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16

FOAM-WATER SPRINKLER AND SPRAY SYSTEMS 1974

NATIONAL FIRE PROTECTION ASSOCIATION
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Standard for the Installation of

Foam-Water Sprinkler Systems and

Foam-Water Spray Systems

NFPA No. 16 — 1974

1974 Edition of No. 16

The 1974 edition of this standard supersedes the 1968 edition and was adopted by the National Fire Protection Association on May 21, 1974. This edition includes new information on aqueous film forming foam and standard sprinklers.

Original History of No. 16

A Standard for Combined Foam and Water Spray Systems was originally published in 1954 by the National Board of Fire Underwriters (now American Insurance Association). In 1959, the National Fire Protection Association, with the cooperation of the National Board and other interested groups, established a Committee on Foam-Water Sprinklers to update and expand the coverage, and the first official NFPA standard was adopted in 1962. This 1968 edition incorporates revisions developed by the Committee during 1967-68. The paragraphs changed include: 1017, 1044, 2053, 2054, 2074, 2125, 4011, 4033, 4041, 4043, 4044, 4045, 4046, 4051, 7011, and A-2052(a). Some editorial updating has also been accomplished. The 1974 edition is the result of Committee review from 1968.

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Interpretation Procedure of the Committee on Foam-Water Sprinklers

Those desiring an interpretation shall supply the Chairman with five identical copies of a statement in which shall appear specific reference to a single problem, paragraph, or section. Such a statement shall be on the business stationery of the inquirer and shall be duly signed.

When applications involve actual field situations they shall so state and all parties shall be named.

The Interpretations Committee will reserve the prerogative to refuse consideration of any application that refers specifically to proprietary items of equipment or devices. Generally inquiries should be confined to interpretation of the literal text or the intent thereof.

Requests for interpretations should be addressed to the National Fire Protection Association, 470 Atlantic Avenue, Boston, MA. 02210.

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

NOTE

Reference herein to the 1974 National Electrical Code, NFPA No. 70, is to that code adopted by the National Fire Protection Association on May 22, 1974 at its Annual Meeting. This code is also known as the 1975 National Electrical Code.

Standard for the Installation of
Foam-Water Sprinkler Systems and Foam-Water Spray Systems

NFPA No. 16 — 1974

Foreword

The uses of air foam (or mechanical foam as it was first called) for fire protection have expanded greatly since its inception in the 1930's. Original applications of this agent utilized a proteinaceous-type liquid foam forming concentrate delivered in water solution to a turbulence-producing foam generator or nozzle which then directed the mechanically-formed air foam to a burning fuel tank or area of burning flammable fuel. (Details of these and similar applications are found in NFPA Nos. 11, 402, 403.) As the technology for using this agent developed over the years, new systems and new devices for applying the foam to the hazard being protected and new foam forming liquid concentrates were proven useful for fire protection purposes. The application of foam from overhead sprinkler type systems using especially designed foam-making nozzles capable of either forming a foam from protein-type foam concentrate solutions or delivering a satisfactory water discharge pattern when supplied with water only was an early development (ca. 1954) in foam fire protection. Protein, fluoroprotein, and aqueous film forming concentrates (as defined in NFPA No. 11) are suitable for use with foam water-sprinklers. This latter type of foam concentrate has also been found to be suitable for use with standard sprinklers of the type referred to in NFPA No. 13, when the system is provided with the necessary foam concentrate proportioning equipment. Care must be exercised to ensure that the choice of concentrate and discharge device are listed for use together.

This standard is based on available test data and design experience concerning the design information, installation recommendations, operating methods and maintenance needs for the above types of foam-water sprinkler systems and foam-water spray systems utilizing protein, fluoroprotein, or aqueous film forming foam concentrates and for standard sprinker systems in which AFFF concentrates are used. These systems possess the common characteristic of being capable of either discharging air foam in a spray form or discharging water in a satisfactory pattern for fire protection purposes.

Standard for the Installation of Foam-Water Sprinkler Systems and Foam-Water Spray Systems

NFPA No. 16 — 1974

Chapter 1. General Information

1010. Scope

1011. This standard covers the minimum requirements for foam-water sprinkler systems, including deluge sprinkler systems employing AFFF, and foam-water spray systems, each of which combines in a single system provision for the alternate discharge of air foam or water.

1012. Accordingly, systems may be designed with the required density for either foam or water application as the controlling factor, depending on the design purpose of the protection.

1013. The devices covered herein are intended primarily for use in foam-water sprinkler systems, including deluge sprinkler systems using standard sprinklers employing AFFF or foam-water spray systems. This standard is not applicable where separate foam, water sprinkler or water-spray fixed systems are to be installed. Reference should be made to either the NFPA Standard for Foam Extinguishing Systems (No. 11), the NFPA Standard for the Installation of Sprinkler Systems (No. 13), the NFPA Standard on Water Spray Fixed Systems for Fire Protection (No. 15), or the NFPA Standard on Synthetic Foam, Combined Agent Systems (No. 11B).

1020. Definitions

1021. Air Foam. Air foam is an aggregation of air-filled bubbles of lower specific gravity than flammable liquids or water. In the cases of the systems covered by this standard, it extinguishes fires by resisting flame and heat attack in the process of falling from an overhead sprinkler type system where it is formed initially, to a burning flammable or combustible liquid surface where it flows freely, progressively removing heat, forming an air-excluding continuous blanket or film over the fuel, thus sealing volatile combustible vapors from access to air or reignition. The air foam produced by these systems possesses qualities of lower expansion, higher fluidity, and more rapid foam solution drainage than foams useful in other circumstances (NFPA Nos. 11, 402, 403, 412, etc.).

1022. Air Foam Concentrates. There are three principal types of liquid foam forming concentrates useful for incorporation in the systems covered by this standard:

(a) Protein-Foam Concentrates: These foam concentrates consist primarily of products from a protein hydrolysis plus stabilizing additives and inhibitors. Current formulations are available for use at recommended nominal concentrations of 3 percent or 6 percent by volume of the solution discharge of the system.

(b) Fluoroprotein-Foam-Concentrates: These concentrates are very similar to protein-foam concentrates as described above but with a synthetic fluorinated surfactant additive. They form an air excluding foam blanket and may also deposit a vaporization-inhibiting film on the surface of a liquid fuel. These concentrates are used at recommended nominal concentrations of 3 percent and 6 percent of the solution discharge, of the system.

(c) Aqueous Film Forming Foam (AFFF) Concentrates: These foam concentrates consist of a fluorinated surfactant with suitable foam stabilizers and additives. Foams formed from these concentrates act as a barrier to exclude air or oxygen and they develop aqueous films on the fuel surface capable of suppressing the evolution of fuel vapors. Current formulations are available for use at recommended nominal concentrations of 3 percent or 6 percent by volume of the solution discharge of the system.

1023. Air Foam Solution. A mixture consisting of an air foam concentrate in suitable proportions in either fresh or salt water.

1024. Discharge Devices. There are three principal types of discharge devices which are installed at the discharge outlets of the systems covered by this standard.

(*a) Foam-Water Sprinklers: These discharge devices are especially designed, open-type air-aspirating heads consisting of an open barrel body foam maker which terminates in a deflector to shape the pattern of the foam or water issuing from the assembly. These devices produce water discharge patterns closely comparable to those of standard sprinklers (see NFPA No. 13) when discharging at the same rates of flow.

(*b) Foam-Water Spray Nozzles: These are also air-aspirating discharge devices, but they differ in design from foam-water sprinklers. They distribute foam, or water, in a special directional pattern peculiar to the particular nozzle.

(c) Standard Sprinklers: These discharge devices are the standard sprinklers, without heat responsive elements, referred to in NFPA No. 13 and they are non-air-aspirating. When they are supplied with aqueous film forming foam (AFFF) air foam solution, a foam discharge pattern is produced closely conforming to the water discharge pattern of these sprinklers.

1025. Foam-Water Sprinkler System. A foam-water sprinkler system is a special system, pipe-connected to a source of air foam concentrates and to a water supply and is equipped with appropriate discharge devices for extinguishing agent discharge and for distribution over the area to be protected. The piping system is connected to the water supply through a control valve which is usually actuated by operation of automatic detection equipment installed in the same areas as the sprinklers. When this valve opens, water flows into the piping system; air foam concentrate is injected into the water; and the resulting air foam solution discharging through the discharge devices generates and distributes air foam. Upon exhaustion of the air foam concentrate supply, water discharge will follow the air foam and continue until shut off manually. Systems may be used for discharge of water first, followed by discharge of air foam for a definite period and this followed by water until manually shut off. Existing sprinklers systems which have been converted to the use of aqueous film forming foam are classed as Foam-Water Sprinkler Systems.

1026. Foam-Water Spray System. A foam-water spray system is a special system, pipe-connected to a source of air foam concentrate and to a water supply and is equipped with foam-water spray nozzles for extinguishing-agent discharge (air foam or water sequentially in that order or in reverse order) and distribution over the area to be protected. System-operation arrangements parallel those for foam-water sprinkler systems as described in the foregoing paragraph.

1027. Density. This term refers to the unit rate of liquid application to an area and is expressed in gallons per minute per square foot. The term "density" is used in this standard with reference to application of water in some cases and in others to application of air foam solution.

1028. Listed. Equipment or materials included in a list published by a nationally recognized testing laboratory that maintains periodic inspection of production of listed equipment or materials, and whose listing states either that the equipment or material meets nationally recognized standards or has been tested and found suitable for use in a specified manner.

1030. System Design Plan

1031. Automatic operation, supplemented by auxiliary manual tripping means is preferred, but manual operation may be acceptable.

1032. Systems shall deliver air foam for a definite period at given densities (gallons per minute of air foam solution per square foot) to the hazards which they protect, either prior to water discharge or following water discharge, depending upon system-design purpose.

1033. Following completion of discharge of air foam to the hazards protected, these special systems shall discharge water until manually shut off.

1034. Authorities having jurisdiction shall be consulted as to the means by which a reserve supply of air foam concentrate shall be made available. The purpose of a reserve supply of concentrate is to have available the means for returning systems to service-ready condition following system operation. Reserve supply shall be listed for use with system components (see Paragraph 2053).

1040. Applicability

1041. Systems of this type shall discharge either air foam or water from the same discharge devices. In view of this dual extinguishing agent discharge characteristic, these systems are selectively applicable to combination Class A and Class B hazards.†

NOTE: Caution must be exercised when auxiliary extinguishing equipment is used with these systems. Some extinguishing agents may be incompatible with some air foams.

1042. Foam-water sprinkler and foam-water spray systems are especially applicable to the protection of most flammable-liquid hazards. They may be used for any of the following purposes or combinations thereof:

(a) Extinguishment. The primary purpose of such systems is the extinguishment of fire in the protected hazard. For this purpose, suitable foam-solution discharge densities (gallons per minute per square foot) shall be provided by system design and use of selected discharge devices; by provision of adequate supplies of air-water supplies at suitable pressures to accomplish the

† As defined in the NFPA Standard for the Installation of Portable Fire Extinguishers (No. 10).

system-design, foam-discharge rates for the design period and following depletion of air foam concentrate supplies, to provide similar rates of water discharge from the system until shut off.

(b) Prevention. Prevention of fire in the protected hazard is a supplemental feature of such systems. Manual operation of a system to selectively discharge foam or water from the discharge devices in case of accumulations of hazardous materials from spills in such occupancies as garages, aircraft hangars, petrochemical plants, paint and varnish plants, or from other causes in the protected area will afford protection against ignition pending clean-up measures. In such cases, manual system operation can provide for foam coverage in the area with water discharge manually available.

(c) Control and Exposure Protection. Control of fire, to permit controlled burning of combustible materials where extinguishment is not practicable, and exposure protection to reduce heat transfer from an exposure fire may be accomplished by water spray and/or foam from these special systems, the degree of accomplishment being related largely to the fixed discharge densities provided by the system design.

1043. Foam of any type is not considered a suitable extinguishing agent on fires involving liquefied or compressed gases, e.g., butane, butadiene, propane, etc., nor on materials which will react violently with water (e.g., metallic sodium) or which produce hazardous materials by reacting with water, nor on fires involving electrical equipment where the electrical nonconductivity of the extinguishing agent is of first importance.

1044. Air foam of any type is not recommended for use on fires in water-soluble solvents and polar solvents. Special "alcohol-type" concentrates are available for production of air foams for protection of such hazards but these foams are generally not considered acceptable for this method of application.

1050. Approvals

1051. Prior to designing a system under consideration, the authority having jurisdiction shall be consulted. All plans and specifications pertinent to the installation shall be approved by the authority having jurisdiction prior to installation and such authority shall be consulted as to devices and materials used in system construction and in selection of the air foam concentrate to be provided for system use. All equipment and concentrates shall be approved for the particular application intended.

Chapter 2. System Components

2010. Approved Devices and Materials

2011. The authority having jurisdiction shall be consulted as to approved devices, materials, and air foam concentrates.

2020. Component Parts

2021. All component parts (including air foam concentrates) of foam-water sprinkler and foam-water spray systems shall be listed.

2030. Foam-Water Sprinklers

***2031.** Foam-water sprinklers shall be of listed makes and types having water passages not less than ¼ inch in any cross-section dimension.

2040. Foam-Water Spray Nozzles

2041. Foam-water spray nozzles shall be listed makes and types having water passages not less than ¼ inch in any cross-section dimension.

2042. These devices are available in a number of discharge patterns and capacities.

2050. Air Foam Concentrates

***2051.** Air foam concentrates shall be of types found acceptable for use with the concentrate-proportioning equipment and with the discharge devices with which a given system is equipped. Original supplies of concentrates and replacement supplies shall be checked by appropriate tests or otherwise to determine acceptability.

2052. The quantities of air foam concentrates to be provided for foam-water sprinkler and spray systems shall be sufficient to maintain the discharge densities for the application time period used as a base in system design. (See Paragraphs 1034, 4022 and 4023.)

NOTE: See paragraph 1044 concerning "alcohol-type" concentrates.

2053. There shall be a readily available supply of air foam concentrate sufficient to meet the design requirements of the system to put the system back in service after operation. This

supply may be in separate tanks or compartments, in drums or cans on the premises, or available from an outside source within 24 hours.

2060. Air Foam Concentrate Proportioning Means

2061. Positive pressure-injection methods shall be used for introduction of air foam concentrates into the water flowing through the supply piping to the system, except that where water-supply conditions require pumps, around-the-pump proportioners may be used.

2062. Positive pressure-injection methods shall mean one of the following:

(*a) Air foam concentrate pump discharging through a metering orifice into the protection-system riser with the foam pressure at the upstream side of the orifice exceeding the water pressure in the system riser by a specific design value.

(*b) A balanced-pressure proportioning system (demand type proportioner) utilizing an air foam concentrate pump discharging through a metering orifice into a proportioning controller (venturi) or orifice in the protection system riser with the foam liquid and water pressures automatically maintained equal by the use of a pressure-control valve.

(*c) Pressure-proportioning tanks with or without a diaphragm to separate the water and foam concentrate.

2063. Orifice plates shall have "tell-tale" indicators giving orifice diameters and indicating flow direction if flow characteristics vary with flow direction.

NOTE: See Appendix A-2062(a) for formula for calculation of size of orifices used in metering air foam concentrates.

*2070. Pumps

2071. Air foam concentrate pumps and water pumps shall have adequate capacities to meet the maximum needs of the system on which they are used. (See Paragraph 3020 for water-supply requirements.) To insure positive injection of concentrates, the discharge pressure ratings of pumps at the design discharge capacity shall be suitably in excess of the maximum water pressure available under any condition at the point of concentrate injection.

2072. Air foam concentrate pumps shall be carefully chosen and have adequate capacity for this special service and special

attention shall be paid to the type of seals used with regard to the type concentrate being pumped.

2073. Provision shall be made to shut off the air foam concentrate pump after the foam supply is exhausted.

2080. Power Supply

2081. Power supply for the drivers of air foam concentrate pumps and water pumps shall be of maximum reliability. Compliance with the applicable requirements of the NFPA Standard for the Installation of Centrifugal Fire Pumps (No. 20), covering the reliability of power supply for fire-pump drivers, is considered as meeting the intent of this chapter.

2082. Controllers governing the starting of air foam concentrate pumps shall be of approved types. Where control equipment listed for fire protection service is not available, suitable listed industrial-control equipment shall be used. Control equipment shall comply with the NFPA Standard for the Installation of Centrifugal Fire Pumps (No. 20).

2090. Air Foam Concentrate Storage Tanks

2091. Storage tanks for air foam concentrates shall be of construction suitable for the liquid, solidly mounted, and permanently located.

2092. Minimum storage temperatures of air foam concentrates shall be considered in locating storage tanks.

2093. Storage tanks shall have capacities to accommodate only the needed quantities of air foam concentrate plus adequate space for thermal expansion, the latter to preferably be accomplished by means of a vertical riser or expansion dome. Tanks meeting this requirement will have minimum surface areas in contact with air and liquid concentrates at the liquid level and thus minimize the possibility of interior corrosion of tanks. Air foam concentrate outlets from tanks shall be raised above the bottoms of the tanks to provide adequate sediment pockets.

2094. The capacities of tank sediment pockets shall be included in determining needed quantities of air foam concentrates.

2095. Tanks shall be equipped with suitable conservation-type vents of adequate capacity; access handholes or manholes located to provide for inspection of interior tank surfaces, connections for pump suction; relief and testing lines; protected sight gages or other liquid-level devices; and adequate filling and draining connections.

2096. Tanks shall be located to furnish a positive head on the pump suction.

2097. Pressure proportioning tanks shall have means for filling, for gaging the level of concentrates and for drainage, cleaning and inspection of interior surfaces, and of the concentrate holding bag, if provided.

2100. Pressure on Air Foam Concentrate Lines

2101. Where air foam concentrate lines to the protective-system injection points are run underground or where they run aboveground for more than 50 feet, air foam concentrate in these lines shall be maintained under pressure to assure prompt foam application and to provide a means of checking on the tightness of the system. Pressure may be maintained by a small auxiliary pump; or by other suitable means.

2110. Location of System-Control Equipment

2111. Equipment items, such as storage tanks and proportioners for air foam concentrates; pumps for water and air foam concentrates; and control valves for water, concentrates, and air foam solution shall be installed where they will be accessible, especially during a fire emergency in the protected area and where there will be no exposure from the protected hazard.

***2112.** Automatically controlled valves shall be as close to the hazard protected as accessibility permits so that a minimum of piping is required between the automatic-control valve and the discharge devices.

2120. Alarms

***2121.** A local alarm, actuated independently of water flow, to indicate operation of the automatic detection equipment shall be provided on each system. An alarm is not required on manually operated systems.

***2122.** When an alarm is installed, the authority having jurisdiction shall be consulted regarding the alarm service to be provided and regarding the need for electrical fittings designed for use in hazardous locations in electric-alarm installations (see National Electrical Code, NFPA No. 70, ANSI C1-1974, Article 500 and other Articles in Chapter 5 thereof).

2123. A suitable trouble alarm shall be provided for each system to indicate failure of automatic detection equipment (including electric supervisory circuits) or other such devices or equipment upon which the system operation is dependent.

Chapter 3. Water Supplies

3010. Types of Water

*3011. Water supplied to foam-water sprinkler systems and foam-water spray systems may be fresh or salt, hard or soft, without affecting the quality or volume of foam produced. The water shall be free of constituents not compatible with air foam concentrates.

3012. Water containing solids of size likely to clog orifices in discharge devices but otherwise acceptable from the foam-making standpoint, shall be supplied to systems after passing through line strainers.

3020. Water-Supply Capacity and Pressure

3021. Water supplies for foam-water sprinkler systems and foam-water spray systems shall be of capacity and pressure capable of maintaining foam discharge and/or water discharge at the design rate for the required period of discharge over the entire area protected by systems expected to operate simultaneously.

3022. Where water supply is dependent on public water sources, attention shall be given to the pollution hazard introduced by the use of air foam concentrate and any cross connections cleared with Public Health Agencies concerned.

3023. Water supplies shall be capable of supplying the systems at the design discharge capacity for at least 60 minutes.

Exception: for aircraft hangars refer to NFPA No. 409, Standard on Aircraft Hangars (ANSI Z214.1).

3030. Strainers For Water and Air-Foam Concentrates

3031. Strainers shall be capable of removing from the water all solids of sufficient size to obstruct the discharge devices and listed for fire protection service. Strainers shall be installed so as to be accessible for cleaning during an emergency. Space shall be provided for basket removal.

3032. Strainers shall be installed in the main water-supply lines feeding orifices (or water passages) smaller than 3/8 inch. Strainers shall be installed on systems having larger orifices where water-supply conditions warrant. The largest dimension of the screen opening shall be 1/16 inch less than the diameter of the smallest orifice to be protected.

3033. Strainers shall be installed in liquid concentrate lines upstream of metering orifices or proportioning devices.

3034. Where listed strainers of the proper size are not available, strainers having a ratio of open-basket area to inlet pipe size of at least 10 to 1 shall be used.

Chapter 4. System Design and Installation

4010. Plans and Specifications

4011. The designing and installation of foam-water sprinkler and spray systems shall be entrusted to experienced and responsible persons. Before such systems are installed, complete working plans and specifications shall be prepared. Working plans shall be drawn to scale, show all essential details, and be easily reproduced. Working plans and specifications shall provide information on the discharge densities and period of discharge; hydraulic calculations; details of tests of available water supply; detailed layout of the piping and of the automatic detection equipment; type of discharge devices to be installed; location and spacing of discharge devices; pipe-hanger installation details; location of draft curtains; an accurate and complete layout of the buildings or hazards to be protected; and other pertinent data to provide a clear explanation of the proposed design.

(a) In addition to the items listed in paragraph 4011, plans and specifications shall indicate the quantity of air foam concentrate to be stored, including the quantity in reserve, and the concentration designation, either 3 percent or 6 percent.

(b) The specifications shall indicate the specific tests to be conducted.

(c) Complete plans and detailed data describing pumps, drivers, controllers, power supply, fittings, suction and discharge connections, and suction conditions shall be submitted by the engineer or contractor to the authority having jurisdiction for approval before installation.

(d) Charts showing head delivery, efficiency and brake horsepower curves of pumps shall be furnished by the contractor.

4020. Design Guides

4021. Foam-water sprinkler and foam-water spray system designs shall conform to all the applicable requirements of the following standards of the National Fire Protection Association except where otherwise specified herein:

Title	NFPA Standard Numbers
Foam Extinguishing Systems	No. 11
Synthetic Foam, Combined Agent	No. 11B
Sprinkler Systems	No. 13
Standpipe and Hose Systems	No. 14
Water Spray Fixed Systems for Fire Protection	No. 15
Centrifugal Fire Pumps	No. 20
Water Tanks for Private Fire Protection Service	No. 22
Outside Protection	No. 24
Supervision and Care of Valves Controlling Water Supplies for Fire Protection	No. 26
National Electrical Code	No. 70
Central Station Protective Signaling Systems	No. 71
Local Protective Signaling Systems	No. 72A
Auxiliary Protective Signaling Systems	No. 72B
Remote Station Protective Signaling Systems	No. 72C
Proprietary Protective Signaling Systems	No. 72D

NOTE: Components of the electrical portions of these protective systems, where installed in locations subject to hazardous vapors or dusts shall be of types approved for use therein.

4022. The design discharge rates for water or air foam solution shall provide densities of not less than 0.16 gallons per minute per square foot of protected area.

Exception: for aircraft hangars refer to NFPA No. 409, Standard on Aircraft Hangars (ANSI Z214.1).

4023. The foam discharge shall continue for a period of 10 minutes at the design rate specified in 4022. Where the system has been designed to have delivery rate higher than specified in the foregoing, proportionate reduction in the discharge period may be made.

4030. Piping, Valves, Pipe Fittings, and Hangers

4031. Applicable parts of Chapter 3 of NFPA Standard for the Installation of Sprinkler Systems (No. 13) shall be consulted for requirements applicable to piping, valves, pipe fittings, and hangers, including corrosion-protection coatings (galvanizing or other means). In these open-head systems, galvanized pipe and fittings shall be used for normal outdoor occupancies. Corrosive atmospheres may require other coatings. Since the systems herein covered are required to be hydraulically designed, the pipe-size tables of the NFPA Standard for the Installation of Sprinkler Systems (No. 13) are not applicable.

4032. Piping carrying air foam concentrate shall be of a material compatible with the particular air foam concentrate to be used.

*4033. All fittings shall be of a type specifically approved for fire protection systems and of a design suitable for the working pressures involved, but not less than 175 psi cold water pressures. Ferrous fittings shall be of steel, malleable iron or ductile iron in dry sections of the piping exposed to possible fire or in self-supporting systems. Galvanized fittings shall be used where galvanized pipe is required.

Exception: Rubber gasketed fittings listed for use in sprinkler systems are acceptable in dry sections of the piping where required for piping flexibility, or for locations subject to earthquake, explosions or similar hazards.

4040. Operating-Means Design

*4041. In automatic systems the detecting equipment shall be connected to means for tripping water-supply valves and other system-control equipment. Supplemental manual means for accomplishment of this purpose shall also be provided.

4042. In automatic systems air foam concentrate injection shall be activated automatically by, or concurrently with, activation of the main water-supply control valve. Manual operating means shall be designed to accomplish this same purpose.

4043. Automatic detection equipment, whether pneumatic, hydraulic, or electric, shall be provided with complete supervision so arranged that failure of equipment or loss of supervising air pressure or loss of electric energy will result in positive notification of the abnormal condition.

4044. Where used in a corrosive atmosphere, the devices shall be of materials not subject to corrosion or be protected to resist corrosion.

4045. Automatic detection equipment of electric type and any auxiliary equipment of electric type, if in hazardous areas,† shall be expressly designed for use in such areas.

4046. In automatic systems manually-operated tripping devices shall actuate the automatic control valve by mechanical, pneumatic, electric, or other approved means. The manual device shall be strong enough to prevent breakage. Manual controls shall not require a pull of more than 40 pounds (force) nor a movement of more than 14 inches to secure operation.

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† See National Electrical Code (NFPA No. 70, ANSI Standard C1-1974), Article 500 and other Articles in Chapter 5 thereof.

4050. Drainage

4051. Facilities shall be provided for the safe removal or retention of the largest anticipated flammable liquid spill, plus the free water reaching the floor from the fixed fire protection system, as well as the discharge from hose streams.

4060. Hydraulic Calculations

4061. System piping shall be hydraulically calculated and sized in order to obtain reasonably uniform foam and water distribution and to allow for loss-of-head in water-supply piping. The adjustment in pipe sizes shall be based on a maximum variation of 15 percent above the specified discharge rate per sprinkler or nozzle.

4062. Pipe sizes shall be adjusted according to detailed friction-loss calculations. These calculations shall show the relation between the water supply and demand.

4063. Hydraulic calculations for determining the air foam solution and water-flow characteristics of systems covered by this Standard shall be in accordance with NFPA Standard for the Installation of Sprinkler Systems (No. 13). Piping carrying air foam solution shall be sized on the same basis as if it were carrying plain water.

***4064.** The friction losses in piping carrying air foam concentrate shall be calculated using the Darcy formula (also known as the Fanning formula). Friction factors for use with this formula shall be selected from the charts, Friction Factors for Commercial Steel and Cast-Iron Pipe (see Appendix for formula and charts). In calculating Reynolds Number for selecting friction factors from the charts, the actual density (or specific gravity) of the air foam concentrate to be used in the system shall be used. The viscosity used shall be the actual viscosity of the air foam concentrate at the lowest anticipated storage temperature.

4065. For purposes of computing friction loss in piping, the following "C" Factors shall be used for Williams and Hazens formula:

Black or Galvanized-Steel Pipe	120
Unlined Cast-Iron Pipe	100
Asbestos-Cement or Cement-Lined Cast Iron	140

Chapter 5. Acceptance Tests

*5010. Flushing of Supply Piping

5011. Mains supplying water for systems shall be flushed out thoroughly before the system risers are connected to the mains. Water shall be flowed through these mains with a velocity of at least 10 feet per second for a sufficient time to give at least two changes of water or until there is no continuing evidence of discharge of foreign materials.

5012. Where the supply will not produce the stipulated flow rate, at least the maximum flow available shall be obtained by employing adequate discharge means.

5020. Hydrostatic Pressure Tests

5021. All piping, including yard piping, air foam concentrate lines and the system piping, shall be tested hydrostatically at not less than 200-pound per square inch pressure for two hours, or at 50-pound per square inch in excess of the maximum static pressure when the maximum static pressure is in excess of 150 pounds.

NOTE: It is recommended that air foam concentrate lines be tested using liquid foam concentrate as the testing medium.

***5022.** The amount of leakage in underground water piping shall be measured at the specific test pressure by pumping from a calibrated container. Leakage shall not exceed two quarts per hour per 100 joints irrespective of pipe diameter.

5023. Air foam concentrate piping shall be shown to be leak tight during hydrostatic pressure tests.

*5030. System Tests Discharging Foam

***5031.** Acceptance tests shall include:

(a) Foam discharge from a single system.

(b) Simultaneous foam discharge of the maximum number of systems expected to operate on a single hazard.

5032. During the tests, the pressure at the discharge devices shall be at least equal to the minimum design operating pressure of the system or systems tested. Percentage of all foam concentrates injected into the water shall be within the following limits: 2.8 percent to 4 percent for nominal 3 percent concentrates and 5 percent to 7 percent for nominal 6 percent concentrates.

5033. The discharge shall be continued for a sufficient time period to obtain stabilized discharge.

5034. Where conditions permit, flow tests shall be conducted to ensure that the hazard is fully protected in conformance with the design specification, and to determine the flow pressures, actual discharge capacity, consumption rate of foam-producing materials, manpower requirements and other operating characteristics.

***5035.** The concentration of foam liquid in solution shall be determined. The rate of solution discharge may be computed from hydraulic calculations utilizing recorded inlet and/or end-of-system operating pressure. The foam liquid concentrate consumption rate may be calculated by timing a given displacement from the storage tank or by refractometric means. The calculated concentration and the foam solution pressure shall be within the operating limit recommended by the authority having jurisdiction.

5036. Systems shall be thoroughly flushed with water after operation with foam, except those portions normally containing air foam concentrate when the system is not operating.

NOTE: Give particular attention to strainers or other small openings.

Chapter 6. Periodic Testing

6010. Testing and Inspection of Air Foam Concentrate Injection Systems

6011. Air foam concentrate injection systems shall be so arranged that periodic tests and inspections are made without discharging air foam solution to the system piping in order to check operation of all mechanical and electrical components of the system. The system shall be so arranged that tests can be performed with as little loss of air foam concentrate as practical.

6020. Inspection of Air Foam Concentrates

***6021.** Periodic inspection shall be made of air foam concentrates and their containers for evidence of excessive sludging or deterioration. Inspection shall include a qualitative test of the air foam concentrate. Presence of specified quantities of concentrates in system-storage equipment in service-ready position and the quantities of reserve concentrates on hand shall be checked with requirements for same.

6030. Tripping of Water-Control Valves

6031. Water-supply control valves and their automatic and manual tripping means shall be trip tested semiannually. Tests shall be such that they may be accomplished without discharging air foam from system discharge devices or diminishing or diluting the air foam concentrate supply.

Chapter 7. Maintenance

7010. Foam-Water Sprinkler and Foam-Water Spray Systems

*7011. Systems shall be serviced, by personnel experienced in this work, at periodic intervals, at least semi-annually.

7012. Proportioning devices and strainers shall be thoroughly inspected and cleaned after each operation or flow test.

7020. Operating and Maintenance Instructions and Layouts

7021. Operating and maintenance instructions and layouts shall be readily available at control equipment and at Fire Headquarters. Selected plant personnel shall be trained and assigned the task of operating and maintaining the equipment.

Chapter 8. Laboratory Tests For the Physical Properties of Foam

8010. General: This chapter relates to the laboratory tests on foam concentrate and foam producing devices which are conducted by the national recognized testing laboratories to correlate the foam quality with fire extinguishing characteristics.

***8011. Scope.** The appendix contains detailed laboratory procedures and references for the sampling and analysis of the fire fighting foam produced by the devices covered in this standard.

Appendix

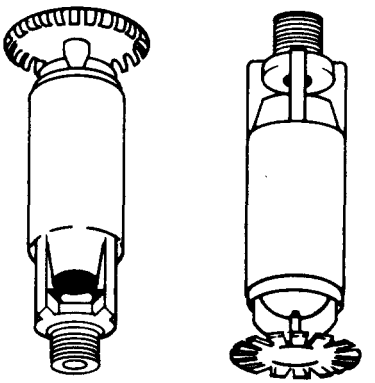

Figure A-1024(a)

Foam-water sprinklers are open-type sprinklers designed: (1) to receive air-foam solution (water plus liquid concentrate); (2) to direct the "solution" through an integral foam maker, the nozzle action of which breaks the "solution" into spray and discharges it into a mixing tube where it combines with air drawn in through openings in the housing; (3) to provide mixing-chamber capacity for development of the air foam; (4) to direct the formed foam discharging from the open end of the mixing tube against a deflector, shaped to distribute the foam in a pattern essentially comparable to the water-distribution pattern of present-day "standard" sprinklers (nomenclature from current edition of NFPA Standard for the Installation of Sprinkler Systems, No. 13) and to do this with essentially no impingement of the foam on the ceiling; and (5), in the case of discharge of water only, that is, in absence of foam, to develop a water-distribution pattern directly comparable to that of "standard" sprinklers.

The normal direction of discharge from foam-water sprinklers is downward. To provide a choice in installation design, foam-water sprinklers are produced for installation in the upright position and in the pendent, with the pattern of discharge in either case being that stated in the foregoing. *Sprinkler deflectors shall be formed to produce the required discharge pattern which may mean differing shapes of deflectors for each of the two positions of installation.* The variation in shape of deflectors is illustrated in the Figure.

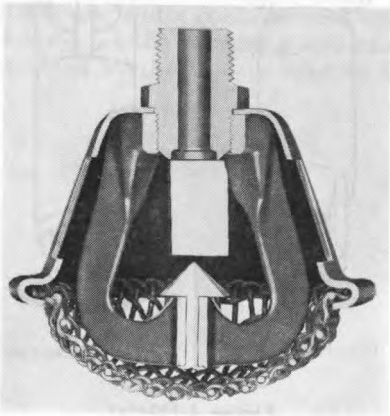

Figure A-1024(b)

Foam-water spray nozzles combine a foam-maker with a body and a distributing deflector. They will generate air foam in the same manner described for foam-water sprinklers, when supplied with air-foam solution under pressure, and will distribute the resulting foam, or water in the absence of foam solution, in a special pattern peculiar to the particular head.

These nozzles are available in a number of patterns with variations in discharge capacity.

Darcy Formula

$$\triangle P = 0.000216 \frac{fL_\rho Q^2}{d^5}$$

Reynolds Number

$$Re = \frac{50.6Q_\rho}{d\mu}$$

ΔP = Friction loss in p.s.i.
L = Length of pipe in feet
f = Friction factor
ρ = Weight density of fluid, pounds per cubic foot
Q = Flow in GPM
d = Pipe diameter in inches
μ = Absolute (dynamic) viscosity in centipoise
Re = Reynolds Number

A-2031. Table 1 shows the range of the water discharge rates of listed foam-water sprinklers.

Table 1

Foam-Water Sprinkler Water Discharge Rates

Pressure at Sprinkler Inlet (Pounds per Square Inch)	Range of Discharge Rates (Gallons per Minute)
20	12-16
30	14-18
40	16-20
50	18-22
75	22-26
100	25-30

Table 2

Standard Sprinkler* Discharge Rates

Pressure At Sprinkler Inlet (Lb per Sq In)	Range Of Discharge Rates (Gal per Min)
7	14 - 16
10	16 - 19
20	23 - 26
30	28 - 32

* Nominal 1/2 in. orifice.

A-2051. Air foam concentrates meeting the requirements of paragraph 2051 are available in 3 percent and 6 percent concentrations. Protein and fluoroprotein foam type concentrates are available for low temperature use.

Figures A-2062 (a) (b) (c) (d) — are schematic arrangements of equipment to illustrate the principle of operation of various proportioning methods. Other arrangements or components may also be used to accomplish the same purpose.

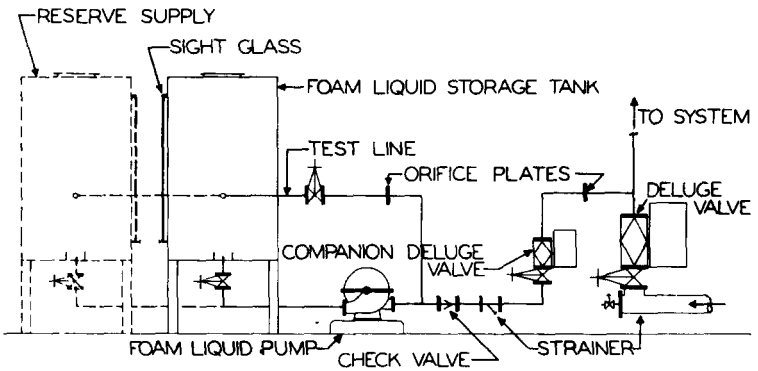

Figure A-2062.(a)

Schematic arrangement of air-foam liquid-concentrate storage tank; liquid-concentrate pump; metering proportioner; and interconnecting piping.

NOTE: The air-foam liquid-concentrate metering orifice can be calculated by using the formula:

$$Q_f = K\ C\ d^2 \sqrt{\Delta P}$$

K — Constant of particular foam liquid concentrate
C — Orifice Constant
d — diameter of orifice in inches
ΔP — Pressure differential across the orifice plate
Q_f — Volume of foam liquid concentrate gpm

The coefficient "C" is affected by several factors which include orifice shape, viscosity of Foam Liquid, velocity, ratio of orifice diameter to pipe diameter, etc.

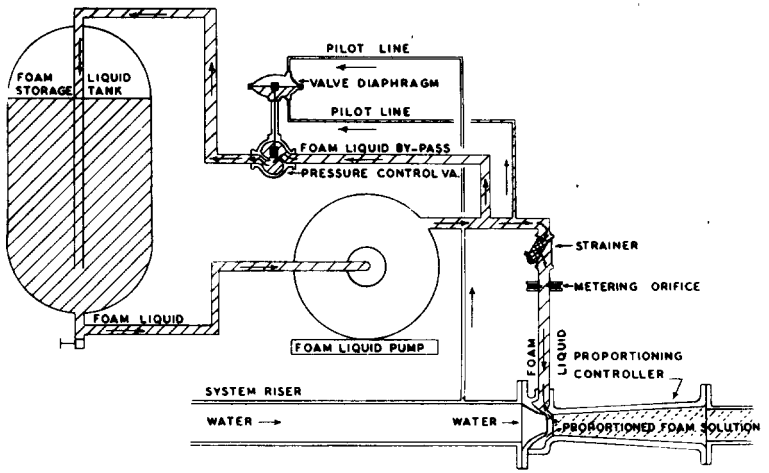

Figure A-2062.(b)

Balanced-Pressure Proportioning System

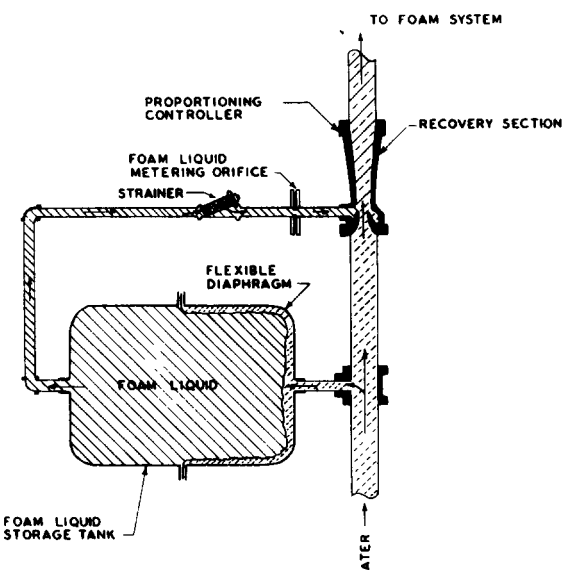

Figure A-2062.(c)

Pressure-Proportioning Tank With Diaphragm

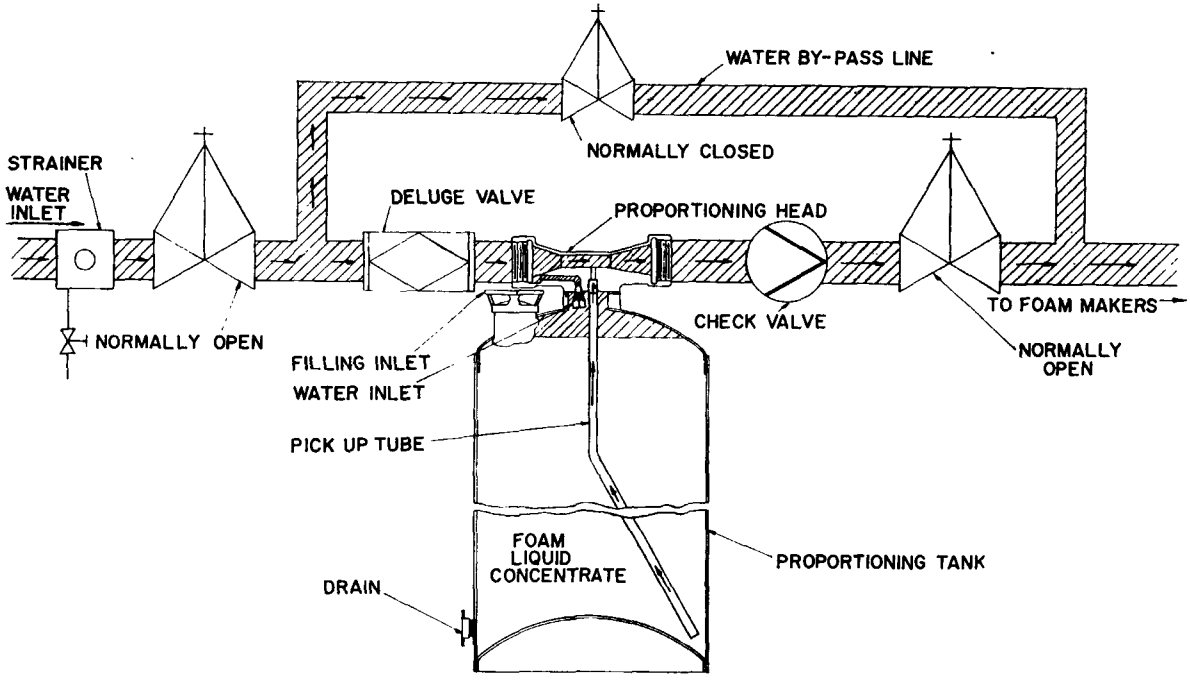

Figure A-2062.(d)

Pressure-Proportioning Tank Method (Pressure-Proportioning Tank Without Diaphragm). The arrangement of these devices may take a variety of forms. A single tank or a battery of tanks manifolded together may be used.

A-2070. Air foam concentrate pumps should have reliability equivalent to that of approved fire pumps.

A-2112. Consideration should be given to provisions of remotely located post-indicator or other shutoff valves to permit system water-supply control under abnormal conditions.

A-2121. Under conditions where central station or proprietary station water-flow alarm service is not available, it may be advisable to connect electrical alarm units to public Fire Department Headquarters or nearest Fire Department Station or other suitable place where aid may be readily secured. Central station or proprietary station water-flow alarm service is desirable but provision of this service does not necessarily waive the local alarm requirement.

A-2122. See NFPA Standards on Central Station Protective Signaling Systems (No. 71), Local Protective Signaling Systems (No. 72A), Auxiliary Protective Signaling Systems (No. 72B), Remote Station Protective Signaling Systems (No. 72C), and on Proprietary Protective Signaling Systems (No. 72D). Outdoor water-motor or electric-alarm gongs, responsive to system water flow, may be required.

A-3011. Fire fighting efficiency of air foams is not significantly affected when water temperature is below about 100° F., although some reduction in expansion occurs with very cold water. If the water temperature exceeds 100° F., however, foam stability and fire-fighting efficiency usually is reduced.

A-4033. Rubber gasketed fittings subject to direct fire exposure are generally not suitable. Where necessary for piping flexibility or for locations subject to earthquake, explosion or similar hazards, such installations are acceptable. In such cases special hanging or bracing may be necessary.

A-4041. The spacing of automatic detection equipment for systems installed for protection against fire exposure may call for a different arrangement from that required for other types of systems.