) shall be passed over the entire liquid surface, including corners, with the tip of the flame impinging on the surface, in an attempt to re-ignite the fuel.

7.6.4.3.2 The fuel shall not re-ignite while the torch is being passed over the fuel.

7.6.5 Acceptable Performance. A water additive concentrate shall be listed for emulsification when the requirements of 7.6.4.2 and 7.6.4.3 have been met for all fuels in 7.6.2.2.

7.7* Fuel in Depth Fire Test. (Reserved)

Chapter 8 Packaging and Labeling

8.1 Packaging.

8.1.1* Regulations. Packaging of water additive concentrates shall conform to regulations governing ground and air transport of materials.

8.1.2 Containers. Containers shall comply with the construction requirements of UL 162, Section 5.2.1, and nonmetallic containers shall comply with the accelerated storage test of UL 162, Section 22.3.

8.2 Storage.

8.2.1 Storage of concentrate and premixed solutions shall be provided in accordance with the manufacturers' recommendations.

8.2.2 Water additive concentrate shall not be stored at a temperature below 0°C (32°F) or above 49°C (120°F).

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

(1) Manufacturer name and address
(2) Product name, lot number, and date of manufacture
(3) Listed uses and application data in the form of a chart that conforms to Figure 8.3. All boxes must contain appropriate information. If the product is not listed, then the label must indicate this.
(4) The manufacturer's recommended proportioning ratios for each listed application
(5) Application rate for each listed application
(6) Recommended minimum and maximum storage temperatures
(7) Emergency and first aid instructions
(8) Volume of concentrate in container
(9) Listing agency mark

Chapter 9 Supply

9.1 System Requirements.

9.1.1* Equipment. Water additive concentrate complying with this standard shall be permitted to be used with standard equipment provided said equipment is primarily designed to utilize water or foam as a medium of fire control and extinguishment.

9.2 Fire Department Supply Requirements.

9.2.1 Tanks. The manufacturer of the water additive concentrate shall specify if premixing is allowed.

9.2.2* Separate Supplies. Where portable tanks are not a part of the apparatus, or where it is desired that the water additive concentrate be carried separately for use either with water from portable tanks or with water from other sources of supply, the amount of concentrate considered necessary shall be carried in a tank connected to proportioning equipment on the apparatus installed in accordance with NFPA 1901.

9.3* Fixed Systems. Fixed systems utilizing water additive solution shall be permitted to be installed in accordance with the following standards as appropriate only after an engineering analysis acceptable to the authority having jurisdiction has been conducted:

(1) NFPA 13
(2) NFPA 14
(3) NFPA 15

Application	Listed Concentration	Listed Application Rate	Listing Agency
Spill fire			
Pool fire			
Fuel in depth fire			
3D aviation			
3D industrial			
Polar solvent			
Emulsification			

FIGURE 8.3 Label Example.

Chapter 10 Inspection, Testing, and Maintenance of Fixed Systems

10.1* Fixed Extinguishing Systems. Fixed extinguishing systems referenced in Section 9.3 shall be inspected, tested, and maintained in accordance with the applicable system requirements of NFPA 25.

10.2 Inspection of Water Additive Concentrate. Annually, samples of water additive concentrate stored in the fixed system shall be sent to the manufacturer or qualified laboratory for quality condition testing.

Annex A Explanatory Material

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

A.1.3 It is not the intent to preclude agents, such as wetting agents that are Class A or Class B foams, that comply with NFPA 11, NFPA 18, or NFPA 1150 from meeting the requirements of this standard. The scope of this document might include products with extinguishing mechanisms that emulsify fuels and render them inert, but it is not the intent of this standard to include long-term retardants and gels.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.4 Class B Fire. The definition of Class B fires includes many substances for which this standard does not currently contain test protocols, for example, fires involving solvents, lacquers, alcohols, and flammable gases.

A.3.3.6 Concentration. The type of water additive used determines the percentage of concentration required. For example, a 3 percent water additive concentrate is mixed in the ratio of 3 parts water additive to 97 parts water. Liquid concentrates are typically proportioned on a volume rate and solid concentrates by weight.

A.3.3.7 Demulsification. The process can proceed very slowly or very quickly, depending on the stability of the emulsion.

A.3.3.8 Discharge Device. Examples include, but are not limited to, sprinklers, spray nozzles, and hose nozzles.

A.3.3.12 Emulsion. Such systems possess a minimal stability, which can be accentuated by such additives as surface active agents, finely divided solids, and so forth.

A.3.3.13 Fixed Monitor (Cannon). The monitor can be fed solution by permanent piping or hose.

A.3.3.15 Handline. The nozzle reaction usually limits the solution flow to about 1135 L/min. [**11**, 2010]

A.3.3.20 Micelle. For purposes of this standard, a micelle consists of a minute droplet of the hydrocarbon fuel surrounded by water and the emulsifying agent.

A.3.3.28 Water Additive. Water additives can materially reduce water's surface tension and increase its penetrating and spreading abilities; they also might provide enhanced cooling, emulsification, and foaming characteristics.

A.3.3.29 Water Additive Concentrate. For the purposes of this document, *water additive concentrate* and *concentrate* are used interchangeably.

A.3.3.30 Water Additive Solution. For the purposes of this document, *water additive solution* and *solution* are used interchangeably.

A.4.2.3.2 Fire test requirements for protection of commercial cooking equipment are addressed by ANSI/UL 300 for fixed fire extinguishing systems and ANSI/UL 711/CAN/ULC S508 for fire extinguishers.

A.4.2.4 If water additive solution comes in contact with electrical equipment, the water additive can remain behind after the water has dried off and can constitute a hazard when the equipment is put back in operation.

A.4.2.5 Fire test requirements for protection of Class D hazards are addressed by UL 711/ULC S508.

A.4.3 The mixing of these concentrates can have adverse effects and render solutions or systems ineffective for fire prevention, control, suppression, extinguishment, or vapor mitigation.

A.5.2.1.2 The toxicity limits listed in Table A.5.2.1.2 have been adopted by several jurisdictions. The limits for oral and dermal toxicity are based on U.S. EPA requirements for the signal word "Caution" required on labels and MSDS data sheets. Higher numbers (LD_{50}) are less toxic to the test species.

A.5.2.2.3 The value of 10 mg/L has been adopted by some authorities having jurisdiction as an acceptable level. This value is based on U.S. EPA categories for testing of aquatic organisms and is equivalent to the categories of slightly toxic and practically nontoxic. Higher numbers are less toxic to the environment.

A.5.2.3.1 If the additive is >60 percent biodegraded after 28 days, it is considered readily biodegradable. If the additive is not readily biodegradable but is ≥60 percent biodegraded after 42 days, the additive is considered to be biodegradable. If it is <60 percent biodegraded after 42 days, it is considered not biodegradable by EPA OPPTS Guidelines.

A.5.3.4.3 The Brookfield viscometer models LVT or LVF are two examples of viscometers that can be used for this test. If a Brookfield viscometer is used, then a No. 2 spindle should be used for viscosities from 1 to 500 centipoise and a No. 4 spindle for viscosities greater than 500 centipoise.

A.5.4.1.3 It is important that a sample not be disturbed during the course of the test. When it is necessary to move the sample, care should be taken to minimize movements of concentrate within the container. Rapid motions, shaking, and tilting the samples are examples of undesirable actions.

A.5.4.2.1 Examples of applications where this could occur include the use in fire extinguishers, pre-primed sprinkler systems, booster tanks, and suction tanks.

A.5.5.2 Testing on additional alloys can be necessary in order to meet the needs of the end user. In accordance with Chapter 5, water additive solutions should be tested for compatibility with the materials with which they will be used.

A.5.5.4.1 Test coupons meeting the dimensions provided in this standard should be obtained from a reputable source of corrosion testing materials. Care should be taken to minimize the possibility of work hardening of the metal at the edges, since such improper cutting may have a statistically significant effect on the corrosion test results.

A.5.5.4.2 Dry powder concentrates need be tested only for uniform corrosion at the maximum and minimum concentrations, as specified by the manufacturer. Ready-to-use products should be tested as received.

A.5.5.5.2 Common degreasers include all-purpose cleaners and dishwasher soaps. The chosen degreaser should be used for all comparative testing.

Table A.5.2.1.2 Toxicity Limits for Water Additive Concentrate and Its Solution

Test Specimen	Acute Oral Toxicity	Acute Dermal Toxicity	Primary Eye Irritation: Unwashed Eyes	Primary Eye Irritation: Washed Eyes	Primary Dermal Irritation
Concentrate	$LD_{50} > 500$ mg/kg	$LD_{50} > 2000$ mg/kg	Mildly irritating or less	Mildly irritating or less	Primary irritation score < 5.0
			If more irritating, recommend protective gear and safe handling procedures		
Solution	$LD_{50} > 5000$ mg/kg	$LD_{50} > 2000$ mg/kg	Mildly irritating or less	Mildly irritating or less	Primary irritation score < 5.0

A.5.5.6.5 The jar lid should be firmly hand-tightened but not sealed. The intent of this requirement is to minimize evaporation of the solution while preventing a buildup of pressure. This level of tightness most closely replicates the storage of materials in service.

A.5.6.1 Intergranular corrosion is not permitted when the solution is delivered by aircraft.

A.7.2 Although water additive solutions and Class B foams are required to pass Class B fire performance tests to obtain a listing, the tests are different. Some of the most important differences are as follows:

(1) The tested application rate for water additive solutions is different from the tested application rate for Class B foam solutions in NFPA 11.
(2) The burnback resistance time is 180 seconds for water additive solutions, compared to 360 seconds for foam solutions.
(3) The published application rate for water additive solutions is 5/3 the test application rate (rounded up) compared to 5/3 for protein and fluoroprotein foam and 5/2 for aqueous film-forming foam (AFFF) and film-forming fluoroprotein (FFFP).

A.7.2.9 Ghost flames or intermittent "flashovers" can occur. They are not to be considered a part of the burnback area unless sustained burning occurs for more than 30 seconds.

A.7.3 Although water additive solutions and Class B foam solutions are required to pass Class B fire performance tests to obtain a listing, the tests are different. Some of the most important differences are as follows:

(1) The tested application rate for water additive solutions in NFPA 18A is different from the tested application rate for Class B foam solutions in UL 162.
(2) The burnback or sealability requirements for water additive solutions are less than those for agents tested to UL 162.
(3) The application rate in NFPA 18A is 10.19 L/min/m^2, which is a 5/2 safety factor over the test application rate. This is the same safety factor as applied to AFFF and FFFP.

Experience with the extinguishment of fires in extreme depth such as tank or dike fires is limited, if any.

A.7.4.3 A slight adjustment in fuel flow is permitted to ensure that both top plates of the vertical cascade receive equal quantities of fuel flowing down both sides of the front vertical column of the cascade test device.

A.7.5 The characteristics of polar solvent fuels are such as to potentially render the Class B extinguishment and/or vapor mitigation test protocols for hydrocarbons inadequate. However, there does not currently exist sufficient information to specify appropriate extinguishment and/or vapor mitigation tests for these agents on polar solvents.

A.7.6.1 An emulsifying agent is one that is capable of rendering the fuel nonflammable by encapsulating the hydrocarbon molecules.

A.7.6.3 The application ratio is agent:fuel:water.

A.7.7 Appropriate test criteria have not been developed and defined.

A.8.1.1 Water additive concentrate containers should conform to the United Nations Performance Based Packaging Standards as codified under U.S. Department of Transportation Regulations, 49 CFR 178.600.

A.8.3 For a completed label example, see Figure A.8.3.

A.9.1.1 This standard does not specify the method whereby the water additive concentrate is added to water. The solution can be premixed in tanks or can result from the water additive

Application	Listed Concentration	Listed Application Rate	Listing Agency
Spill fire	3%	6.89 L/min/m^2	UL
Pool fire	6%	10.19 L/min/m^2	UL
Fuel in depth fire	Not listed	Not listed	—
3D aviation	3%	43.15 L/min	UL
3D industrial	3%	64.73 L/min	UL
Polar solvent	Not listed	Not listed	—
Emulsification	See listing	See listing	UL

FIGURE A.8.3 Completed Label Example.

concentrate being brought into contact with water by any suitable proportioning device, provided said device is approved in accordance with applicable standards.

A.9.2.2 Where such equipment is also used to take suction from a hydrant supplied by potable water, extra care should be exercised to prevent contamination of such potable water supplies with the water additive concentrate or solution.

A.9.3 In such installations, consideration should be given primarily to limitations outlined in Chapter 4 and to the following:

(1) Possibility of increased water damage due to the potentially high absorption ability of the water additive solution
(2) Possibility of increased floor loads due to the potential retention of large volumes of water additive solution
(3) Potential for contaminating the public water supply when a fixed system is supplied through the fire department connection

If, during pre-incident planning, supplying a fixed system with a water additive solution is considered, an engineering evaluation should be conducted.

A.10.1 Some water additive concentrates and solutions could have greater penetrating power than water and consequently could be capable of passing through small openings that would be impassable to water. For that reason, it will often be found that old but apparently sound equipment will have a tendency to leak when charged with water additive solution, especially at worn packing glands. Packing glands, retainers, bushings, threaded joints, and screw unions should be inspected and replaced as necessary, and regular inspections made thereafter.

Annex B Residual Fire Retardancy

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

B.1 Residual fire retardancy is defined as the retardant effects that are provided by a water additive after all the moisture contained in the water additive solution has been removed by evaporation.

B.1.1 The residual fire retardancy is determined by utilizing the test beds.

B.1.2 The moisture content of the treated fuel beds is monitored until they reach equilibrium.

B.1.3 Once equilibrium is reached, the fuel beds are burned in the wind tunnel.

B.1.4 To accomplish the burning, a starter bed 0.9 m long is prepared identically to the standard fuel beds (same fuel, fuel loading, and porosity) and conditioned.

B.1.5 The starter bed is placed upwind of the treated bed and ignited by an electronically heated wire placed across the width of the fuel bed.

B.1.6 The starter bed provides an established flame front that impinges on the treated bed.

B.1.7 When the flame front reaches each 152 mm point along the test bed, a switch is manually pressed to record the advance of the flame front.

B.1.8 The bed weight is then recorded at 10-second intervals throughout the test burn.

B.1.9 At the conclusion of the burn test, the rates of spread and weight loss are calculated based on the fire spread and weight loss over the 0.9 m to 2.1 m portion of the test bed.

B.1.10 A minimum of three beds of each fuel type are burned to determine the average residual fire retardancy.

B.1.11 Untreated fuel beds and fuel beds treated with water are used as a standard and for comparison.

B.1.12 In order to be considered effective as a residual fire retardant, as defined herein, the average performance of the beds treated with the water additive solution has to be greater than comparable beds treated with plain water by at least as great as two times the standard deviation of the average value.

The percent reduction in rates of spread and weight loss is calculated as follows:

$$\frac{\left(\begin{array}{c}\text{Rated Spread}\\ \dfrac{\text{Untreated} - \text{Treated}}{\text{Untreated}}\end{array}\right) + \left(\begin{array}{c}\text{Weight Loss}\\ \dfrac{\text{Untreated} - \text{Treated}}{\text{Untreated}}\end{array}\right)}{2} = \%\ \text{Reduction}$$

The rate of spread and weight loss of beds treated with the water additive solution has to be a minimum of two times the standard deviation greater than the average rate of spread and weight loss of the beds treated with plain water.

Annex C ICAL Radiant Panel Test for Exposure Protection

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

C.1 General Description.

C.1.1 The resistance to ignition of a Class A fuel treated with a water additive needs to exceed 15 minutes as determined using intermediate scale calorimeter (ICAL)–based testing protocols (NIST GCR 00-792).

C.1.2 The ICAL radiant panel replicates several scenarios, including burning brands in close proximity to the siding, burning shrubbery near the house, mild to moderate radiant heat from a wildland fire, and intense radiation for a relatively brief duration.

C.1.3 An ICAL apparatus conforms with the requirements of ASTM E 1623, which include an approximately 1.5 m × 1.5 m propane fired radiant panel, the means to measure heat flux across the surface of a specimen as a function of distance from the panel, a load cell on a movable cart, and an exhaust hood.

C.2 Test Protocol. A modified ICAL test protocol should be employed to evaluate the fire retarding effects of temporary, water-based exposure protection gels on wood and plastic sidings.

C.2.1 Treated and untreated wood, plastic siding, and windows mounted in wood sidings should be used and exposed at a heat flux of 15 and 25 kW/m^2.

C.2.2 The "T"-burner will be modified for use as the ignition source (the head of the igniter retained, only the length of the tube and the method of connection to the apparatus changed; as described in California Technical Bulletin 129).

C.3 Application Water Additive Solution. The exposure protection gel should be prepared at the manufacturer's recommended mix level.

C.3.1 Physical and chemical characteristics should be measured and described.

C.3.2 Application of the water additive solution should be controlled by maintaining a constant water flow rate and pressure.

C.3.3 A consistent coating thickness of 6 mm to 10 mm should be achieved by spraying the substrate for approximately 35 seconds.

C.3.4 Weight pickup after each application should be made to verify the consistency of the application rate.

C.4 Measurements. During the tests, the following measurements should be made:

(1) Time to smoke, ignition, and full flaming over the surface of the specimen at the selected heat flux
(2) Observations of sustained flaming over the exposed surface and/or failure of the coating
(3) Weight of the specimen prior to treatment
(4) Weight of the specimen after treatment
(5) Weight loss rate during drying
(6) Weight loss rate during heat exposure, prior to ignition

Video tape and still photographs should be taken during the test.

C.5 Test Procedure.

C.5.1 Plywood T1-11 sheets are to be used for the substrate and cut into 1 m × 1 m panels.

C.5.2 A single heavy coat of red latex paint is to be applied to each panel and allowed to dry in a conditioned environment until equilibrium moisture is reached (1 to 2 weeks).

C.5.3 The panels are to be instrumented with two type K thermocouples at the center of each panel, one to be placed at the surface of the panel and the other to be located 1 cm away from the surface of the panel.

C.6 Calibration.

C.6.1 The ICAL radiant panel then is to be calibrated for heat flux as a function of the distance between the panel face and the specimen surface.

C.6.2 Specimens are to be exposed to heat flux at exposures of 15 kW/m^2 and 25 kW/m^2 at distances of 0.79 m and 0.46 m, respectively.

C.6.3 A distance of 3.23 m should correspond with the "drying" heat exposure of 1 kW/m^2.

C.7 Specimen.

C.7.1 The support frame is to be weighed, a specimen then is to be mounted on the support frame, and the frame then reweighed.

C.7.2 The specimen then is to be sprayed and reweighed to determine the weight of the coating on the specimen.

C.7.3 The weight of the specimen is to be recorded at 5-minute intervals during the drying period and every 15 seconds during exposure to the predetermined heat flux.

C.7.4 Temperature and relative humidity of the surrounding test area are to be recorded before each experiment.

Annex D Three-Dimensional Fire Test Apparatus

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

D.1 Figure D.1(a) through Figure D.1(f) depict the apparatus used for three-dimensional fire testing.

Annex E Informational References

E.1 Referenced Publications. The documents or portions thereof listed in this annex are referenced within the informational sections of this standard and are not part of the requirements of this document unless also listed in Chapter 2 for other reasons.

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

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, 2010 edition.

NFPA 18, *Standard on Wetting Agents*, 2011 edition.

NFPA 1150, *Standard on Foam Chemicals for Fires in Class A Fuels*, 2010 edition.

E.1.2 Other Publications.

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

ASTM E 1623, *Standard Test Method for Determination of Fire and Thermal Parameters of Materials, Products, and Systems Using an Intermediate Scale Calorimeter (ICAL)*, 2004.

E.1.2.2 NIST Publications. National Institute of Standards and Technology, 100 Bureau Drive, Gaithersburg, MD 20899-1070.

NIST GCR 00-792, *An Investigation of the Effectiveness of Fire Resistant Durable Agents on Residential Siding Using an ICAL-Based Testing Protocol*, 2000.

E.1.2.3 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 162, *Foam Equipment and Liquid Concentrates*, 1994, revised 1999.

ANSI/UL 300, *Fire Testing of Fire Extinguishing Systems for Protection of Commercial Cooking Equipment,* 2005.

ANSI/UL711/CAN/ULC S508, *Rating and Fire Testing of Fire Extinguishers*, 2004, revised 2009.

E.1.2.4 State of California Publications. State of California Department of Consumer Affairs, Bureau of Home Furnishing and Thermal Insulation, 3485 Orange Grove Avenue, North Highlands, CA 95660.

California Technical Bulletin 129, *Flammability Test for Mattresses for Use in Public Buildings,* 1992.

E.1.2.5 U.S. Government Publications. U.S. Government Printing Office, Washington, DC 20402.

Title 49, Code of Federal Regulations, Part 178.600, Specifications for Packaging, "Purpose and Scope."

E.2 Informational References. (Reserved)

E.3 References for Extracts in Informational Sections. NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam,* 2010 edition.

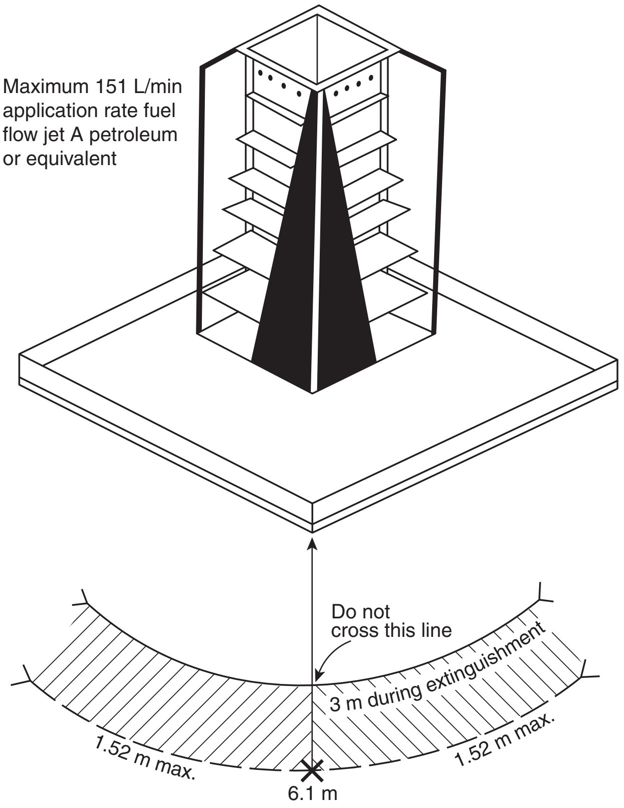
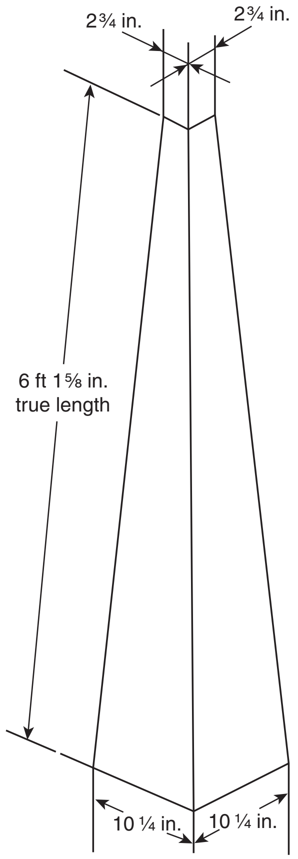
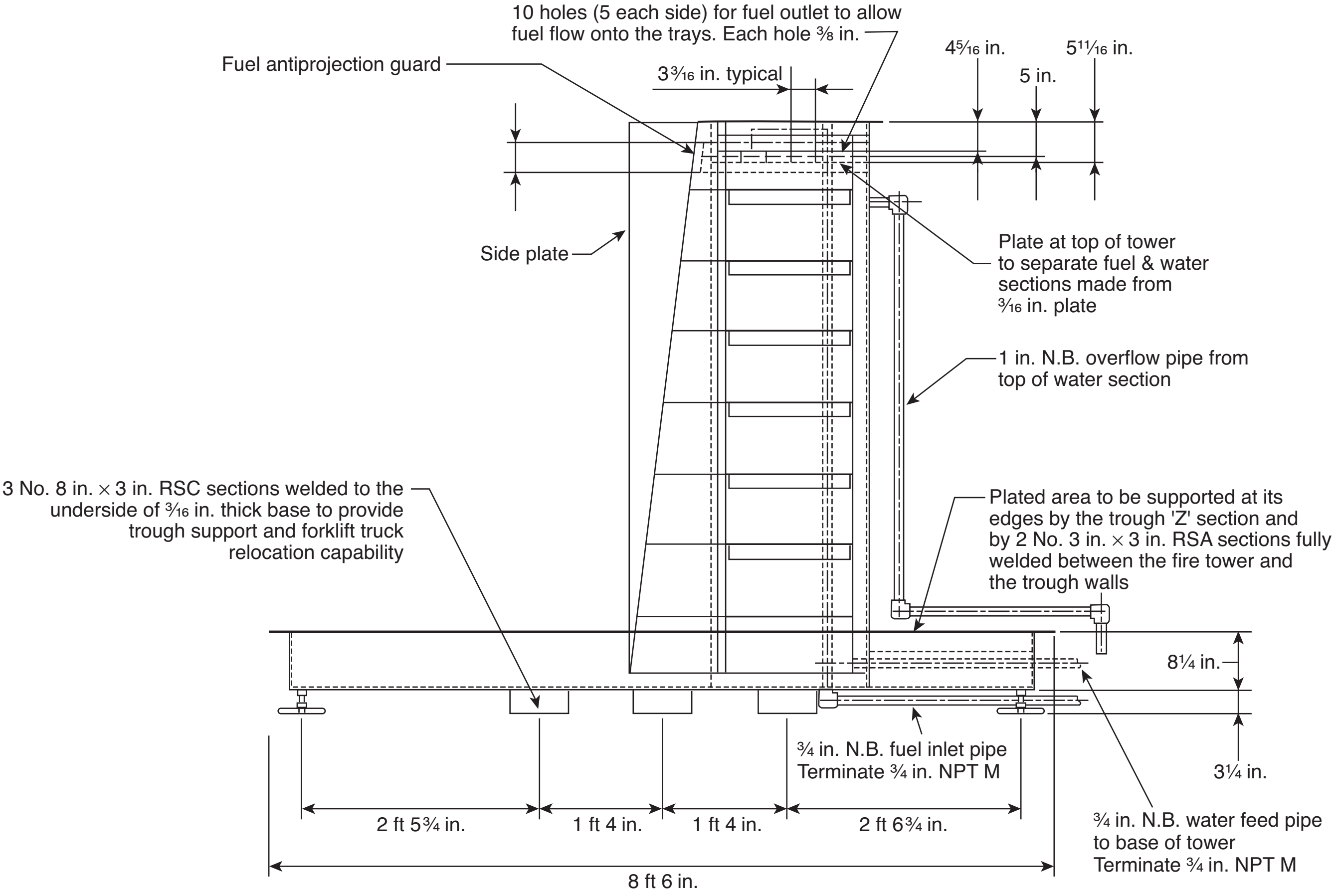


FIGURE D.1(a) Fire Fighter Start Position.



For SI units, 1 in. = 25.4 mm, 1 ft = 0.304 m.

FIGURE D.1(b) Corner Plate Detail.



For SI units, 1 in. = 25.4 mm, 1 ft = 0.304 m.

FIGURE D.1(c) FAA — Running Fuel Fire Cascade, 2.4 m × 2.4 m (8 ft × 8 ft) Basin — Tower 0.6 m × 0.6 m (2 ft × 2 ft) Side Elevation on the Fire Tower and Water Trough.