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NFPA 412
Evaluating Aircraft Rescue and Fire Fighting Foam Equipment
1987 Edition

NFPA

National Fire Protection Association Batterymarch Park, Quincy, MA 02269

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Policy Adopted by NFPA Board of Directors on December 3, 1982

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

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

Statement on NFPA Procedures

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Standard for

Evaluating Aircraft Rescue and Fire Fighting Foam Equipment

1987 Edition

This edition of NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire Fighting Foam Equipment*, was prepared by the Technical Committee on Aircraft Rescue and Fire Fighting, released by the Correlating Committee on Aviation, and acted on by the National Fire Protection Association, Inc. at its Annual Meeting held May 18-21, 1987 in Cincinnati, Ohio. It was issued by the Standards Council on June 10, 1987, with an effective date of June 30, 1987, and supersedes all previous editions.

The 1987 edition of this standard has been approved by the American National Standards Institute.

Origin and Development of NFPA 412

Work on this material started in 1955 when the NFPA Subcommittee on Aircraft Rescue and Fire Fighting (as then constituted) initiated a study on methods of evaluating aircraft rescue and fire fighting vehicles. A tentative text was adopted by the Association in 1957 and a revised text officially adopted in 1959. Revisions were made in 1960, 1964, 1965, 1969, 1973, and 1974. With the introduction of new types of foam liquid concentrates over the years for this specialized service, the text has been broadened to cover these concentrates.

This 1987 edition represents a complete rewrite of the text to bring it into conformance with the *Manual of Style* and to refine the test methods.

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Contents

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Standard for

Evaluating Aircraft Rescue and Fire Fighting Foam Equipment

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

Information on referenced publications can be found in Chapter 5.

Chapter 1 Administration

1-1 Scope.

1-1.1 This standard establishes test procedures for evaluating the foam fire fighting equipment installed on rescue and fire fighting vehicles designed in accordance with the applicable portions of NFPA 414, *Standard for Aircraft Rescue and Fire Fighting Vehicles.*

1-2 Purpose.

1-2.1 The tests specified in this standard provide procedures for the evaluation of foam fire fighting equipment in the field to determine compliance with NFPA 414, *Standard for Aircraft Rescue and Fire Fighting Vehicles*, and NFPA 403, *Recommended Practice for Aircraft Rescue and Fire Fighting Services at Airports and Heliports.*

1-3 Definitions.*

Aqueous Film Forming Foam (AFFF).* These concentrates are used to produce fire fighting foam for extingishing hydrocarbon fires and are based on perfluorinated and hydrocarbon surfactants in a solvent/stabilizer system.

Fluoroprotein Foam (FPF).* These concentrates are used to produce a fire fighting foam for extinguishing hydrocarbon fires and are basically protein-foam concentrates, but with a synthetic fluorochemical surfactant additive.

Foam.* Fire fighting foam, within the scope of this standard, is a stable aggregation of small bubbles made by mixing air into a water solution containing a foam concentrate.

Foam Drainage Time (Quarter Life). The time in minutes that it takes for 25 percent of the total liquid contained in the foam sample to drain out from the foam.

Foam Expansion. The ratio between the volume of foam produced and the volume of solution used in its production.

Foam Pattern. The ground area over which foam is distributed during the discharge of a foam making device.

Foam Solution. A homogenous mixture of water and foam liquid concentrate.

Foam Stability. The degree to which a foam resists spontaneous collapse or degradation caused by external influences such as heat or chemical action.

Foam Weep. That portion of foam that is separated from the principal foam stream during discharge and falls at short range.

Heat Resistance. The property of a foam to withstand exposure to high heat fluxes without loss of stability.

Protein Foam (PF).* These concentrates are used to produce a fire fighting foam for extinguishing hydrocarbon fires and consist primarily of hydrolyzed protein and stabilizing additives.

Shall. Indicates a mandatory requirement.

Should. This term, as used in the Appendix, indicates a recommendation or that which is advised but not required.

Chapter 2 Rescue and Fire Fighting Vehicle Foam Production Performance Testing

2-1 Foam and Foam System Tests.

2-1.1 The expansion and 25 percent drainage time are the foam characteristics that shall be determined. Additionally, the foam concentration shall be determined, both as a test of the vehicle proportioning system, and to establish the legitimacy of the expansion and drainage data obtained. Foam distribution patterns shall be determined for use in calculating the area of fire that the vehicle is capable of controlling.

2-2 Turret Nozzles.

2-2.1 The foam distribution patterns shall meet the requirements of 2-15.6.3 for major RFF vehicles, 3-13.9.3 for rapid intervention vehicles, and 4-13.9.3 for combined agent vehicles of NFPA 414, *Standard for Aircraft Rescue and Fire Fighting Vehicles*, when tested as specified in Section 4-1 of this standard.

2-2.2 Foam samples shall be obtained by the methods given in 4-3.1.2 of this standard.

2-2.3 Foam samples shall be analyzed for expansion and drainage time using a method specified in Section 3-1 of this standard.

2-2.4 Foam samples shall be analyzed for concentration as specified in Section 3-2 of this standard.

2-3 Ground Sweep Nozzles.

2-3.1 The foam distribution patterns shall meet the requirements of 2-15.8.1 of NFPA 414, *Standard for Aircraft Rescue and Fire Fighting Vehicles*, when tested as specified in Section 4-2 of this standard.

2-3.2 Foam samples shall be obtained by the methods given in 4-3.1.2 of this standard.

2-3.3 Foam samples shall be analyzed for expansion and drainage time using a method specified in Section 3-1 of this standard.

2-3.4 Foam samples shall be analyzed for concentration as specified in Section 3-2 of this standard.

2-4 Hand Line Nozzles.

2-4.1 The foam distribution patterns shall meet the requirements of 2-15.7.3.3 for major RFF vehicles, 3-13.10.2.3 for rapid intervention vehicles, and 4-13.10.2.3 for combined agent vehicles of NFPA 414, *Standard for Aircraft Rescue and Fire Fighting Vehicles*, when tested as specified in Section 4-2 of this standard.

2-4.2 Foam samples shall be obtained by the methods given in 4-3.1.2 of this standard.

2-4.3 Foam samples shall be analyzed for expansion and drainage time using a method specified in Section 3-1 of this standard.

2-4.4 Foam samples shall be analyzed for concentration as specified in Section 3-2 of this standard.

2-5 Undertruck Nozzles.

2-5.1 The foam distribution pattern shall provide protection for the area beneath the vehicle.

2-5.2 Foam samples shall be collected and analyzed for concentration as specified in Section 3-2 of this standard.

Chapter 3 Performance Criteria

3-1 Expansion Ratio and Drainage Time Requirements.

3-1.1 AFFF shall be tested to either Test Method A specified in 4-3.2 or Test Method C specified in 4-3.4 of this standard, and shall meet at least the performance requirements specified in Table 3-1 of this chapter.

3-1.2 Protein and fluoroprotein foams shall be tested to either Test Method B specified in 4-3.3 or Test Method C specified in 4-3.4 of this standard, and shall meet at least the performance requirements specified in Table 3-1 of this chapter.

3-2 Foam Solution Concentration.

3-2.1 Foam solution concentration shall be tested in accordance with Section 4-4 of this standard.

Table 3-1 Foam Quality Requirements

		Minimum Solution 25% Drainage Time in Minutes		
Foam Agents	Minimum Expansion Ratio	Test Method A	Test Method B	Test Method C
AFFF Air-Aspirated	5:1	3	N/A	2.25
AFFF Non-Air-Aspirated	3:1	1	N/A	0.75
Protein	8:1	N/A	5	10
Fluoroprotein	6:1	N/A	5	10

3-2.2* For nominal 6 percent concentrates, the concentration shall be between 5.5 and 7.0 percent for turret and ground sweep nozzles, and between 5.5 and 8.0 percent for hand line and undertruck nozzles.

3-2.3 For nominal 3 percent concentrates the concentration shall be between 2.8 and 3.5 percent for turret and ground sweep nozzles, and between 2.8 and 4.0 percent for hand line and undertruck nozzles.

Chapter 4 Test Methods and Calculations

4-1 Turret Ground Pattern Test.

4-1.1 Prior to the start of the tests, the water tank shall be full, the foam concentrate tank shall be full with the type of foam concentrate to be used during the actual emergencies, and the proportioner shall be set for normal fire fighting operation. For premixed systems, the tank shall be full with the premixed solution in the correct proportion for normal fire fighting operations.

4-1.2* Discharge tests shall be conducted to establish the fire fighting foam discharge patterns produced and the maximum range attainable by the turret nozzle. The test shall be conducted under wind conditions of 5 mph or less. To determine maximum discharge range, the turret nozzles shall be tilted upward to form a 30-degree angle with the horizontal.

4-1.3 Foam shall be discharged onto a paved surface for a period of 30 seconds at the specified pressure, in both the straight stream and fully dispersed nozzle settings. Immediately after foam discharge has stopped, markers shall be placed around the outside perimeter to preserve the identity of the foam pattern as it fell on the ground. For purposes of defining the edge of the pattern, any foam of less than ½ inch in depth shall be disregarded. Distances between markers shall be plotted on graph paper. The vertical axis shall show the reach, and the horizontal axis shall show the pattern width for each nozzle setting. The distance from the nozzle to the end of the effective foam pattern shall be measured and plotted on the graph paper.

4-2 Ground Sweep and Hand Line Nozzle Tests.

4-2.1 Ground sweep nozzles and hand line foam nozzles shall be discharged onto a paved surface for a period of 30 seconds.

4-2.2 Ground sweep nozzles shall be discharged from their fixed positions.

4-2.3 Hand line nozzles shall be held at its normal working height and tilted upward to form a 30-degree angle with the horizontal.

4-2.4 Markers shall be set out to denote the outline of the effective foam pattern and plotted, as described under the turret test 4-1.3.

4-2.5 Patterns from both the straight stream and the fully dispersed nozzle settings shall be established, measured, and recorded.

4-3 Foam Tests.

4-3.1 General Requirements for All Test Methods.

4-3.1.1 The tests shall be conducted with the temperature of the water or foam solution in the range of 60° - 80°F (16° - 27°C).

4-3.1.2 The following corrections shall be applied to protective foams:

Expansion: If the solution temperature is higher than 70°F, no correction shall apply. If the temperature is lower than 70°F, 0.1 unit of expansion shall be added for each 3°F below 70°F.

Drainage Time: If the solution temperature is higher than 70°F, 0.1 minute shall be added for each 3°F above 70°F. If the solution temperature is lower than 70°F, 0.1 minute shall be subtracted for each 3°F lower than 70°F.

4-3.1.3 Foam samples selected for analysis shall be representative of the foam produced by the nozzle as it would be applied onto the fire hazard. This shall be accomplished by placing a foam sample collector in the center of the ground pattern as determined in the nozzle pattern test.

4-3.2 Test Method A.

4-3.2.1 Foam Sampling Apparatus.

4-3.2.1.1 The foam sample collector shall be constructed as specified in Figure 4-3.2.1.

4-3.2.1.2 The foam sample shall be collected in a standard 1000-ml capacity graduated cylinder. The cylinder shall be cut off at the 1000-ml mark to ensure a fixed volume of foam as a sample. The cylinder shall be marked in 10-ml graduations below the 100-ml mark.

4-3.2.2 Test Procedure.

4-3.2.2.1 The empty weight of the foam sample container shall be recorded to the nearest gram on a balance having a maximum capacity sufficient to weigh the foam sample container and the foam sample. The foam sample collector shall then be located in the center of the discharge pattern determined in Section 4-1. The foam sample container shall be positioned at the bottom of the foam collector so that the foam hitting the collector will

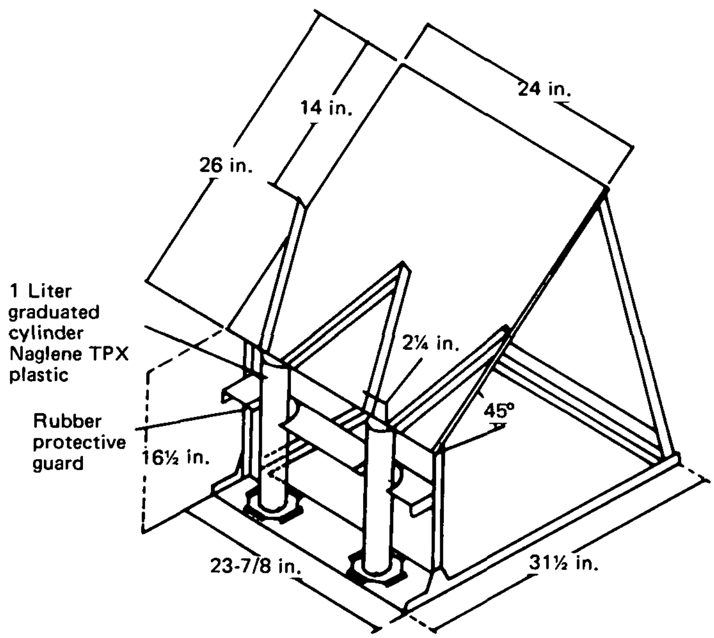


Figure 4-3.2.1 Aqueous Film Forming Foam Sample Collector

flow into the container. The foam nozzle shall be aimed off the side of the foam collector, adjusted to its normal operating pressure, and then moved so as to discharge foam onto the foam sample collector. As soon as the foam sample container has been completely filled with foam, the discharge nozzle shall be shut off and the timing of the 25 percent drainage started.

4-3.2.2.2 The foam sample container shall be removed from the base of foam collector, excess foam struck off the top of the foam container using a straight edge, and any remaining foam wiped from the outside surface of the container. The container shall then be placed on the balance. The total weight of the foam sample and container shall be determined to the nearest gram. The weight of the foam sample in the container shall be determined by subtracting the weight of the empty container from the weight of the container filled with the foam. The weight of the foam sample in grams shall be divided by four to obtain the equivalent 25 percent drainage volume in milliliters.

4-3.2.2.3* The foam sample container shall be placed on a level surface at a convenient height. At 30-second intervals, the level of accumulated solution in the bottom of the cylinder shall be noted and recorded. The drainage time versus the volume relationship shall be recorded until the 25 percent volume has been exceeded. The 25 percent drainage time shall then be interpolated from the data.

4-3.2.2.4 Foam samples shall be weighed to the nearest gram. The expansion of the foam shall be calculated by the following equation:

$$\text{Expansion:} = \frac{1000 \text{ ml}}{\text{full weight minus empty weight in grams}}$$

4-3.3 Test Method B.

4-3.3.1 Foam Sampling Apparatus.

4-3.3.1.1 The foam sample collector shall be constructed as specified in Figure 4-3.3.1.1.

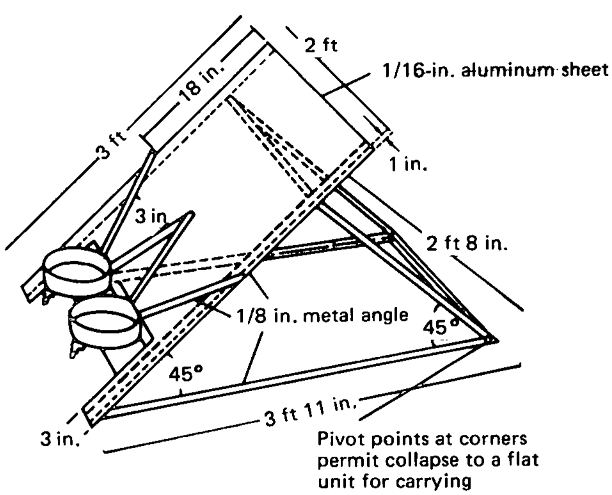


Figure 4-3.3.1.1 Protein and Fluoroprotein Foam Sample Collector

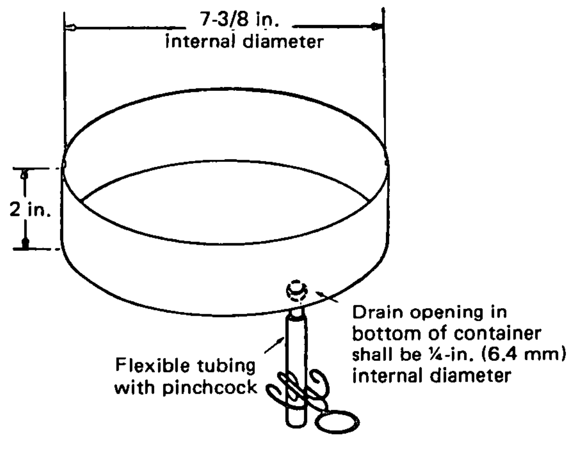


Figure 4-3.3.1.2 Protein and Fluoroprotein Foam Sample Container

4-3.3.1.2 The foam sample shall be collected in a container that shall conform to Figure 4-3.3.1.2.

4-3.3.2 Test Procedure.

4-3.3.2.1 The empty weight of the foam sample container shall be recorded to the nearest gram on a balance having a maximum capacity sufficient to weigh the foam sample container and the foam sample. The foam sample collector shall then be located in the center of the discharge pattern determined in Section 4-1. The foam sample container shall be positioned at the bottom of the foam collector so that the foam hitting the collector will flow into the container. The foam nozzle shall be aimed off the side of the foam collector, adjusted to its normal operating pressure, and then moved so as to discharge foam onto the foam sample collector. As soon as the foam sample container has been completely filled with foam, the discharge nozzle shall be shut off and the timing of the 25 percent drainage started.

4-3.3.2.2 The foam sample container shall be removed from the base of foam collector, excess foam struck off the top of the foam container using a straight edge, and any remaining foam wiped from the outside surface of the container. The container shall then be placed on the balance. The total weight of the foam sample and container shall be determined to the nearest gram. The weight of the foam sample in the container shall be determined by subtracting the weight of the empty container from the weight of the container filled with the foam. The weight of the foam sample in grams shall be divided by four to obtain the equivalent 25 percent drainage volume in milliliters.

4-3.3.2.3* The foam sample container shall be placed on a stand conforming to Figure 4-3.3.2.3. At 30-second intervals, the accumulated solution in the bottom of the pan shall be drawn off into a graduated cylinder and the amount recorded. The drainage time versus the volume relationship shall be recorded until the 25 percent volume has been exceeded. The 25 percent drainage time shall then be interpolated from the data.

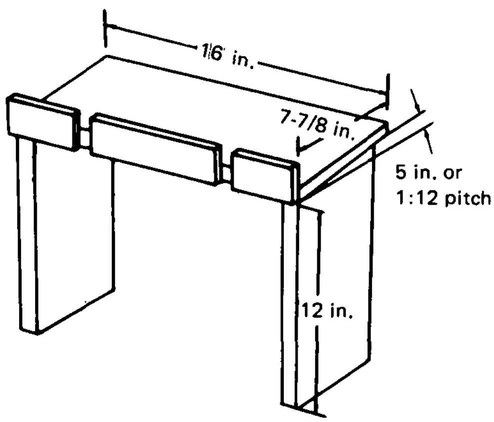


Figure 4-3.3.2.3 Protein and Fluoroprotein Foam Sample Container Stand

4-3.3.2.4 Foam samples shall be weighed to the nearest gram. The expansion of the foam shall be calculated by the following equation:

$$\text{Expansion:} = \frac{1400 \text{ ml}}{\text{full weight minus empty weight in grams}}$$

4-3.4 Test Method C.

4-3.4.1 Foam Sampling Apparatus.

4-3.4.1.1 The foam sample collector shall be constructed as specified in Figure 4-3.4.1.1.

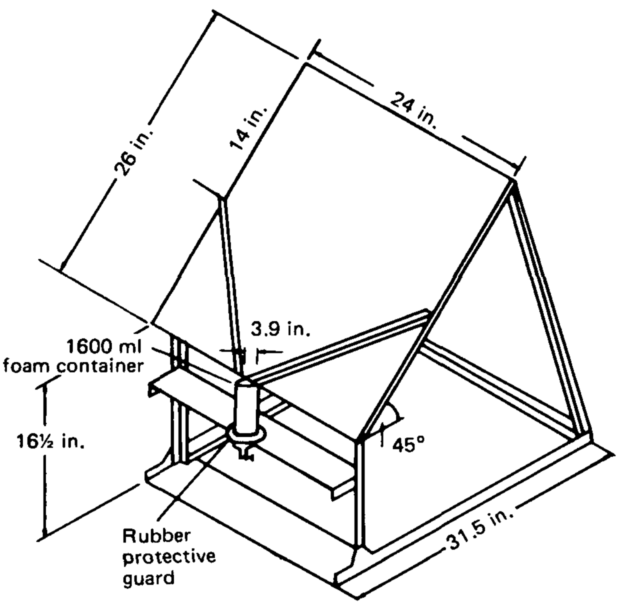


Figure 4-3.4.1.1 Foam Sample Collector

4-3.4.1.2 The foam sample shall be collected in a cylindrical 1600-ml container. The foam sample container shall be constructed as specified in Figure 4-3.4.1.2.

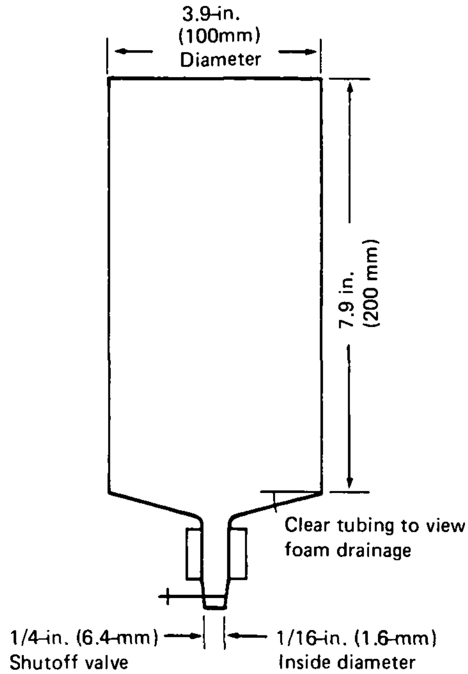


Figure 4-3.4.1.2 1600-ml Foam Sample Container

4-3.4.2 Test Procedure.

4-3.4.2.1 The empty weight of the foam sample container shall be recorded to the nearest gram on a balance having a maximum capacity sufficient to weigh the foam sample container, test stand, and the foam sample. The foam sample collector shall then be located in the center of the discharge pattern determined in Section 4-1. The foam sample container shall be positioned at the bottom of the foam collector so that the foam hitting the collector will flow into the container. The foam nozzle shall be aimed off the side of the foam collector, adjusted to its normal operating pressure, and then moved so as to discharge foam onto the foam sample collector. As soon as the foam sample container has been completely filled with foam, the discharge nozzle shall be shut off and the timing of the 25 percent drainage started.

4-3.4.2.2 The foam sample container shall be removed from the base of foam collector, excess foam struck off the top of the foam container using a straight edge, and any remaining foam wiped from the outside surface of the container. The container shall then be placed on the balance. The total weight of the foam sample and container shall be determined to the nearest gram. The weight of the foam sample in the container shall be determined by subtracting the weight of the empty container from the weight of the container filled with the foam. The weight of the foam sample in grams shall be divided by four to obtain the equivalent 25 percent drainage volume in milliliters.

4-3.4.2.3* The foam sample container shall then be placed on a test stand and a graduated cylinder placed below the drain spout. At 30-second intervals, the accumulated solution in the bottom of the foam sample container shall be drawn off into a graduated cylinder and the amount recorded. If the expected expansion ratio is more than 5:1, then a 100-ml graduated cylinder shall be used to collect the drainage, and if the expected expansion ratio is 5:1 or less, then a 250-ml graduated cylinder shall be used.

4-3.4.2.4* Foam samples shall be weighed to the nearest gram. The expansion of the foam shall be calculated by the following equation:

$$\text{Expansion:} = \frac{1600 \text{ ml}}{\text{full weight minus empty weight in grams}}$$

4-4 Foam Solution Concentration Determination.

4-4.1 A hand-held refractometer shall be used to measure the refractive index of the solution, from which the solution concentration may be calculated. Special care shall be taken when determining the concentration of AFFFs due to the very low refractive index exhibited by these products.

4-4.2* A calibration curve shall be prepared using the following apparatus:

(a) Three 100-milliliter graduates

(b) One measuring pipette (10-milliliter capacity)

(c) One 100-milliliter beaker

(d) One 500-milliliter beaker

(e) One hand-held refractometer - American Optical Co. Model No. 10430 or equivalent.

4-4.3* Using water and foam concentrate from the tanks of the vehicle to be tested, three standard solutions shall be made up by pipetting into three 100-milliliter graduated cylinders, volumes of foam concentrate in milliliters equal to:

(a) the nominal concentration of the foam concentrate

(b) ⅓ more than the nominal concentration

(c) ⅓ less than the nominal concentration.

The graduated cylinders shall then be filled to the 100-milliliter mark with the water. After thoroughly mixing, a refractive index reading shall be taken of each standard by placing a few drops of the solution on the refractometer prism, closing the cover plate, and observing the scale reading at the dark field intersection. A plot shall be made on graph paper of the scale reading against the known foam solution concentrates and shall serve as a calibration curve for this particular series of foam tests.

4-4.4 Portions of solution drained out during the previously described drainage rate test shall be used as a source of test sample for the concentration determination. Refractive index readings of the unknown shall be compared to the calibration curve and the corresponding foam solution concentration read from the graph.

4-5 Report of Results of Tests.

4-5.1* All test reports shall include a statement of the operating conditions, such as pressures, temperatures, wind velocities and direction in relation to vehicle position, and a full description of the materials and equipment used.

Chapter 5 Referenced Publications

5-1 The following document or portion thereof is referenced within this document and shall be considered part of the requirements of this document. The edition indicated for the reference shall be the current edition as of the date of the NFPA issuance of this document.

5-1.1* NFPA Publication.

NFPA 414-1984, *Standard for Aircraft Rescue and Fire Fighting Vehicles.*

Appendix A

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

A-1-3 Aqueous Film Forming Foam (AFFF) Concentrates. These concentrates utilize fluorochemical and hydrocarbon surfactants. The foam produced acts both as a barrier to exclude air or oxygen, and as a reservoir that releases a vapor-suppressing aqueous film with the ability to spread over the surface of most aviation fuels. This film-forming activity will continue as long as foam is present, but the foam blanket should not be relied on to be permanent and should be renewed from time to time during a lengthy rescue operation.

Fluoroprotein Foam Concentrates. These concentrates are essentially similar to protein foam concentrates with the addition of a fluorochemical surfactant, giving the foam greater tolerance to fuel contamination. They form a fluid air-excluding blanket of foam and may also deposit a vapor-suppressing aqueous film on some fuels.

Foam. Foams used for control and extinguishment of aircraft fires involving fuel spills are produced by incorporation of air into a solution of foam concentrate and water. Their characteristics, as indicated by expansion and drainage rate, are influenced by the amount of mechanical agitation to which the water, foam concentrate, and air are subjected. They extinguish fire by physically separating the fuel vapors from the heat and oxygen necessary for combustion, spreading over the surface of the fuel to effectively suppress vaporization and secure an extinguished area by protecting it from reignition. Foam, being essentially water, cools the surface of the fuel and any metal surfaces in the fuel. The solution drainage from some foams forms an aqueous film on most aviation fuels. It is advantageous for a foam blanket to re-seal if disrupted. It is essential that provision is made to continueously maintain the foam blanket during a lengthy rescue operation when there is any possibility of re-igntion of the fuel.

Protein Foam Concentrates. These concentrates consist primarily of protein hydrolysate with stabilizing additives to give good fire resistance, and other additives to enhance the properties of the foam concentrate and resist bacterial decomposition. They form a stable cohesive foam blanket on the fuel surface.

Foam liquid concentrates of different types or of different manufacturers should not be mixed unless it is first established that they are compatible. Protein and fluoroprotein foam concentrates, in particular, are generally not compatible with AFFF concentrates and should not be mixed, although foams generated separately from these concentrates are compatible and can be applied simultaneously to a fire. All foams used as primary agents are available for use at 3 percent and 6 percent concentrations, in fresh or salt water, and some are available for use at other concentrations such as one percent.

Aqueous film forming foams are generally considered to be dry chemical compatible. Some fluoroprotein foams have an acceptable degree of compatibility with certain dry chemical extinguishing agents. The user should establish through the agent manufacturer(s) that an acceptable degree of compatibility exists between any foam and dry chemical agents that are intended for use in combined application techniques.

The quality of water used in making foam might affect the foam's performance. No corrosion inhibitors, freezing point depressants, or any other additives should be used in the water supply without prior consultation and approval of the foam concentrate manufacturer.

Foams are produced in a number of ways. The method of foam production selected should be carefully weighed, considering the techniques best suited for the equipment concerned, the rates and patterns of discharge desired, and the manpower needed to properly utilize the foam capabilities of the vehicles. The principal methods of foam production are:

(a) *Nozzle Aspirating Systems.* Foam is produced by pumping a proportioned solution of water and foam liquid concentrate under pressure into a specialized discharge appliance or nozzle that draws in atmospheric air and mixes it with the solution. Various devices are used to shape the discharge pattern between a straight stream and a spray.

(b) *Inline Compressed Air Systems.* Air under pressure is injected into the proportioned solution of water and foam liquid concentrate, where it is mixed with the solution to form foam within the system piping. The air is supplied by a compressor on the vehicle. Nozzles serve only to distribute the foam in various patterns.

(c) *Inline Foam Pump Systems.* A proportioned solution of water and foam liquid concentrate is injected into the suction side of a positive displacement type pump which draws in atmospheric air and mixes it with the solution to generate foam. The foam is formed in the discharge piping as in the inline compresed air system. Nozzles serve only to distribute the foam in various patterns.

(d) *Inline Aspirating Systems.* Foam solution passes through an educator in the pump discharge line and aspirates air into the foam solution. This air is mixed with the solution to form foam in the discharge lines. Nozzles serve only to distribute the foam in various patterns.

(e) *Non-Aspirating Nozzles.* Certain conventional variable pattern nozzles used in structural fire fighing have been found to be effective for use with AFFF agents. Foam characteristics will differ from those produced when using aspirating nozzles.

CAUTION: Converting rescue and fire fighting vehicles to use a type of foam concentrate other than that for which they were initially designed should not be accomplished without consultation with the equipment manufacturer and without a thorough flushing of the agent and the complete foam-delivery system. Particular attention should be given to assuring that the system component materials are suitable for the particular concentrate being substituted and that, where necessary, the proportioning equipment is recalibrated and reset.

A-3-2.2 The amount of foam concentrate in the solution fed to the foam maker plays an important part, not only in the making of foam with the proper expansion and drainage rate, but also in making a fire-resistant foam. Therefore, it is essential that correct proportioning is maintained and that the concentration meets the required level even if the foam meets the minimum expansion and drainage time values at other levels of concentration.

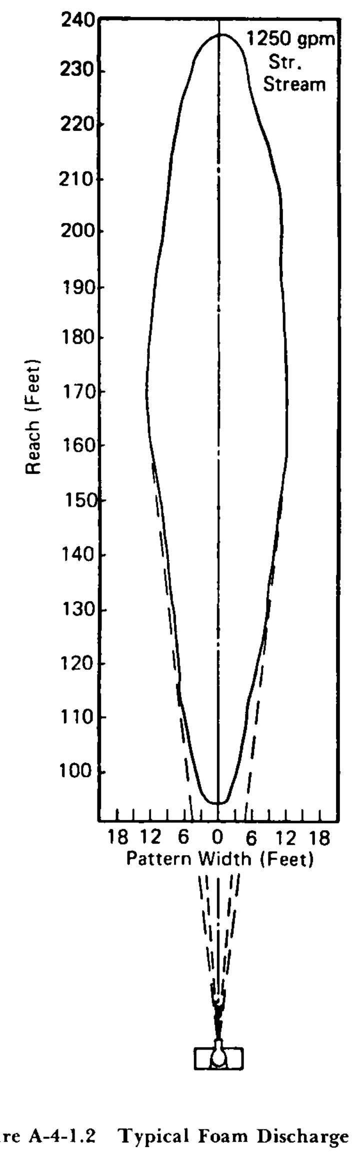


Figure A-4-1.2 Typical Foam Discharge Pattern

A-4-3.2.2.3 The following is an example calculation of drainage time. The net weight of the foam sample in the foam container is assumed to be 200 grams. Since one gram of foam solution occupies approximately one milliliter (ml), the total volume of foam solution contained in the given foam sample is 200 ml.

$$25\%\ \text{Drainage Volume} = \frac{\text{Volume of Solution}}{4} = \frac{200\ \text{ml}}{4} = 50\ \text{ml}$$

The time versus solution volume data is recorded as follows:

Time Min:sec	Assumed Drained Solution Volume in Milliliters
0:00	0
0:30	10
1:00	20
1:30	30
2:00	40
2:30	50
3:00	60

It is seen that the 25 percent volume of 50 ml. lies within the 2- to 3-minute period. The increment to be added to the lower value of 2 minutes is found by interpolation of the data:

$$\frac{50\ \text{ml (25\% Volume)} - 40\ \text{ml (2 min Volume)}}{60\ \text{ml (3 min Volume)} - 40\ \text{ml (2 min Volume)}} = \frac{10}{20} = 0.5$$

Therefore, the 25 percent drainage time is found by adding 0.5 min to 2.0 min, giving a final value of 2.5 min or 2 min 30 sec.

A-4-3.3.2.3 *(See A-4-3.2.2.3.)*

A-4-3.4.2.4 The following shows the calculation of expansion. The net weight of the foam sample (see drainage example) is assumed to be 200 grams; therefore, the volume of foam solution contained in the 1600 ml foam sample is 200 ml.

$$\text{Expansion} = \frac{\text{volume of foam}}{\text{volume of solution}} = \frac{1400\ \text{ml}}{200\ \text{ml}} = 7$$

A-4-4.2 (e) ATAGO Co. Ltd. Model No. N10, AO Model No. 10441, or equivalent showing 0-10 on the BRIX scale is recommended to enable low readings given by AFFF solutions to be read easily.

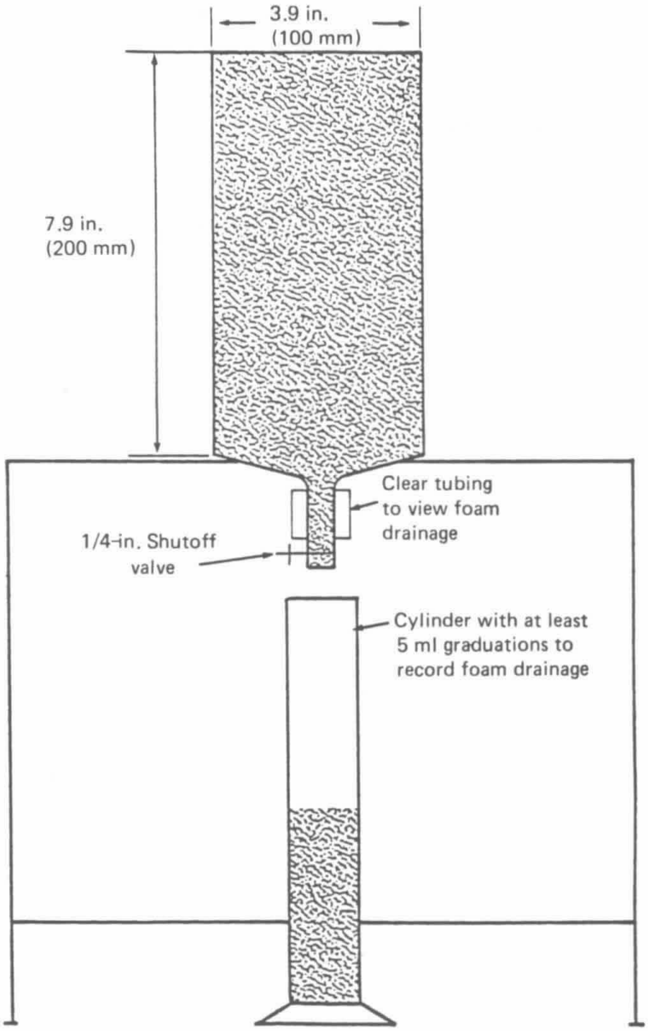


Figure A-4-3.4.2.3 1600 ml Foam Container and Stand

A-4-4.3 (a)

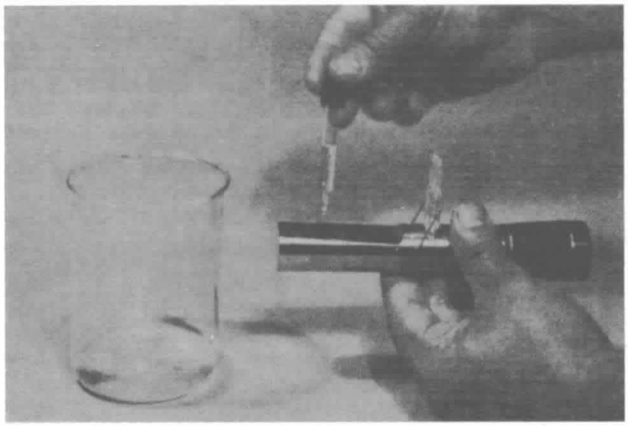


Figure A-4-4.3 (a) The index of refraction is measured by placing a few drops of the solution to be tested on the prism of a refractometer and closing the cover plate. This is a typical refractometer suitable for this purpose.

A-4-4.3 (b)

Figure 4-4.3 (b) When this type refractometer is held up to a light source, a reading is taken where the dark field intersects the numbered scale.

A-4-4.3 (c)

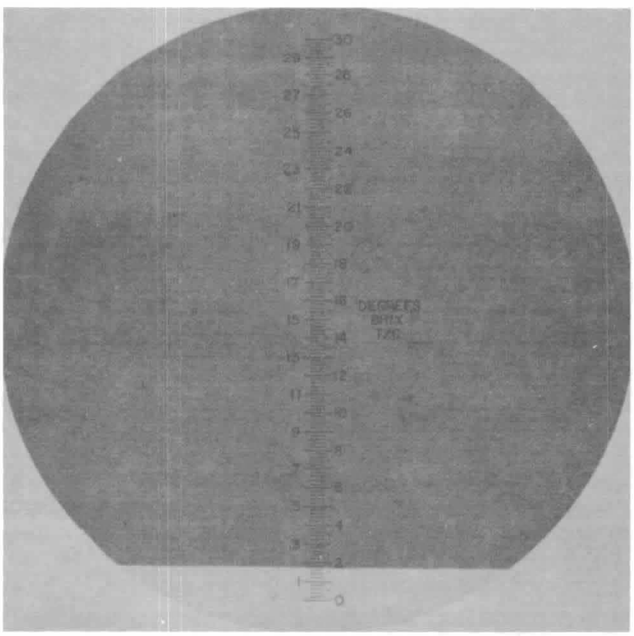


Figure A-4-4.3 (c) This illustrates the field of view looking into the refractometer illustrated in Figures A-4-4.3 (a) and A-4-4.3 (b) containing a 6 percent AFFF solution. The dark intersects the scale at 1.7 and this value is recorded as the reading for a 6 percent concentration.

A-4-5.1 Foam Physical Property Tests Work Sheet

FOAM PHYSICAL PROPERTY TESTS WORK SHEET
(In accordance with NFPA Standard 412)

DATE:..

TEST NO:................................

LOCATION: ....

TEST SUBJECT:..

....

....

VEHICLE:..

TYPE FOAM LIQUID CONCENTRATE:..

FOAM MAKER:.............................. PATTERN SETTING:..................

OPERATING PRESSURE:........................psi AT PUMP, NOZZLE

FLOW:........................gpm

AIR TEMP:....................°F WATER TEMP. ....°F

WIND:........mph DIRECTION RELATIVE TO PATTERN AXIS:......

Gross weight of full foam container*	........................grams
Weight of empty container	........................grams
Net weight of foam sample	........................grams

*Foam container must have the dimensions as specified in NFPA 412.

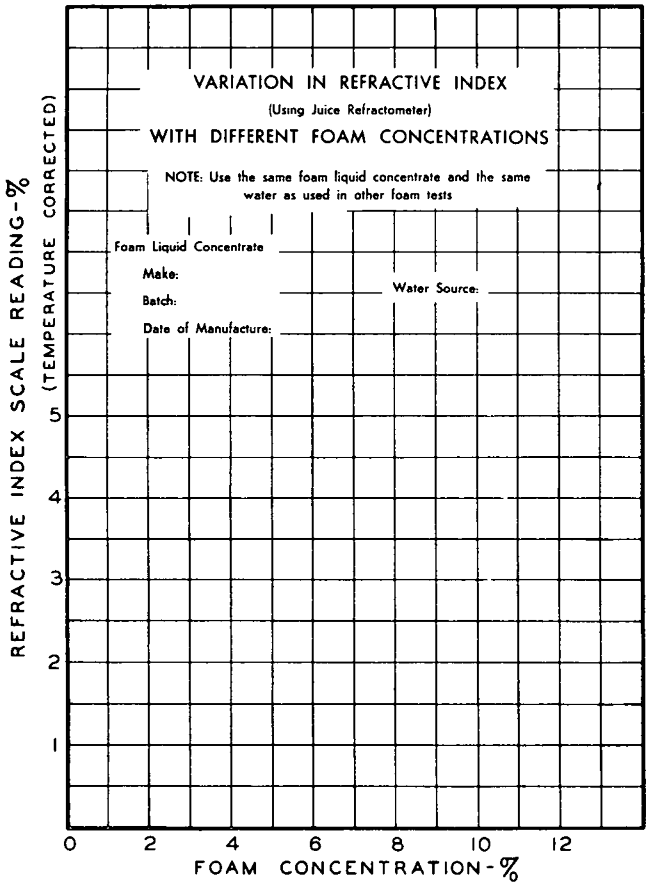
$$\text{Foam expansion} = \frac{\text{Volume of foam container}}{\text{Net weight of foam sample}}$$

$$= \frac{\text{............ml}}{\text{............grams (from above)}} = \text{............}$$

$$\text{25\% Volume} = \frac{\text{Net weight of foam sample}}{4}$$

$$= \frac{\text{............grams (from above)}}{4} = \text{............ milliliters}$$

A-4-5.1 *(continued)*



A-5-1.1 Available from National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

Appendix B

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

B-1 Foam Extinguishing System Capability.

B-1.1 The following is a suggested method for evaluating the basic extinguishing capability of the foam fire fighting system.

B-1.2 Basic Extinguishing Capability.

B-1.2.1 Foam performance is judged on two criteria: (1) ability for quick knockdown of flames and (2) ability to keep fuel area secure against re-ignition. To obtain meaningful information, it is necessary that the foam be applied at low rates per square foot of fuel surface. This will represent the performance to be expected when the system is pushed to its ultimate capability on a large fire. High application rates will overwhelm the fire and obscure any possible shortcomings. Fire tests sufficiently large to challenge the foam equipment are very costly and difficult to conduct without creating undue environmental problems. Therefore, an attempt is made in this standard to devise a restricted but still significant procedure.

B-1.2.2 A foam vehicle user might utilize the basic test procedure in several ways. For example, it might be desired to establish the minimum rate of foam application at which a fire can be extinguished. By using this rate and the time for extinguishment, the volume of water required to extinguish one unit fire area (square foot or square meter), and the maximum fire area the vehicle is capable of extinguishing, can be calculated. It should be kept in mind, however, that the most efficient use of water lends to long extinguishing times. In practice, a high application rate is required because it gives the most rapid knockdown of flame, although it will be less efficient in terms of agent consumed. Operation of the turret to achieve complete extinguishment is also wasteful of water. Generally, after the fire has been 90 percent extinguished, it is better to shut down the turret and complete the extinguishment by application of foam from handlines or by the application of one of the complementary agents.

B-1.2.3 A user might desire to compare his system on two different fuels or under several different weather conditions such as high winds, heavy rain, or extreme low temperatures, or with obstacles within the fire area. In this type of testing, care must be taken to change only one variable at a time. All other conditions must remain the same.

B-1.2.4 A user might desire to check his foam against its "as purchased" condition. Here the tests must be conducted under the same conditions as those prevailing during the original tests.

B-1.3 Turret or Hand Line Extinguishing Tests.

B-1.3.1 The exact size of the fire to be used is not critical; however, it should be not less than 100 sq ft (10 × 10 ft) in area. Large-scale testing has shown that larger fire areas do not necessarily require higher application rates or greater quantities of agent (foam) per unit area.

B-1.3.2 The choice of fuel is optional depending on the data desired. Gasolines are normally the most difficult fuels to extinguish, a Jet A (JP-5) the easiest. Jet B (JP-4) is a variable fuel without a definitive flash point.

B-1.3.3 Water may be used to level a large pit to ensure a level fuel area, and bare ground should be presoaked to prevent the loss of fuel. The amount of fuel is partially dependent on the length of preburn to be allowed. With preburn times of one minute, at least one gallon of fuel for each two square feet of area should be used.

B-1.3.4 Local clean air regulations might dictate the length of preburn as this is the period of greatest smoke generation.

B-1.3.5 Establishing and maintaining the desired rate of foam application will require some work and practice prior to the conducting of the fire test. The object is to sweep the turret or nozzle back and forth over the fire area at an even rate in order to apply the foam at the desired gallons per minute (gpm) per square foot.

B-1.3.6 The actual rate is checked by placing one foot square (or other known convenient size of known area) shallow pans near the edges of the fire area. After the foam discharge pattern has been swept back and forth over the fire area and pans for a measured period of time, the stream is shut off, the weight of the contents of each pan determined, and the application rate calculated. If the rate was too high, a faster rate and wider angle of sweep will be required and vice versa. Once the proper technique has been worked out, the fire is extinguished in the same manner. The pans can be used during the fire test to verify the application rate. NFPA 403 requires a rate of 0.13 gpm per square foot for AFFF, 0.20 gpm per square foot for protein foam, and 0.18 gpm per square foot for fluoroprotein foam.

B-1.3.7 The following calculations are typical of those used in the determination of the basic extinguishing capability of an aircraft rescue and fire fighting vehicle of 1000 gal water capacity:

Gross weight of pan with collected foam	412 oz
Empty weight of pan	350
Net weight of foam sample	62 oz

$$\text{Water collected} = \frac{\text{foam wt. oz}}{133.3} = \frac{62}{133.3} = 0.465 \text{ gallons}$$

$$\text{Total water applied} = \frac{\text{water collected, gal}}{\text{area of pan, ft}^2} = \frac{0.465}{3.5}$$

$$= 0.133 \text{ gal/ft}^2$$

$$\text{Basic extinguishing capability} = \frac{1000 \text{ gal}}{0.133 \text{ gal/ft}^2}$$

$$= 7600 \text{ ft}^2/1000 \text{ gal water}$$

B-1.4 Burnback Test.

B-1.4.1 The resistance of the foam blanket to the fire is important. Wind plays a big role in the determination of this property and repeat results are difficult to obtain with an outdoor test. Another factor, but one easier to control, is the size of the fire area at the start of re-ignition. To standardize this, a short section of stovepipe 12 in. in diameter is dropped into the foam blanket like a cookie cutter. The foam is removed from the inside, and the fuel surface is ignited and allowed to burn for one minute before the stovepipe is removed. The rate of enlargement of the fire is then observed. A long period of confinement is desired. The delay period after end of foam application and start of re-ignition may be varied, but for comparative tests, it must be kept constant.

B-1.4.2 Burnback resistance is related to the amount of foam that has been applied to the fire. A burnback test on a fire area that has been extinguished with a minimum application of foam will not afford a high level of protection.

B-1.4.3 To compare the degree of burnback protection of different agents and depths of foam, and to familiarize crew with the degree of protection afforded, repeated tests using varied delays between end of foam application and start of re-ignition are suggested.

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SUBMITTING PROPOSALS ON NFPA TECHNICAL COMMITTEE DOCUMENTS

Contact NFPA Standards Administration for final date for receipt of proposals on a specific document.

INSTRUCTIONS

Please use the forms which follow for submitting proposed amendments. Use a separate form for each proposal.

1. For each document on which you are proposing amendment indicate:
   (a) The number and title of the document
   (b) The specific section or paragraph.

2. Check the box indicating whether or not this proposal recommends new text, revised text, or to delete text.

3. In the space identified as "Proposal" include the wording you propose as new or revised text, or indicate if you wish to delete text.

4. In the space titled "Statement of Problem and Substantiation for Proposal" state the problem which will be resolved by your recommendation and give the specific reason for your proposal including copies of tests, research papers, fire experience, etc. If a statement is more than 200 words in length, the technical committee is authorized to abstract it for the Technical Committee Report.

5. Check the box indicating whether or not this proposal is original material, and if it is not, indicate source.

6. If supplementary material (photographs, diagrams, reports, etc.) is included, you may be required to submit sufficient copies for all members and alternates of the technical committee.

NOTE: The NFPA Regulations Governing Committee Projects in Paragraph 10-10 state: Each proposal shall be submitted to the Council Secretary and shall include:

(a) identification of the submitter and his affiliation (Committee, organization, company) where appropriate, and

(b) identification of the document, paragraph of the document to which the proposal is directed, and

(c) a statement of the problem and substantiation for the proposal, and

(d) proposed text of proposal, including the wording to be added, revised (and how revised), or deleted.

FORM FOR PROPOSALS ON NFPA TECHNICAL COMMITTEE DOCUMENTS

Mail to: Secretary, Standards Council
National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269

Date 5/18/85 Name John B. Smith Tel. No. 617-555-1212

Address 9 Seattle St., Seattle, WA 02255

Representing (Please indicate organization, company or self) Fire Marshals Assn. of North America

1. a) Document Title: Protective Signaling Systems NFPA No. & Year NFPA 72D

   b) Section/Paragraph: 2-7.1 (Exception)

2. Proposal recommends: (Check one)
   - ☐ new text
   - ☐ revised text
   - ☒ deleted text.

3. Proposal (include proposed new or revised wording, or identification of wording to be deleted):

   Delete exception.

4. Statement of Problem and Substantiation for Proposal:

   A properly installed and maintained system should be free of ground faults. The occurrence of one or more ground faults should be required to cause a "trouble" signal because it indicates a condition that could contribute to future malfunction of the system. Ground fault protection has been widely available on these systems for years and its cost is negligible. Requiring it on all systems will promote better installations, maintenance and reliability.

5. ☒ This Proposal is original material.
   ☐ This Proposal is not original material; its source (if known) is as follows: ______

(Note: Original material is considered to be the submitter's own idea based on or as a result of his own experience, thought, or research and, to the best of his knowledge, is not copied from another source.)

I agree to give NFPA all and full rights, including rights of copyright, in this Proposal and I understand that I acquire no rights in any publication of NFPA in which this Proposal in this or another similar or analogous form is used.

John B. Smith

Signature

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