

NFPA 1145

Guide for the Use of Class A Foams in Manual Structural Fire Fighting 2000 Edition



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An International Codes and Standards Organization

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Guide for the

Use of Class A Foams in Manual Structural Fire Fighting

2000 Edition

This edition of NFPA 1145, *Guide for the Use of Class A Foams in Manual Structural Fire Fighting*, was prepared by the Technical Committee on Forest and Rural Fire Protection, and acted on by the National Fire Protection Association, Inc., at its World Fire Safety Congress and Exposition™ held May 14–17, 2000, in Denver, CO. It was issued by the Standards Council on July 20, 2000, with an effective date of August 18, 2000.

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Origin and Development of NFPA 1145

At the request of the NFPA Standards Council in 1998, the Technical Committee on Forest and Rural Fire Protection developed NFPA 1145 as a guide to assist fire departments and wild-land fire agencies in the use of Class A foams for structural fire suppression and protection. The Committee acknowledges its appreciation to the task group who drafted the initial document, relying heavily on the group's experience and knowledge of Class A foam applications.

The Committee initially considered the document might become a standard on the application of Class A foam but, because of the still evolving use of Class A foam and its associated hardware and proportioning systems, the Committee decided that a guide to the use would be of greater benefit to the many fire departments and agencies that are beginning to explore Class A foam as a valuable and effective agent that can be used for structural fire protection as well as fire suppression and extinguishment.

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on fire protection for rural, suburban, forest, grass, brush, and tundra areas. This Committee shall also have primary responsibility for documents on Class A foam and its utilization for all wildland and structural fire fighting. This excludes fixed fire protection 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 Appendix A.

Information on referenced publications can be found in Chapter 6 and Appendix B.

Chapter 1 Introduction

1.1 Foreword. Fire-fighting foam is a mass of air-filled bubbles formed by mixing air with a surfactant solution. Surfactant solutions are prepared by proportioning a foam concentrate with water. Fire-fighting foams have been designed for use on different fuel types. There are two broad categories of fire-fighting foam — Class A and Class B. Class B foams are designed for use on flammable and combustible liquids and are discussed in NFPA 11, *Standard for Low-Expansion Foam*. Class A foams are best suited for use on ordinary combustibles (Class A fuels) and are not recommended for use on Class B fuels unless listed for this purpose. Class A foam concentrates, when mixed with water at concentrations in the range of 0.1 to 1.0 percent by volume, produce an array of foam solutions and foams. Class A foam used in manually fighting structural fire is discussed in this guide.

1.1.1 Although shown to be effective as early as the 1930s, fire-fighting foam was not generally used on Class A fuels until the mid 1980s. By that time, improvements in foam concentrate and application systems had progressed to the point where use was practical and growing. Since that time, a number of effective Class A foam concentrates and an array of generation and application hardware have been developed and optimized. For more information on Class A foam and equipment, see NFPA 1150, *Standard on Fire-Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas*; NFPA 1901, *Standard for Automotive Fire Apparatus*; and NFPA 1906, *Standard for Wildland Fire Apparatus*. The resulting systems use Class A additives to produce foams that are applied aerially from water-scooping fixed- and rotary-wing aircraft and from ground engines using foam proportioners, aerating nozzles, and compressed air foam systems (CAFS). The resulting foams are effective on fires in the variety of fuels found in wildlands and in the rural/urban interface.

1.1.2 Class A foams can be characterized by expansion ratio, drain time, and appearance. It is important to be able to identify the type of foam being produced based on the foam's appearance and to understand which type of foam is needed for a given fire situation. Wet and fluid foams contain more water per unit volume than dry foams and are consequently more effective in fire extinguishment. Dry foams may, however, be more appropriately used in many situations for exposure protection due to their longer drain times and adhesion to vertical surfaces. Class A foams can have significantly different fire extinguishment and exposure protection capabilities, depending on their expansion ratio and drain time. Thus, the

most effective type of foam will depend on the type and geometry of the fuel involved.

1.1.3 The effectiveness of Class A foam primarily depends on the amount of water that it brings into contact with the fuel/fire interface for insulating or cooling, or both. Aqueous solutions that contain low concentrations of the foam additive exhibit surface tensions less than half that of water alone. This reduction improves the penetrating capability of the solution, allowing a greater amount of the applied liquid to be captured and sorbed by porous fuels. As increasing amounts of air are introduced into the foam solution, the foam consistency changes from a wet to a fluid and, finally, to a dry or stiff, lather-like foam.

1.1.4 The fire fighter should be aware that by changing the characteristics of the foam, the rate of drained solution available to wet the fuel will change. Fast draining foams provide more solution to the fuel in a shorter time frame than do slow draining foams. Consequently, more is not always better. The fire fighter has the ability to change the characteristics of the foam to meet different situations. This can be accomplished by changing the mix ratio, the type or operating pressure of the foam hardware, or the application technique.

1.1.5 Mix ratio affects physical properties such as surface tension and the wetting ability of the foam solution. Mix ratios in the range of 0.1 to 1.0 percent significantly reduce surface tension values below that exhibited by water, resulting in improved spreading of the applied solution and wetting of the fuel.

1.1.6 Mix ratio also affects the characteristics of the foam that are produced with a given foam-generating system. The foam expansion and the drain time control where and how fast the foam solution is released to the fuel. Foam-generating systems that increase the amount of air captured within the foam solution generally result in greater expansion and slower drain times. Higher mix ratios generally increase the ease of obtaining more highly expanded foams with slower drain times, which decreases the rate of penetration and wetting.

1.1.7 Users of this guide should understand that the use of Class A foam in structural fire suppression is relatively new and very dynamic. As a result, available materials and products are rapidly changing and developing.

1.2 Scope.

1.2.1 This document presents fundamental information for agencies planning to use Class A foam for structural fire fighting and protection. It presents necessary and useful information on foam properties and characteristics, proportioning and discharge hardware, application techniques, and safety considerations.

1.2.2 For agent and application criteria, specific reference should be made to NFPA 1150, *Standard on Fire-Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas*; NFPA 1901, *Standard for Automotive Fire Apparatus*; and NFPA 1906, *Standard for Wildland Fire Apparatus*.

1.2.3 This document does not apply to the use of Class A foam in sprinkler systems or for its use on fires involving Class B flammable or combustible liquids.

1.2.4 This document is not intended to discourage the use of future technologies and practices provided that the recommended level of safety is not lessened.

1.3 Purpose. The primary purpose of this document is to present information on the safe and effective use of Class A foam, as defined by NFPA 1150, *Standard on Fire-Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas*, for manual structural fire fighting and protection.

1.4 Definitions.

1.4.1 Aspirate. To draw in air; nozzle-aspirating systems draw air into the nozzle to mix with the foam solution.

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

1.4.3 Batch Mix. The manual addition of foam concentrate to a water storage container or tank to make foam solution.

1.4.4 Bubble. The building block of foam composed of a film of fluid enclosing a volume of air.

1.4.5 Class A Fire. A fire in Class A fuels.

1.4.6* Class A Foam. An aggregation of bubbles having a lower density than water, generally referred to as foam in this document.

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

1.4.8 Compressed Air Foam System (CAFS). A foam system that combines air under pressure with foam solution to create foam in the hose or a mixing chamber. A CAFS consists of a pressurized air source, water pump, means to apply the foam (hose, nozzle, turret, etc.), and source of foam solution.

1.4.9 Direct Attack. Fire-fighting operations involving the application of extinguishing agents directly onto the burning fuel.

1.4.10 Drain Time. The time that it takes for a specified portion (customarily 25 percent) of the total solution contained in the foam to revert to liquid and drain out of the bubble structure.

1.4.11 Eductor. A device that uses the Venturi principle to introduce a proportionate quantity of foam concentrate into a water flow. The pressure at the throat is below atmospheric pressure, allowing concentrate at atmospheric pressure in storage to flow into the water.

1.4.12 Expansion (or Expansion Ratio). The ratio of the volume of the foam in its aerated state to the original volume of the nonaerated foam solution.

1.4.13 Exposure Protection. Application of an agent to uninvolved areas to limit absorption of heat to a level that will minimize damage and resist ignition, whether the source of heat is external or internal.

1.4.14 Fire Situation. Factors pertaining to a fire that affect decisions relating to fire suppression including, but not limited to, fuel types and geometry, fire characteristics and behavior, life safety hazard, type of structure, exposure, and weather.

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

1.4.15.1 Foam, High-Expansion. Foams with expansion ratios ranging from 200:1 to approximately 1000:1.

1.4.15.2 Foam, Low-Expansion. Foams with expansion ratios up to 20:1.

1.4.15.3 Foam, Medium-Expansion. Foams with expansion ratios ranging from 20:1 to 200:1.

1.4.16 Foam Blanket. A covering of foam over the surface of combustible materials to provide extinguishment and/or prevent ignition.

1.4.17 Foam Concentrate. The foaming agent as received from the supplier that, when mixed with water, becomes foam solution.

1.4.18 Foam Concentrate Proportioning System. The hardware and techniques used to mix concentrate with water to make foam solution.

1.4.19 Foam-Producing System. A collection of equipment that, by various means, combines water and a controlled amount of foam concentrate into a foam solution and then aerates that solution.

1.4.20 Foam Solution. A homogeneous mixture of foam concentrate and water, in the mix ratio required to meet the needs of the user, to which air is added to produce foam.

1.4.21 High-Energy Foam System. A device or system that adds the energy of a pressurized air source to the energy of a pressurized water source to create foam.

1.4.22 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.

1.4.23 Injector. A device used in a discharge or intake line to force foam concentrate into the water stream.

1.4.24 Low-Energy Foam System. A device or system that uses only energy produced by the velocity of the water stream to create foam.

1.4.25 Mix Ratio. The ratio of foam concentrate to water, usually expressed as a volumetric percentage.

1.4.26 Mixing Chamber. A device used to mix foam solution and air.

1.4.27 Mop-up. See Overhaul.

1.4.28 Overhaul. The final stages of fire extinguishment, following knockdown of the main body of fire, during which pockets of fire are sought out to complete extinguishment. Also referred to as mop-up.

1.4.29 Proportioning Ratio. See Mix Ratio.

1.4.30 scfm (standard cubic feet per minute). An expression of airflow rate in which the airflow rate is corrected to standard temperature and pressure.

1.4.31 Scrubbing. A process of agitating foam solution and air in a confined space such as a hose, pipe, or mixing chamber to produce bubbles.

1.4.32 Slug Flow. The discharge of distinct pockets of air and water or weak foam solution due to the insufficient or uneven mixing of foam concentrate, water, and air in a compressed air foam system (CAFS).

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

1.4.34 Surge. The sudden decompression of a discharge line caused by the rapid opening of the discharge appliance.

1.4.35 Wetting Ability. The ability of solution to penetrate and soak into a solid.

1.4.36 Wetting Agent. A chemical added to water to reduce surface tension, allowing the solution to spread and penetrate more effectively than water alone.

Chapter 2 Foam Properties and Characteristics

2.1 Foam Concentrate.

2.1.1 Acceptability. Only Class A foam concentrates that meet the requirements of NFPA 1150, *Standard on Fire-Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas*, as demonstrated by the results of testing conducted by a qualified independent laboratory, are acceptable for use in structural fire fighting.

2.1.2 Handling.

2.1.2.1 Storage.

2.1.2.1.1* Class A foam concentrates intended for immediate use in fire-fighting operations should be stored above 40°F (4°C). Concentrate not intended for immediate use can be stored in sealed containers for at least 1 year at ambient outdoor temperatures with no significant impact on performance. Storage for longer periods would not be expected to affect performance, but visual inspection and testing according to 2.1.4 should be conducted annually to confirm acceptability.

2.1.2.1.2 Alternative storage containers, vessels, and transfer systems should be fabricated in accordance with NFPA 1901, *Standard for Automotive Fire Apparatus*. Foam concentrates contain solvents that are susceptible to evaporation and should be stored at all times in closed containers.

2.1.2.2 Personal Protection.

2.1.2.2.1 The user should obtain a current Material Safety Data Sheet (MSDS) for the Class A foam concentrate and keep the sheet immediately available. The use and handling recommendations described therein should be followed.

2.1.2.2.2 All personnel involved in handling foam concentrate should be trained with respect to occupational safety and health and environmental impact. All personnel should follow the manufacturer's recommendations on the product label and on the MSDS.

Class A foam concentrates are generally irritating to both the eyes and skin. Prolonged contact with concentrate should be avoided. Showering is recommended as soon as possible after prolonged contact with concentrate. Clothing wetted with concentrate should be changed and washed. Soiled clothes should be cleaned on a daily basis. Personnel handling foam concentrates should wear protective clothing including eye protection and should avoid ingestion.

Individuals who have ingested a concentrate should seek medical attention as soon as possible. Skin or eyes that come in contact with a concentrate should be rinsed and washed immediately. Freshwater should be available on site for this purpose.

2.1.2.3 Environmental Protection.

2.1.2.3.1 The user should consult a copy of the current MSDS for the Class A foam concentrate to be used in regard to environmental concerns. (See Appendix B.)

2.1.2.3.2 Class A foam concentrates consist primarily of readily biodegradable surfactants. However, significant quan-

ties of unrecovered foam concentrate can negatively impact the ecosystem and municipal water treatment operations.

2.1.2.3.3 When filling concentrate reservoirs, proper methods and equipment should be used to avoid water source contamination. Tanks should not leak, and operators should avoid overflow spills and discharge hose spills. All operations involving the handling of foam concentrate should be located so that concentrate does not come closer than 100 ft (30 m) to bodies of water. Check valves should be provided to isolate and prevent backflow to water supplies.

2.1.2.3.4 Foam concentrate spills should be contained or absorbed, or both, and disposed of in accordance with the authority having jurisdiction.

2.1.3 Compatibility. Different brands of Class A foam concentrates might be incompatible and should not be mixed. When changing from one brand to another, the operator should flush the system thoroughly with water to remove residual concentrate. Class A foam concentrates should not be mixed with Class B foam concentrates.

2.1.4 Inspection. Class A foam concentrate should be inspected visually for nonhomogeneity, the presence of foreign matter, or crystals prior to transfer and use. In addition, the foaming properties of foam concentrate should be tested annually in accordance with NFPA 1150, *Standard on Fire-Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas*. If the concentrate contains foreign matter or crystals or is nonhomogeneous, or if it is incapable of producing acceptable foam, the manufacturer should be contacted.

2.2 Foam Solution.

2.2.1 Mix Ratio. The mix ratio of foam concentrate, as specified by NFPA 1150, *Standard on Fire-Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas*, is between 0.1 and 1.0 percent by volume. The mix ratio can be altered within this range, depending on the specific foam-generating hardware or system used, to create the desired foam properties, expansion, and drain time, depending on the fuel and fire application.

2.2.2 Water. Water temperature and water quality have little effect on the surface tension or penetrating ability of foam solution. However, they can have an impact on foam generation and foam characteristics. (See Section 2.3.)

2.2.3 Handling. Most foam solutions are generated on demand. However, in some instances a batch or pre-mix system may be used. Storage time, contamination, and bacteria can have significant impacts on foam development. Biodegradability is a desirable characteristic of foam solutions. Because of biodegradation, storage for more than a few days may result in deterioration of foam properties. It is recommended that the foaming characteristics of aged foam solutions be tested according to NFPA 1150, *Standard on Fire-Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas*, prior to use. Even when foam properties are affected, the surface tension and penetrating ability of foam solution may be unaffected and may be used when wetting characteristics are desired.

2.2.3.1 Personal Protection.

2.2.3.1.1 The user should obtain a copy of a current MSDS for the Class A foam concentrate to be used. Any handling recommendations for foam solutions therein should be followed.

2.2.3.1.2 All personnel involved in handling, mixing, and applying foam solutions should be trained in the proper procedure with respect to occupational safety and health and environmental impact. All personnel should follow the manufacturer's recommendations on the product label and on the MSDS.

Class A foam solutions are generally irritating to the eyes and skin. Prolonged contact with the solution should be avoided. Rinsing affected areas or showering is recommended as soon as practicable after contact occurs. Contaminated clothing should be changed and washed. Foam solution should not be ingested. If foam solution is ingested, the MSDS should be consulted for recommended treatment. Human health risk assessments are available and may be consulted for additional information. (See Appendix B.)

2.2.3.2 Environmental Protection. The environmental impacts of foam solutions are less than those of foam concentrates (see 2.1.2.3). However, foam solutions can have a detrimental impact on water quality, fish, and other aquatic plants and animals. Discharge of foam solution into natural waters or storm drains should be avoided whenever possible. Many factors are involved in determining the ultimate ecological impact of these chemicals. Environmental risk assessments are available and can be consulted for additional information. (See Appendix B.)

2.2.4 Compatibility. Although Class A foam concentrates might not be compatible with each other, foam solutions prepared from different concentrate brands are rarely incompatible.

2.3 Foam.

2.3.1 Water Quality Impact. Water temperature and quality, including hardness, affect foam properties such as expansion and drain time. Individual foam brands might behave differently in this regard and their characteristics should be considered when a specific type of foam is desired. Although Class A foam solutions are normally prepared with fresh water, there are occasions when salt or brackish water is used. The compatibility of specific brands with salt or brackish

water should be predetermined. Because the characteristics of individual brands vary, foam development is likely to be affected.

2.3.2 Foam Type. Class A foams can be characterized by expansion ratio, drain time, and consistency. Class A foams can have significantly different fire extinguishment and exposure protection capabilities, depending on their expansion ratio and drain time. It is important to be able to identify the type of foam being produced and to understand which type of foam is needed for a given fire situation. For simplification, low-expansion Class A foams are generally described as one of three types: wet, fluid, or stiff. (See Table 2.3.2.)

The type of foam used in fire-fighting operations has a major impact on its effectiveness. Three major factors impact foam type: mix ratio, type of foam generating system, and its operating parameters. Other factors that affect foam type include water quality and temperature as well as atmospheric conditions such as humidity, temperature, and wind.

2.3.2.1 Wet Foam. Wet foam can range from a foam solution that has an expansion ratio of 1:1 (no expansion) and a 25 percent drain time of 0 second to a watery mass of large and small bubbles that lack body. Wet foams have an expansion ratio of $\leq 5:1$ and a 25 percent drain time of ≤ 30 seconds. Wet foams can be used for direct and indirect fire attack. Wet foams are well suited for penetrating fuels, making them an ideal overhaul tool. Wet foams can be generated with all types of nozzles and systems.

2.3.2.2 Fluid Foam. Fluid foams have an appearance similar to watery shaving lather, with expansion ratios from 5:1 to 10:1, and 25 percent drain times of typically ≤ 90 seconds. Fluid foams can be used for direct and indirect fire attack. Fluid foams can be used to coat fuel surfaces and to effectively apply to vertical and horizontal surfaces to provide cooling for extinguishment or for short-term exposure protection. Fluid foams would typically be generated with aspirating nozzles or compressed air foam systems (CAFS).

Table 2.3.2 Typical Foam Characteristics

Foam Type	Low Expansion			Medium Expansion	High Expansion
Characteristic	Wet	Fluid	Stiff or dry		
Expansion ratio	1-5	5-10	10-20	20-200	200-1000
Consistency	Watery, sloppy	Watery shaving lather, sloppy	Dry or stiff lather	Dry foam, medium to large bubbles	Very dry foam, large bubbles
25% Drain time (sec)	<30	30-90	90-120	>120	>300
Generator	Non-aspirating, aspirating, CAFS	Aspirating, CAFS	CAFS	Large screened foam tubes	High-expansion generator
Usage	← Direct/indirect attack →			Indirect attack	
	Penetration overhaul	↔	Exposure protection, blanketing	Exposure protection, blanketing, fill voids, overhaul	Fill voids and spaces

2.3.2.3 Stiff or Dry Foam. Stiff foams have the appearance of shaving lather, expansion ratios greater than 10:1, and drain times greater than fluid foam. The structure of a stiff foam consists of uniform, small bubbles. Given the higher expansion ratios of stiff foam, the foam structure contains a large volume of air. Stiff foams are ideally suited for exposure protection and blanketing operations, especially on vertical and inverted surfaces. Stiff foams are typically generated by a CAFS discharged through an open ball valve.

2.3.3 Personal Protection. All personnel involved in handling, mixing, and applying foams should be trained in the proper procedure with respect to occupational safety and health and fire fighting with Class A foams. All personnel should follow the manufacturer's recommendations on the product label and on the MSDS.

Personnel handling foam should wear protective clothing, including eye protection, and should avoid ingestion. Foams can cause eye irritation and dryness of skin.

2.3.4 Environmental Protection. Refer to 2.2.3.2.

Chapter 3 Hardware

3.1 General. When Class A foam is to be manually applied for structural fire fighting, the hardware used to produce it

should comply with the applicable sections of this chapter and with the following NFPA documents: NFPA 11, *Standard for Low-Expansion Foam*; NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*; NFPA 1901, *Standard for Automotive Fire Apparatus*; NFPA 1906, *Standard for Wildland Fire Apparatus*; NFPA 1961, *Standard on Fire Hose*; NFPA 1962, *Standard for the Care, Use, and Service Testing of Fire Hose Including Couplings and Nozzles*; NFPA 1963, *Standard for Fire Hose Connections*; and NFPA 1964, *Standard for Spray Nozzles (Shutoff and Tip)*.

Class A foam concentrates and solutions have detergent-like properties and can remove lubricants from equipment such as pumps, seals, valves, and nozzles that come in contact with them. The manufacturer of the foam concentrate or equipment should be consulted for recommended lubricants, packing materials, or both.

For detailed information on the following foam proportioning and generating systems, see NFPA 1901, *Standard for Automotive Fire Apparatus*, and NFPA 1906, *Standard for Wildland Fire Apparatus*, respectively.

3.2* Proportioning. Except for batch mixing, proportioning systems that operate in the range of 0.1 to 1.0 percent foam solutions are available at either variable or fixed proportioning rates. It is recommended that systems that allow both variable water flow rates and mix ratios be used for proportioning Class A foam solutions. (See Table 3.2.)

Table 3.2 Operating Characteristics of Proportioning Methods

Operating Characteristics	Proportioning Methods							
	Manually Regulated				Automatically Regulated			
	Manual Batch Mixing	Adjustable in-Line Eductor	Intake-side Regulator	Around-the-Pump Propportioner	Balanced-Pressure Bladder Tank	Balanced Pressure Pump	Electronically Controlled Direct Injection	Water-Powered Injection
Maintain desired mix ratio despite changes in water flow and pressure					X	X	X	X
Unlimited hose length	X		X	X	X	X	X	X
Unlimited number of hose lines	X		X	X	X	X	X	X
Easily adjusted mix ratios			X	X	X	X	X	X
No moving parts	X	X	X	X	X			
No loss in water flow or pressure	X		X				X	

Table 3.2 Operating Characteristics of Proportioning Methods (Continued)

Operating Characteristics	Proportioning Methods							
	Manually Regulated				Automatically Regulated			
	Manual Batch Mixing	Adjustable in-Line Eductor	Intake-side Regulator	Around-the-Pump Proportioner	Balanced-Pressure Bladder Tank	Balanced Pressure Pump	Electronically Controlled Direct Injection	Water-Powered Injection
Introduces foam concentrate into water tank	X		X	X				
Potential loss of pump prime and/or cavitation	X		X	X				
Potential discontinuity of foam supply	X				X			
Potentially inconsistent mix ratio	X	X	X	X				
Potential solution degradation during storage	X							
Specific water flow and pressure requirements		X						
Limited nozzle elevation		X						
Depends on pump vacuum			X					
Requires auxiliary power						X	X	

3.2.1 Batch Mixing. Batch mixing refers to a method where a calculated quantity of foam concentrate is manually added to a known quantity of water in a storage container or tank, with mild agitation, to prepare a uniform foam solution.

3.2.1.1 Water. Water for manual batch mixing should be transferred from the source to the mix tank in such a manner that backflow is prevented. For accurate proportioning, the water tank should be filled to capacity or to a predetermined volume.

3.2.1.2 Concentrate Storage. Class A foam concentrate should be stored in the original container or in containers

that meet the recommendations of the manufacturer. Because foam concentrates evaporate, they should be stored in sealed containers. Intermixing of brands should be avoided.

3.2.1.3 Solution. Some mild agitation will generally be required to obtain a homogeneous foam solution. Minimal recirculation is generally sufficient. Violent agitation will cause excessive foam development within the mix tank and can result in overflowing, tank level gauge misreading, loss of pump prime, and so forth.

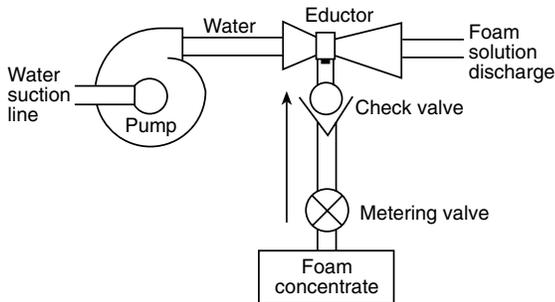
CAFS-generated foam can be used for interior and exterior attack (both direct or indirect), exposure protection, and

overhaul. Unless specifically designed for the purpose, the use of standpipe systems or fixed aerial apparatus piping might be detrimental to the quality of the foam, the system, or both. Elevation differences between the nozzle and the pump or hose-lay length or both can impact the quality of the CAFS-produced foam. Radical changes in the flow direction or conduit diameter can adversely affect foam quality.

3.2.2 Manually Regulated Proportioning System. A proportioning system that requires operator adjustment to maintain the mix ratio when there is a change of flow or pressure through the proportioner is referred to as a *manually regulated proportioning system*.

3.2.2.1 Adjustable In-Line Eductor. In an in-line eductor system, water is forced through the eductor venturi by water pump discharge pressure, creating a vacuum that causes foam concentrate to be drawn into the eductor at the mix ratio as determined by the metering orifice setting. In-line eductors are available in a by-pass configuration that allows the operator to choose between water and foam solution. The flow rate of the discharge nozzle should be the same as the eductor. This should be taken into account when using adjustable flow-rate nozzles with eductor systems. If incorrect mix ratios (from too rich to no concentrate at all) are to be avoided, adjustment by the operator may be required to compensate for changes in water flow. The eductor manufacturer's operational manual should be consulted for inlet pressure requirements and hose line and nozzle parameters. (See Figure 3.2.2.1.)

FIGURE 3.2.2.1 Adjustable in-line eductor. (Reprinted courtesy of National Wildfire Coordinating Group.)



3.2.2.2 Intake Side Regulator. In an intake side regulator, vacuum created by the water pump draws foam concentrate directly into the pump intake. The regulator requires adjustment to compensate for changes in water flow. Refer to the manufacturer's operational recommendations for accurate use and system limitations. (See Figure 3.2.2.2.)

3.2.2.3 Around-the-Pump Proportioner. In this system, an eductor is installed between the water pump discharge and the intake. A small flow of water from the water pump discharge passes through the eductor, creating a vacuum that causes foam concentrate to be drawn into the eductor and discharged into the pump intake. The around-the-pump proportioner requires adjustment by the operator to compensate for changes in water flow and pressure. (See Figure 3.2.2.3.)

FIGURE 3.2.2.2 Intake side regulator. (Reprinted courtesy of National Wildfire Coordinating Group.)

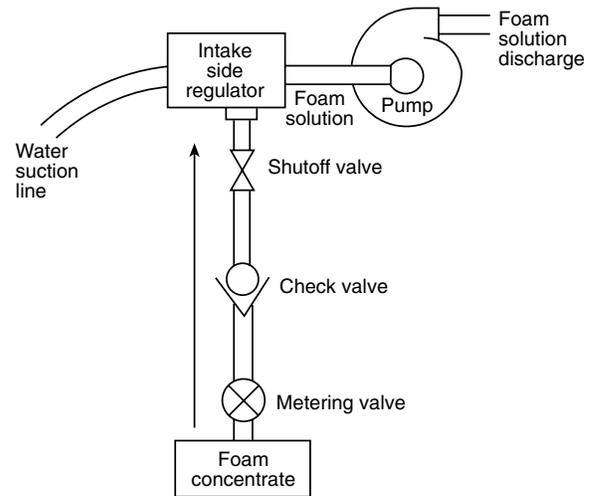
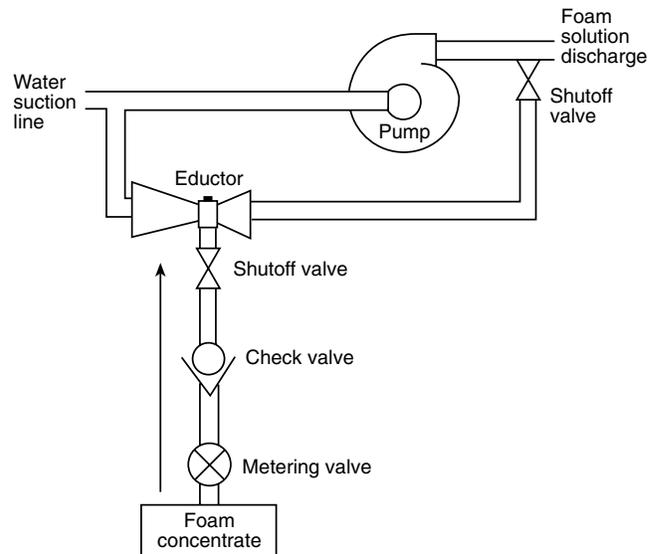


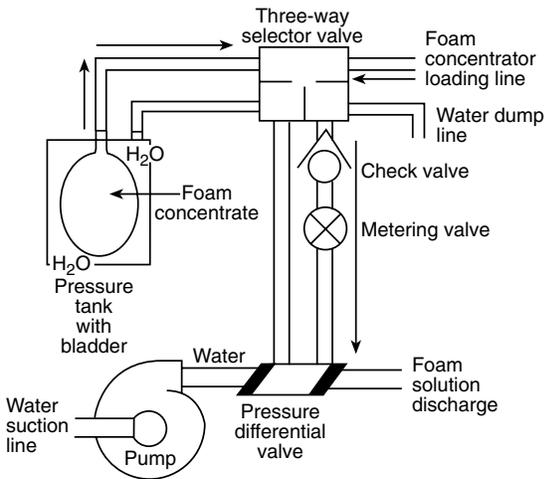
FIGURE 3.2.2.3 Around-the-pump proportioner. (Reprinted courtesy of National Wildfire Coordinating Group.)



3.2.3 Automatically Regulated Proportioning System. An automatically regulated proportioning system automatically adjusts to maintain the desired mix ratio. These automatic adjustments are made based on changes in water flow, pressure, or solution conductivity. Some of these systems are able to proportion foam concentrate into single- or multiple-discharge outlets without adjustment.

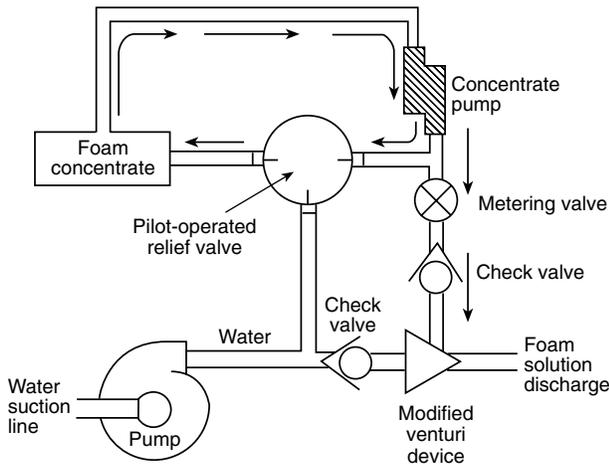
3.2.3.1 Balanced-Pressure Bladder Tank System. The balanced-pressure bladder tank system uses a small diversion of water to pressurize a bladder that contains foam concentrate. The concentrate passes through a metering valve before it enters the water stream on the low-pressure side of a pressure differential valve or venturi. As water flow and differences in pressure occur, foam concentrate flow adjusts automatically. (See Figure 3.2.3.1.)

FIGURE 3.2.3.1 Balanced-pressure bladder tank system. (Reprinted courtesy of National Wildfire Coordinating Group.)



3.2.3.2 Balanced-Pressure Pump System. The balanced-pressure pump system senses water pressure and activates a pilot-operated relief or diaphragm valve. The pressure of the pumped concentrate is automatically regulated and supplied through a venturi in the water line. (See Figure 3.2.3.2.)

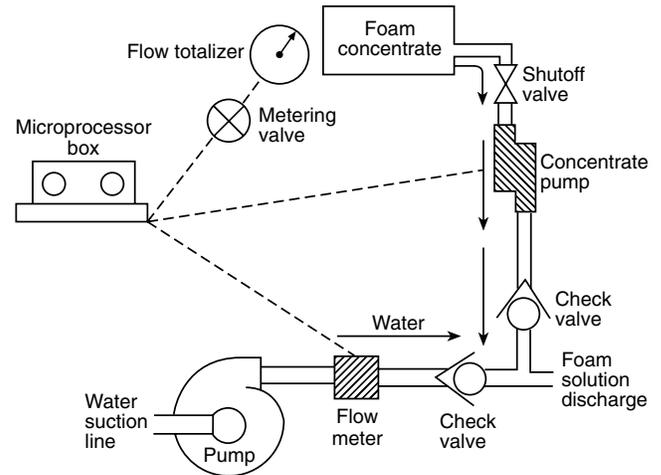
FIGURE 3.2.3.2 Balanced-pressure pump system. (Reprinted courtesy of National Wildfire Coordinating Group.)



3.2.3.3 Electronically Controlled Direct-Injection System. The electronically controlled proportioner adds concentrate based on measured water flow or solution conductivity. An in-line sensor(s) signals a microprocessor that automatically commands a pump to deliver concentrate into the water stream at the desired mix ratio. (See Figure 3.2.3.3.)

3.2.3.4 Water-Powered Injection System. In a water-powered injection system, a water motor drives a concentrate pump. The speed of the concentrate pump is directly proportional to the water flow through the system and automatically delivers concentrate at the desired mix ratio.

FIGURE 3.2.3.3 Electronically controlled direct-injection system. (Reprinted courtesy of National Wildfire Coordinating Group.)



3.3 Foam Generation and Discharge. Class A foam can be applied with any discharge device. Discharge systems (both low and high energy) are discussed in the following paragraphs. The user should choose the most appropriate device to meet the objective of each application.

3.3.1 Low-Energy Foam Systems. Several different low-energy foam systems are available to generate and deliver foam.

3.3.1.1 Nonaspirating-Type Nozzles. Class A foam solution can be applied with any type of nonaspirating nozzle, for example, straight bore and combination. When using adjustable flow rate nozzles with manually regulated proportioning systems, changing the nozzle flow rate requires adjustment to the proportioner. If not adjusted, the proportioning system might be rendered inoperable. Application is made using standard water-only techniques at typical concentrations of 0.2 to 0.5 percent. These types of nozzles produce a wet foam that is most effectively used for direct and indirect attack and overhaul.

3.3.1.2 Aspirating-Type Nozzles. Aspirating nozzles entrain air into the foam solution stream. Such nozzles generally produce higher expansion ratios than nonaspirating nozzles. Many designs are available to users who are pursuing the desired foam expansion at the greatest discharge distance. In general, nozzles designed for greater discharge distance produce relatively low-expansion ratio foam, while those designed for increased expansion ratios have shorter discharge distances.

3.3.1.2.1* Low-Expansion Nozzles. Low-expansion nozzles develop expansion ratios up to 20:1. However, at 0.1 to 1.0 percent mix ratios, foam with expansion ratios greater than 10:1 are rarely obtained. Low-expansion nozzles produce wet or fluid foam that is most effectively used for exposure protection, direct attack, and overhaul.

The various types of low-expansion aspirating nozzles are illustrated in Figures 3.3.1.2.1(a) through (e).

FIGURE 3.3.1.2.1(a) Single-function foam device.

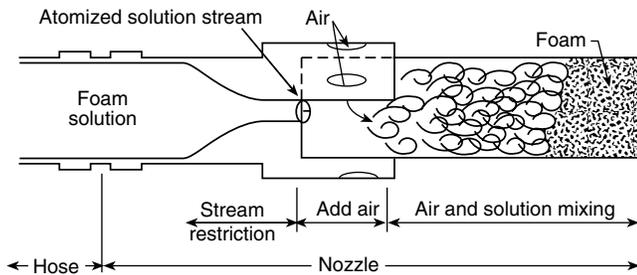


FIGURE 3.3.1.2.1(b) Combination nozzle with low-expansion foam attachment.

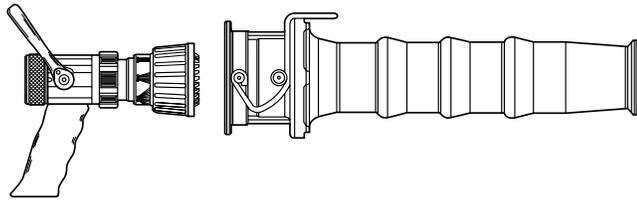


FIGURE 3.3.1.2.1(c) Combination nozzle with multi-expansion foam attachment.

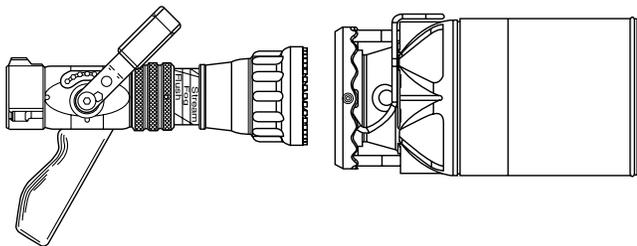
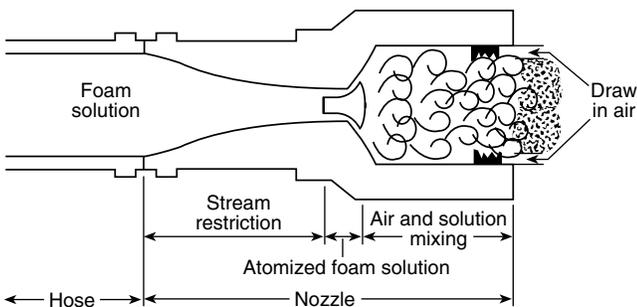
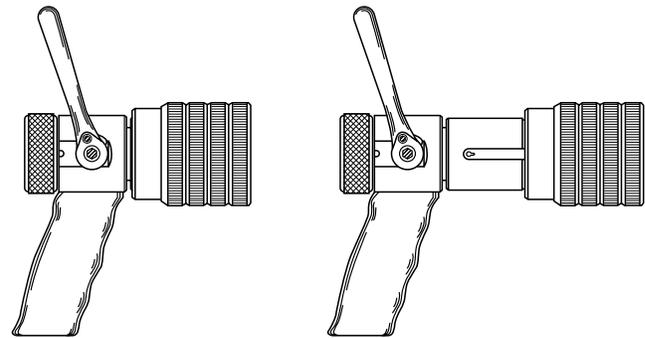


FIGURE 3.3.1.2.1(d) Multifunction foam device.



3.3.1.2.2* Medium-Expansion Nozzles. Medium-expansion foam nozzles are designed to develop foam expansions between 20:1 and 200:1. These nozzles have larger diameter foam tubes than low-expansion nozzles and often employ a screen at the end of the tube. They are also limited to relatively short discharge distances. Medium-expansion foam is useful in blanketing operations. It is most effectively used for overhaul and exposure protection. See NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*, for more information.

FIGURE 3.3.1.2.1(e) Combination nozzle with retractable sleeve.



3.3.1.2.3* High-Expansion Generators. The use of high-expansion generators is generally limited to fires in confined spaces. See NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*, for more information.

3.3.1.3 Fire Hose. Typically, hose used by the fire service for the delivery of water is appropriate for use with low-energy foam systems. Hydraulic calculations used for flowing foam solution are essentially the same as for flowing water.

3.3.2 High-Energy Foam System. The only high-energy foam system currently in use is the compressed air foam system (CAFS).

3.3.2.1 Compressed Air Foam System. CAFS is a foam generation and delivery system that combines air under pressure with foam solution to create foam in the hose or mixing chamber. See 3.3.2.1.2 for the impact of hose on foam generation. A CAFS consists of a pressurized air source, a source of foam solution (water pump and proportioner), and a means to apply the foam (hose and nozzle). CAFS allows the operator to control the three elements of foam production: water, foam concentrate, and air.

CAFS-generated foam can be used for interior and exterior attack (both direct or indirect), exposure protection, and overhaul. Unless specifically designed for the purpose, the use of standpipe systems or fixed aerial apparatus piping might be detrimental to the quality of the foam, the system, or both. Elevation differences between the nozzle and the pump or hose-lay length, or both, may impact the quality of the CAFS-produced foam. Radical changes in the flow direction or conduit diameter can adversely affect foam quality.

The type of foam can be controlled by varying the mix ratio of concentrate to water, the ratio of airflow to solution flow, or both. Typical CAFS mix ratios are 0.2 to 0.5 percent foam concentrate and 0.5 to 3.0 scfm/gal · min of solution flow. It is important for safety and effectiveness that a CAFS be designed to provide a homogeneous mix of solution and pressurized air to create the appropriate foam type for each fire-fighting situation.

CAFS has the capability of increasing the discharge distance of low-expansion foam at any given water flow rate. This is due to the energy provided by the compressed air.

3.3.2.1.1* Nozzles. Typically, a full flow ball valve or smooth bore nozzle is used to discharge CAFS foam. The larger the discharge opening, the drier the CAFS foam. Other nozzle types, for example, combination nozzles, will remove air from the foam, resulting in a wetter discharge with reduced range. Variable pattern nozzles allow CAFS foam to be discharged in

protective fog patterns. The choice of nozzle depends on how the foam is to be applied and the type of foam desired.

3.3.2.1.2* Fire Hose. Typically, hose used by the fire service for the delivery of water is appropriate for use with CAFS. Hose length and liner surface affect foam characteristics. Without a mixing chamber or other in-line mixer, CAFS depends on friction between the foam solution and the hose liner to mix foam solution and air. Fire hose filled with CAFS foam weighs less than hose filled with foam solution or water but will kink more readily than water-filled hose. Kinking causes a change in foam quality and flow rate.

3.4 Check Valves. Check valves should be provided to isolate and prevent backflow to water supplies, system supply reservoirs, and pumps.

Chapter 4 Foam Operations

4.1 General. This chapter provides guidelines on the selection of foam types for various fire situations, use of that foam type during fire fighting, and post-incident system maintenance. In most situations, fire-fighting techniques are similar for both Class A foam and water attack. However, Class A foam has greater versatility in certain situations. Prior to using Class A foam in a fire situation, fire fighters should develop practical knowledge of its use. The proper selection of foam type and application technique varies depending on resources, fire situation, material to be protected, and time available.

4.2 Foam Type Selection and Application Techniques. The choice of foam type varies depending on the fire situation (*see* 2.3.2). Foam solution flow rates and hose sizes for any given fire should be the same as the generally accepted flow rates and hose sizes for plain water. A combination of the various foam types might be of particular benefit depending on the fire situation. The mix ratio necessary to produce the desired foam type varies depending on several factors, for example, manufacturer, temperature, system type and operating parameters, and water quality. The concentrate and hardware manufacturer's instructions should be consulted for guidelines in this regard.

4.2.1 Exterior Structure Fire.

4.2.1.1 Direct Attack. When making a direct attack on the exterior of an involved structure, knockdown through cooling of fuels is a primary consideration. A wet- or fluid-type foam should be used in the same manner as water. When using a low-energy foam system, a nonaspirating conventional nozzle is recommended for reach, penetration, and pattern adjustments. Aspirating nozzles or attachments can be used but will not allow pattern adjustment and will reduce the range of stream. When using a high-energy foam system (CAFS), the system should be adjusted to provide a wet foam. A conventional combination nozzle can be used to provide a protective fog pattern, though reach and foam quality might be diminished.

4.2.1.2 Overhaul. During overhaul, primary consideration should be given to surface penetration and cooling of involved fuels. The choice of foam type used for overhaul should be varied depending on the geometry of the fuel that is being cooled. Penetration of the involved fuels will best be accomplished with wet foam. It is recommended to start with a wet foam to cover the burned material, then change to a dry foam.

The dry foam will release water/solution over a prolonged period of time. It also aids in locating hidden hot spots. If suspected hot spots exist, any trapped heat will cause the foam bubbles to enlarge and steam might rise from the spot. If voids or cavities exist, filling them with a low-expansion stiff or medium-expansion foam might be desirable. This procedure does not alter the need to follow conventional overhaul practices.

Wet foam can be produced as indicated in 4.2.1.1. Obtaining a dry foam when using a low-energy foam system can be accomplished with a low- or medium-expansion aspirating nozzle or attachment. Mix ratio, nozzle operating pressures, or both might have to be altered to produce dry foam.

High-energy dry foam can be produced by increasing the air-to-solution ratio, increasing the mix ratio, or increasing both. Generally, the largest diameter discharge device should be used (e.g., smooth bore nozzle, open ball valves).

4.2.1.3* Exposure Protection. When providing exposure protection for untreated wood and other absorbing surfaces, such as vegetation or canvas, initial consideration should be given to raising the moisture content of the exposure with an application of wet foam, followed by a blanketing of the exposed surface with a dry foam to provide increased resistance to ignition. The dry foam will release water/solution over a prolonged period of time.

When providing exposure protection for non-absorbing surfaces, such as vinyl and metal siding, glass, painted wood surfaces, fiberglass shingles, and mobile properties, blanketing of the exposed surface with a dry foam is recommended. The dry foam will provide an increased resistance to ignition. Initial use of wet foam or water on the surface might reduce dry foam adhesion. A high-energy foam system can be particularly effective in this situation.

Foam should be used to protect construction features or openings, such as roofing tile, soffit or gable vents, and wooden decks, from ignition by embers. This can be accomplished with a blanket of dry or stiff foam.

Wet foam can be produced as indicated in 4.2.1.1. Obtaining a dry foam when using a low-energy foam system can be accomplished using a low- or medium-expansion aspirating nozzle or attachment. Foam produced from medium-expansion nozzles or attachments does not lend itself to application on vertical surfaces. The mix ratio, nozzle operating pressures, or both might have to be altered to produce dry foam.

High-energy foam systems can produce either wet or dry foam. The appropriate foam can be produced by varying the air-to-solution ratio, varying the mix ratio, and/or changing the discharge device. Smooth bore nozzle or open ball valves should be used for the delivery of dry foam in CAFS.

4.2.2 Interior Structure and Contents.

4.2.2.1 Direct Attack. When making a direct attack inside an involved structure, knockdown through cooling of fuels is a primary consideration. A wet- or fluid-type foam should be used in the same manner as water. When using a low-energy foam system, a nonaspirating conventional nozzle is recommended for reach, penetration, and pattern adjustments. Aspirating nozzles or attachments should not be used, as they do not provide for pattern adjustment for personnel protection and will reduce the range of stream. When using a high-energy foam system (CAFS), the system should be adjusted to provide a wet foam. A conventional combination nozzle should be used to provide a protective fog pattern, though reach and foam quality might be diminished.

4.2.2.2 Indirect Attack. When making an indirect attack on a fire within a structure, rapid cooling of products of combustion is the primary consideration. A wet- or fluid-type foam should be used in the same manner as water. Although most wet foams can be used, a wet compressed air foam might be more effective for this purpose.

When using a low-energy foam system, a nonaspirating conventional nozzle is recommended for reach, penetration, and pattern adjustments. When within a structure, aspirating nozzles or attachments should not be used, as they do not provide for pattern adjustment for personnel protection and will reduce the range of stream. When making an indirect attack from the outside through doorways, windows, and so on, either an aspirating or nonaspirating nozzle can be used.

When using a high-energy foam system (CAFS) within a structure, the system should be adjusted to provide a wet foam. A conventional combination nozzle should be used to provide a protective fog pattern, though reach and foam quality might be diminished. When making an indirect attack from the outside, through doorways, windows, and so on, a smooth bore nozzle will produce superior foam.

4.2.2.3 Heat and Ventilation. Knockdown might be achieved more rapidly with Class A foam than with water. Because temperature reduction primarily depends on the quantity of water applied, high compartment temperatures will likely exist at the time of knockdown. When victims remain in a structure, it might be advisable to continue flows after knockdown to further cool the interior. Active and aggressive ventilation should be considered by the incident commander at every stage of fireground operations.

4.2.2.4 Overhaul. During overhaul, primary consideration should be given to surface penetration and cooling of involved fuels. The choice of foam type used for overhaul should be varied depending on the geometry of the fuel being cooled. Penetration of the involved fuels is best made with a wet foam. Starting with a wet foam to soak and penetrate the burned material is recommended, followed by a change to a dry foam to blanket the material. The dry foam will release water/solution over a prolonged period of time. It also aids in penetrating hidden hot spots. If suspected hot spots exist, any trapped heat will cause the foam bubbles to enlarge and steam might rise from the spot. If voids or cavities exist, filling them with a low-expansion stiff or medium-expansion foam might be desirable. This procedure does not alter the need to follow conventional overhaul practices.

Wet foam can be produced as indicated in 4.2.1.1. Obtaining a dry foam when using a low-energy foam system can be accomplished with a low- or medium-expansion aspirating nozzle or attachment. Mix ratio, nozzle operating pressures, or both might have to be altered to produce dry foam.

High-energy dry foam can be produced by increasing the air-to-solution ratio, increasing the mix ratio, or increasing both. Generally, the largest diameter discharge device should be used (e.g., smooth bore nozzle or open ball valves).

4.2.3 Open Storage and Refuse. Class A foam can be used to advantage in the suppression of fires involving log decks, rubber tires, pallets, landfills, rubbish containers, and other Class A materials stored in the open.

4.2.3.1 Direct Attack. When making a direct attack on open storage or refuse, knockdown through cooling of fuels is a primary consideration. A wet- or fluid-type foam should be used in the same manner as water. When using a low-energy foam

system, a nonaspirating conventional nozzle is recommended for reach, penetration, and pattern adjustments. Aspirating nozzles or attachments can be used, but they do not allow pattern adjustment and they will reduce range of stream. When using a high-energy foam system (CAFS), the system should be adjusted to provide a wet foam. A conventional combination nozzle can be used to provide a protective fog pattern, though reach and foam quality may be diminished.

4.2.3.2 Overhaul. During overhaul, primary consideration should be given to surface penetration and cooling of involved fuels. The choice of foam type used for overhaul should be varied depending on the geometry of the fuel being cooled. Penetration of the involved fuels is best made with a wet foam. Consideration should be given to the use of penetrating-type nozzles to provide improved foam distribution within the fuel.

Starting with a wet foam to soak and penetrate the burned material is recommended, followed by a change to a dry foam to blanket the material. The dry foam will release water/solution over a prolonged period of time. It will also aid in locating hidden hot spots. If suspected hot spots exist, any trapped heat causes the foam bubbles to enlarge and steam might rise from the spot. If voids or cavities exist, filling them with a low-expansion stiff or medium-expansion foam might be desirable. This procedure does not alter the need to follow conventional overhaul practices.

Wet foam can be produced as indicated in 4.2.1.1. When using a low-energy foam system, a dry foam can be obtained using a low- or medium-expansion aspirating nozzle or attachment. Mix ratio, nozzle operating pressures, or both might have to be altered to produce dry foam.

High-energy dry foam can be produced by increasing the air-to-solution ratio, increasing the mix ratio, or increasing both. Generally, the largest diameter discharge device should be used (e.g., smooth bore nozzle or open ball valves).

4.2.3.3* Exposure Protection. When providing exposure protection for untreated wood and other absorbing surfaces, such as vegetation and canvas, initial consideration should be given to raising the moisture content of the exposed material with an application of wet foam, followed by a blanketing of the exposed surface with a dry foam to provide increased resistance to ignition. The dry foam will release water/solution over a prolonged period of time.

When providing exposure protection for nonabsorbing surfaces, such as vinyl and metal siding, glass, painted wood surfaces, fiberglass shingles, and mobile properties, blanketing of the exposed surface with a dry foam to provide increased resistance to ignition is recommended. Beginning with a dry foam application is recommended because the use of wet foam or water on the surface might reduce foam adhesion. A high-energy foam system can be particularly effective in this situation.

Foam should be used to protect construction features, such as roofing tile, soffit or gable vents, and wooden decks, from ignition by embers. This can be accomplished with a blanket of dry or stiff foam.

Wet foam can be produced as indicated in 4.2.1.1. Obtaining a dry foam when using a low-energy foam system can be accomplished using a low- or medium-expansion aspirating nozzle or attachment. Foam produced from medium-expansion nozzles or attachments does not lend itself to application on vertical surfaces. The mix ratio, nozzle operating pressures, or both might have to be altered to produce dry foam.

High-energy foam systems can produce either wet or dry foam. The appropriate foam can be produced by varying the air-to-solution ratio, varying the mix ratio, and/or changing the discharge device. Smooth bore nozzle or open ball valves should be used for the delivery of dry foam in CAFS.

4.2.4* Mobile Properties and Other Applications. The application of Class A foam on fires involving motor vehicles, trailers, cargo containers, train cars, recreational vehicles, mobile homes, boats, and other mobile properties and vehicles should be identical to those used on structures. If voids or cavities exist, filling them with a low-expansion stiff foam or a medium-expansion foam might be desirable. Consideration should be given to the use of penetrating-type nozzles to provide improved foam distribution within the fuel.

4.3 Other Operator Information.

4.3.1 Operators should be aware that foam system design and components, such as motionless mixers, plumbing, and educators, can result in additional friction loss, which could affect fireground hydraulic calculations.

4.3.2 The foam-generating system should be tested and calibrated prior to use. Information on testing and calibration can be found in the appropriate sections of NFPA 1901, *Standard for Automotive Fire Apparatus*, and NFPA 1906, *Standard for Wildland Fire Apparatus*, and the manufacturer's use instructions.

4.4 Post-Incident System Maintenance. Maintenance of the foam system should be performed following the manufacturer's recommendations.

4.4.1 The entire system should be flushed following the manufacturer's recommendations for care, lubrication, and maintenance of equipment. Generally, flushing is accomplished by turning off the proportioner and air source, if used, and allowing the flow to continue until clear water flows from the nozzle. This should be performed prior to leaving the scene or in accordance with the policies of the authority having jurisdiction. Some agencies have found it convenient to perform this task during the last phase of overhaul to avoid unnecessary contamination of surrounding terrain.

4.4.2 Due to the potential for incompatibility, concentrate tanks should be properly cleaned according to the concentrate and/or hardware manufacturer's recommendations when different Class A concentrates are introduced into the system. This should also be done whenever different concentrates are introduced during fire operations.

Class A and B concentrates should not be mixed because of potential incompatibility or performance difficulties. If it is desired to use Class B foam concentrate in a Class A concentrate tank, or vice versa, extra care should be taken to avoid contamination of the two.

4.4.3 Before leaving the scene, areas where concentrate has been handled should be examined for evidence of spillage. Any spilled concentrate and empty containers should be collected and disposed of properly. (See 2.1.2.3.4.)

4.5 Post-Incident Documentation. The incident report should reflect the use of Class A foam including the amount of concentrate used, the mixing ratios, the brand, and the specific location of use. During cause and origin investigations, the use of Class A foam should be noted, because some components of Class A foam concentrate might mask or mimic accelerants.

Chapter 5 Operational Safety

5.1 General. Foam concentrates and solutions are similar in composition to common household detergents and shampoos. However, some safety considerations should be noted because of the prolonged exposure and large volumes that are used in fire-fighting applications. Fire-suppressant foams, diluted for use in fire fighting, are more than 99 percent water. The remaining 1 percent contains surfactants and other functional components. The manufacturer's MSDS should be referred to for recommendations and information on the specific foam to be used. The MSDS should be readily available, by some means, to operators of vehicles carrying Class A foam.

5.2 Working Conditions.

5.2.1 Personal Protective Equipment. When handling concentrates, splashproof eye protection and waterproof gloves and boots (rubber or plastic) should be worn. Personal protective equipment is further discussed in 2.1.2.2, 2.2.3.1, and 2.3.3.

5.2.2 Visibility. Foam on the fireground can mask weak and damaged floors, structural features, objects, and terrain. Vision through vehicle windshields, face shields, SCBA masks, thermal imaging cameras, or eye protection can be obscured or obstructed by foam.

5.2.3 Footing. Foam concentrates, foam solutions, and foam itself can be slippery. Caution should be exercised when moving about firegrounds on which any form of foam has been used and applied.

5.2.4 Electronic Equipment. Due to the reduced surface tension of foam solutions, containers and seals that under normal conditions are watertight might leak, and contents (e.g., radios and personal alert devices) might be damaged and might cease to operate.

5.2.5 Electrical Hazards. The same electrical shock hazards exist when using Class A foam as when using water.

5.2.6 Nozzles. As is the case with water, care should be taken when opening and closing pressurized valves.

5.2.7 Heat and Ventilation. Knockdown can be achieved more rapidly with Class A foam than with water. Because temperature reduction primarily depends on the quantity of water applied, it is likely that high compartment temperatures will exist at the time of knockdown. When there are life safety concerns, it might be advisable to continue flows after knockdown to cause further cooling of the interior. Active and aggressive ventilation should be considered by the incident commander at every stage of fireground operations.

5.2.8 Medium- and High-Expansion Foam Considerations. The discharge of large amounts of medium- and high-expansion foam might inundate personnel, thereby blocking vision, making hearing difficult, creating some discomfort in breathing, and causing spatial disorientation. The breathing discomfort will increase with a reduction in expansion ratio of the foam.

5.2.9 High-Energy (CAFS) Considerations. High-energy foam systems create some safety issues unique to their operation. Personnel using CAFS should receive training in proper operation of the pumping system and handling of the hose and nozzle. With the additional consideration of the foam proportioner and air compressor, the pump operator's responsibility to provide the appropriate foam to the nozzle includes more than operation of

the water pump. Foam generation in the hose depends on adequate foam concentrate and air being added to the water. Commonly accepted formulas for friction loss do not apply. Because compressed air foam is a compressible medium, water hammer does not occur when shutting down discharge devices.

5.2.9.1 Slug Flow. The continuity of foam production can be interrupted, resulting in slug flow for a number of reasons. This compromises effective discharge operations, nozzle control, and operator safety. To prevent slug flow, it is important to provide a continuous flow of a homogeneous mix of solution and air to create the appropriate foam type. Some of the factors that can create slug flow include interruption of foam solution supply and the inadequate mixing of air and foam solution.

5.2.9.2 Discharge Devices. The nozzle operator should understand the effect on nozzle reaction created by the compressed air in the hose. While a discharge device is closed, energy continues to build in the hose line. When the discharge device is opened, this built-up energy can create extreme nozzle reaction. The shutoff should be opened slowly, and the operator should stand with feet apart and a low center of gravity. A pistol grip ball shutoff is recommended for further stability and safety.

Chapter 6 Referenced Publications

6.1 The following documents or portions thereof are referenced within this guide and should be considered as part of its recommendations. The edition indicated for each referenced document is the current edition as of the date of the NFPA issuance of this guide. Some of these documents might also be referenced in this guide for specific informational purposes and, therefore, are also listed in Appendix B.

6.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 11, *Standard for Low-Expansion Foam*, 1998 edition.

NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*, 1999 edition.

NFPA 1150, *Standard on Fire-Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas*, 1999 edition.

NFPA 1901, *Standard for Automotive Fire Apparatus*, 1999 edition.

NFPA 1906, *Standard for Wildland Fire Apparatus*, 1995 edition.

NFPA 1961, *Standard on Fire Hose*, 1997 edition.

NFPA 1962, *Standard for the Care, Use, and Service Testing of Fire Hose Including Couplings and Nozzles*, 1998 edition.

NFPA 1963, *Standard for Fire Hose Connections*, 1998 edition.

NFPA 1964, *Standard for Spray Nozzles (Shutoff and Tip)*, 1998 edition.

6.1.2 Other Publication.

Foam Versus Fire, Class A Foam for Wildland Fires, October 1993, National Wildfire Coordinating Group (available from Interagency Fire Center, 3833 South Development Avenue, Boise, ID 83705-5354).

Appendix A Explanatory Material

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

A.1.4.2 Authority Having Jurisdiction. The phrase “authority having jurisdiction” is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.1.4.6 The foam bubbles and the solution draining from them attach to and penetrate Class A fuels due to the reduced surface tension imparted to the water by the foam concentrate. The bubbles hold moisture and release it as the foam breaks down, prolonging the time the moisture can be absorbed by the fuels. When applied in adequate quantities, the foam acts to exclude air from the fuel-air interface, envelop combustible vapors, and resist disruption due to wind, heat, and flame.

A.2.1.2.1.1 Class A foam concentrates generally become thicker (more viscous) at cold temperatures. This can result in a situation at temperatures below about 40°F (4°C) where they are difficult to handle, transfer, and/or proportion. Although they will return to a usable condition when warmed, a quantity equivalent to one day’s anticipated use should be stored at a temperature at which it can be used without difficulty.

A.3.2 Systems are available that are capable of proportioning Class A or some Class B agents or both.

A.3.3.1.2.1 Most low-expansion nozzles result in a fixed straight stream discharge that offers little to no margin of safety from radiant heat in an interior application. For this reason, a low-expansion, single-function nozzle or low-expansion attachment is not recommended for interior attack.

A.3.3.1.2.2 At the present time, foam generators for medium- and high-expansion foam are of two types, depending on the means of introducing air, for example, by aspirator or blower. In either case, the foam solution impinges on a screen or series of screens in a moving airstream. The liquid films formed on the screen are distended by the moving airstream to form a medium- or high-expansion foam. Foam expansion ratios vary from about 20:1 to 1000:1 depending on generator design.

Aspirator-type generators can be either portable or fixed and usually produce foam with expansion ratios not over 250:1. Blower-type generators can be engine mounted or portable and usually produce foam with expansion ratios greater than 250:1.