ANSI/NFPA 16 An American National Standard February 8, 1991

NFPA 16 Deluge Foam-Water Sprinkler and Foam-Water Spray Systems 1991 Edition

National Fire Protection Association 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101

NOTICE

All questions or other communications relating to this document should be sent only to NFPA Headquarters, addressed to the attention of the Committee responsible for the document.

For information on the procedures for requesting Technical Committees to issue Formal Interpretations, proposing Tentative Interim Amendments, proposing amendments for Committee consideration, and appeals on matters relating to the content of the document, write to the Secretary, Standards Council, National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

A statement, written or oral, that is not processed in accordance with Section 16 of the Regulations Governing Committee Projects shall not be considered the official position of NFPA or any of its Committees and shall not be considered to be, nor be relied upon as, a Formal Interpretation.

Users of this document should consult applicable Federal, State and local laws and regulations. NFPA does not, by the publication of this document, intend to urge action which is not in compliance with applicable laws and this document may not be construed as doing so.

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

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

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

---

1. Adoption by Reference — Public authorities and others are urged to reference this document in laws, ordinances, regulations, administrative orders or similar instruments. Any deletions, additions and changes desired by the adopting authority must be noted separately. Those using this method are requested to notify the NFPA (Attention: Secretary, Standards Council) in writing of such use. The term "adoption by reference" means the citing of title and publishing information only.

2. Adoption by Transcription — A. Public authorities with lawmaking or rule-making powers only, upon written notice to the NFPA (Attention: Secretary, Standards Council), will be granted a royalty-free license to print and republish this document in whole or in part, with changes and additions, if any, noted separately, in laws, ordinances, regulations, administrative orders or similar instruments having the force of law, provided that: (1) due notice of NFPA's copyright is contained in each law and in each copy thereof; and, (2) that such printing and republication is limited to numbers sufficient to satisfy the jurisdiction's lawmaking or rulemaking process. **B.** Once this NFPA Code or Standard has been adopted into law, all printings of this document by public authorities with lawmaking or rulemaking powers or any other persons desiring to reproduce this document or its contents as adopted by the jurisdiction in whole or in part, in any form, upon written request to NFPA (Attention: Secretary, Standards Council), will be granted a nonexclusive license to print, republish, and vend this document in whole or in part, with changes and additions, if any, noted separately provided that due notice of NFPA's copyright is contained in each copy. Such license shall be granted only upon agreement to pay NFPA a royalty. This royalty is required to provide funds for the research and development necessary to continue the work of NFPA and its volunteers in continually updating and revising NFPA standards. Under certain circumstances, public authorities with lawmaking or rulemaking powers may apply for and may receive a special royalty when the public interest will be served thereby.

3. Scope of License Grant — The terms and conditions set forth above do not extend to the index to this document.

(For further explanation, see the Policy Concerning the Adoption, Printing and Publication of NFPA Documents which is available upon request from the NFPA.)

Statement on NFPA Procedures

This material has been developed under the published procedures of the National Fire Protection Association, which are designed to assure the appointment of technically competent Committees having balanced representation. While these procedures assure the highest degree of care, neither the National Fire Protection Association, its members, nor those participating in its activities accepts any liability resulting from compliance or noncompliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text.

NFPA has no power or authority to police or enforce compliance with the contents of this document and any certification of products stating compliance with requirements of this document is made at the peril of the certifier.

NFPA 16

Standard on

Deluge Foam-Water Sprinkler and Foam-Water Spray Systems

1991 Edition

This edition of NFPA 16, *Standard on Deluge Foam-Water Sprinkler and Foam-Water Spray Systems*, was prepared by the Technical Committee on Foam-Water Sprinklers, released by the Correlating Committee on Water Extinguishing Systems, and acted on by the National Fire Protection Association, Inc. at its Fall Meeting held November 12-14, 1990 in Miami, FL. It was issued by the Standards Council on January 11, 1991, with an effective date of February 8, 1991, and supersedes all previous editions.

The 1991 edition of this document has been approved by the American National Standards Institute.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

Origin and Development of NFPA 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.

Amendments to the standard in 1968, 1974, 1980, and 1988 were completed to recognize the changing performance characteristics of various foam concentrates. The 1991 edition recognizes another type of foam concentrate and clarifies certain common requirements that are applicable regardless of foam type.

Committee on Water Extinguishing Systems

Correlating Committee

Paul D. Smith, *Chairman*
Gage-Babcock & Associates, Inc.

Robert E. Solomon, *Secretary*
National Fire Protection Association
(nonvoting)

Wayne E. Ault, Rolf Jensen & Associates Inc.
Thomas J. Brown, Jr., Factory Mutual Research Corp.
Casimir J. Drygas, Jr., M&M Protection Consultants
Richard Martineau, Mid Hudson Automatic Sprinkler Corp.
Rep. NFSA
Robert H. Merz, Moorestown, NJ
James W. Nolan, James W. Nolan Co.
Chester W. Schirmer, Schirmer Engineering Corp.
William L. Testa, Grinnell Fire Protection Systems Co.

Technical Committee on Foam-Water Sprinklers

Casimir J. Drygas, Jr., *Chairman*
M&M Protection Consultants

Peter Papavasiliou, *Secretary*
Schirmer Engineering Corp.

V. Frank Bateman, Minnesota Mining and Mfg. Co.
William M. Carey, Underwriters Laboratories Inc.
Salvatore A. Chines, Industrual Risk Insurers
Phillip A. Davis, Kemper Group
Rep. AAI
Donald W. Hering, 3S Incorporated
Rep. FSSA
George R. Herzog, Ansul Fire Protection
Rep. FEMA
Alan L. Holder, Louisiana Power & Light Co.
Rep. EEI
Fred M. Linde, Chubb Nat'l Foam
Edward R. Lising, Underwriters Laboratories of Canada
David Malek, Star Sprinkler, Inc.
Rep. NFSA
Giorgio Marini, Genova, ITALY
Robert C. Merritt, Factory Mutual Research Corp.
Richard F. Murphy, Exxon Research & Engr Co.
Rep. Technical Committee on Foam
Tommy Preuett, Road Sprinkler Fitters Local 669
Rep. UAPPF
Joseph L. Scheffey, Hughes Associates Inc.
E. J. Schiffhauer, Eastman-Kodak Co.
Rep. Technical Committee Automatic Sprinklers
Terry L. Victor, Automatic Sprinkler Corp. of America
Rep. NFSA
Andrew M. Wahl, Rolf Jensen & Assoc. Inc.
Fred K. Walker, HQ United States Air Force/LEEDE
Kenneth G. Wohlers, U.S. Dept of the Air Force
Rep. NFPA IFPS

Alternates

Wayne E. Ault, Rolf Jensen & Assoc. Inc.
(Alternate to A. M. Wahl)
Marco Bosoni, Snamprogetti
(Alternate to G. Marini)
Win Chaiyabhat, Kemper Group
(Alternate to P. A. Davis)
David Dixon, Security Fire Protection
Rep. NFSA
(Alternate to T. L. Victor)

Chris P. Hanauska, 3M
(Alternate to W. F. Bateman)
Emil W. Misichko, Underwriters Laboratories Inc.
(Alternate to W. M. Carey)
Keith Olson, Ansul Fire Protection
Rep. FEMA
(Alternate to G. R. Herzog)

Ray M. Puhalla, Road Sprinkler Fitters Local 669
(Alternate to T. Preuett)
Larry M. Romine, Schirmer Engineering Corp.
(Alternate to P. Papavasiliou)
Mark A. Tschiegg, Industrial Risk Insurers
(Alternate to S. A. Chines)

Robert E. Solomon, NFPA Staff Liaison

This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

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.

Contents

NFPA 16

Standard on

Deluge Foam-Water Sprinkler and Foam-Water Spray Systems

1991 Edition

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

Information on referenced publications can be found in Chapter 8 and Appendix B.

Foreword

The uses of foam (or mechanical foam as it was first called) for fire protection have expanded greatly since its inception in the 1930s. 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 that then directed the mechanically formed foam to a burning fuel tank or area of burning flammable fuel. (Details of these and similar applications are found in NFPA 11, 402M, and 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 specially 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 or film forming fluoroprotein foam concentrates (as defined in NFPA 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 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 or film forming fluoroprotein foam concentrates. These systems possess the common characteristic of being capable of either discharging foam in a spray form or discharging water in a satisfactory pattern for fire protection purposes.

Chapter 1 General Information

1-1 Scope.

1-1.1 This standard covers the minimum requirements for open head deluge-type foam-water sprinkler systems and foam-water spray systems, each of which combines in a single system provision for the alternate discharge of foam or water.

1-1.2 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.

1-1.3* The devices covered herein are intended primarily for use in foam-water deluge sprinkler systems 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 shall be made to either NFPA 11, *Standard for Low Expansion Foam and Combined Agent Systems*; NFPA 13, *Standard for the Installation of Sprinkler Systems*; or NFPA 15, *Standard on Water Spray Fixed Systems for Fire Protection.*

1-2 Purpose. The purpose of this standard is to provide a reasonable degree of protection for life and property from fire through installation requirements for foam-water deluge sprinkler systems and foam-water spray systems based upon sound engineering principles, test data, and field experience.

Nothing in this standard is intended to restrict new technologies or alternate arrangements, providing the level of safety prescribed by the standard is not lowered.

1-2.1 Unless otherwise noted, it is not intended that the provisions of this document be applied to facilities, equipment, structures, or installations that were existing or approved for construction or installation prior to the effective date of the document, except in those cases where it is determined by the authority having jurisdiction that the existing situations involves a distinct hazard to life or adjacent property.

1-3 Definitions.

Approved. Acceptable to the "authority having jurisdiction."

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

Authority Having Jurisdiction. The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

NOTE: 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, 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 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."

Density. This term refers to the unit rate of liquid application to an area and is expressed in gal per min per sq ft. The term "density" is used in this standard with reference to application of water in some cases and in others to application of foam solution.

Discharge Devices. There are four principal types of discharge devices that are installed at the discharge outlets of the systems covered by this standard.

*Foam-Water Sprinklers.** These discharge devices are specially designed, open-type air-aspirating heads consisting of an open barrel body foam maker that 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 13, *Standard for the Installation of Sprinkler Systems*) when discharging at the same rates of flow.

*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.

Non-Air-Aspirated Spray Nozzles. These discharge devices are open, directional spray nozzles. When supplied with an approved foam solution such as AFFF, they discharge foam in a pattern peculiar to the discharge device. See NFPA 11, *Standard for Low Expansion Foam and Combined Agent Systems*, for specifics on application rates.

Standard Sprinklers. These discharge devices are the standard sprinklers, without heat responsive elements, referred to in NFPA 13, *Standard for the Installation of Sprinkler Systems*, and they are non-air-aspirating. When they are supplied with aqueous film forming foam (AFFF) air foam solution, or film forming fluoroprotein (FFFP) air foam solution, a foam discharge pattern is produced closely conforming to the water discharge pattern of these sprinklers.

Foam. 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 and forming an air-excluding continuous blanket or film over the fuel, thus sealing volatile combustible vapors from access to air or reignition. The 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 11, Standard for Low Expansion Foam and Combined Agent Systems; NFPA 402M, Manual for Aircraft Rescue and Fire Fighting Operations; NFPA 403, Standard for Aircraft Rescue and Fire Fighting Services at Airports; and NFPA 412, Standard for Evaluating Foam Fire Fighting Equipment on Aircraft Rescue and Fire Fighting Vehicles.*)

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

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.

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.

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 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.

Film Forming Fluoroprotein (FFFP) Foam Concentrates. These foam concentrates use fluorinated surfactants to produce a fluid aqueous film for suppressing hydrocarbon fuel vapors. This type of foam also utilizes a protein base, plus stabilizing additives and inhibitors. The foam is usually diluted with water to a three or six percent solution.

Foam Solution. A mixture consisting of a foam concentrate in suitable proportions in either fresh or salt water.

Foam-Water Sprinkler System. A foam-water sprinkler system is a special system pipe-connected to a source of foam concentrates and to a water supply and 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 that 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, foam concentrate is injected into the water, and the resulting foam solution discharging through the discharge devices generates and distributes

foam. Upon exhaustion of the foam concentrate supply, water discharge will follow the foam and continue until shut off manually. Systems may be used for discharge of water first, followed by discharge of foam for a definite period, and this followed by water until manually shut off. Existing deluge sprinkler systems that have been converted to the use of aqueous film forming foam or film forming fluoroprotein foam are classed as foam-water sprinkler systems.

Foam-Water Spray System. A foam-water spray system is a special system pipe-connected to a source of foam concentrate and to a water supply and equipped with foam-water spray nozzles for extinguishing agent discharge (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 preceding paragraph.

Listed. Equipment or materials included in a list published by an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The "authority having jurisdiction" should utilize the system employed by the listing organization to identify a listed product.

Shall. Indicates a mandatory requirement.

Should. Indicates a recommendation or that which is advised but not required.

1-4 System Design.

1-4.1 Automatic operation shall be provided and supplemented by auxiliary manual tripping means.

Exception: Manual operation only may be provided when acceptable to the authority having jurisdiction.

1-4.2 Systems shall deliver foam for a definite period at given densities (gal per min of foam solution per sq ft) [(L/min)/m^2] to the hazards they protect, either prior to water discharge or following water discharge, depending upon system-design purpose.

1-4.3 Following completion of discharge of foam to the hazards protected, these special systems shall discharge water until manually shut off.

1-4.4 Authorities having jurisdiction shall be consulted as to the means by which a reserve supply of 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 Section 2-3*).

1-5 Applicability.

1-5.1 Systems of this type shall discharge 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, as defined in NFPA 10, *Standard for Portable Fire Extinguishers*.

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

1-5.2 Foam-water deluge 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 [gal per min per sq ft or (L/min)/m^2] shall be provided by system design and use of selected discharge devices and by provision of adequate supplies of air-water at suitable pressures to accomplish the system design. Foam-discharge rates shall be suitable for the design period and following depletion of 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.

1-5.3 Foam of any type is not considered a suitable extinguishing agent on fires involving liquefied or compressed gases, e.g., butane, butadiene, propane, etc., or on materials that will react violently with water (e.g., metallic sodium) or that produce hazardous materials by reacting with water, or on fires involving electrical equipment where the electrical nonconductivity of the extinguishing agent is of first importance.

1-5.4 Ordinary foam concentrates shall not be used on fires in water-soluble solvents and polar solvents. Special "alcohol-type" concentrates are available for production of foams for protection of such hazards.

1-6 Approvals.

1-6.1 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 foam concentrate to be provided for system use. All equipment and concentrates shall be approved for the particular application intended.

1-6.2 Provisions of this standard are not intended to be applied retroactively. Where the system is being altered, extended, or renovated, the requirements of this standard apply only to the work being undertaken.

1-7 Units. Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). Two units (liter and bar), outside of but recognized by SI, are commonly used in international fire protection. These units are listed in Table 1-7 with conversion factors.

Table 1-7

Name of Unit	Unit Symbol	Conversion Factor
liter	L	1 gal = 3.785L
liter per minute per square meter	$(L/min)/m^2$	1 gpm/ft^2 = 40.746 $(L/min)/m^2$
millimeter per minute	mm/min	1 gpm/ft^2 = 40.746 mm/min
cubic decimeter	dm^3	1 gal = 3.785 dm^3
pascal	Pa	1 psi = 6894.757 Pa
bar	bar	1 psi = 0.0689 bar
bar	bar	1 bar = 105 Pa

For additional conversions and information, see ASTM E 380, *Standard for Metric Practice.*

1-7.1 If a value for measurement as given in this standard is followed by an equivalent value in other units, the first stated shall be regarded as the requirement. A given equivalent value may be approximate.

1-7.2 The conversion procedure for the SI units has been to multiply the quantity by the conversion factor and then round the result to the appropriate number of significant digits.

Chapter 2 System Components

2-1 Approved Devices and Materials. All components and parts including foam concentrates of foam-water spinkler and foam-water spray systems shall be listed for the intended application.

2-2* Discharge Devices. Discharge devices may be air-aspirating, such as foam-water sprinkler and foam-water spray nozzles, or they may be non-air-aspirating, such as standard sprinklers.

2-2.1 Discharge devices and foam concentrates shall be listed for use together.

2-2.2 Non-air-aspirating devices shall be used only with concentrates, such as AFFF or FFFP, that have been tested and listed for use in these devices.

2-3 Foam Concentrates.

2-3.1* Foam concentrates shall be listed for use with the concentrate proportioning equipment and with the discharge device to be used.

2-3.2 The quantities of 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 1-4.4, 4-2.2, and 4-2.3.*)

2-3.3 There shall be a readily available supply of 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.

2-3.4 Replacement supplies of concentrates shall be checked by appropriate tests to determine acceptability.

2-4 Foam Concentrate Proportioning Means.

2-4.1 Positive pressure-injection is the preferred method for introduction of foam concentrates into the water flowing through the supply piping to the system.

2-4.2* Positive pressure-injection methods shall mean one of the following:

(a) 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 a 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.

2-4.3 Orifice plates shall have "tell-tale" indicators giving orifice diameters and indicating flow direction if flow characteristics vary with flow direction.

NOTE: See A-2-4.2 for formula for calculation of size of orifices used in metering foam concentrates.

2-4.4 Where special conditions warrant, other proportioning methods may be used, such as around-the-pump proportioners and in-line inductors.

2-5* Pumps.

2-5.1 Foam concentrate pumps and water pumps shall have adequate capacities to meet the maximum needs of the system on which they are used. (*See Section 3-2 for water supply requirements.*) To ensure 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.

2-5.2 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 of concentrate being pumped.

2-5.3 Provision shall be made to shut off the foam concentrate pump after the foam supply is exhausted.

2-6 Power Supply.

2-6.1 Power supply for the drivers of foam concentrate pumps and water pumps shall be of maximum reliability. Compliance with the applicable requirements of NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps*, covering the reliability of power supply for fire-pump drivers, is considered to meet the intent of this chapter.

2-6.2 Controllers governing the starting of foam concentrate pumps shall be of approved types. Control equipment shall comply with NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps*.

2-7 Air Foam Concentrate Storage Tanks.

2-7.1 Storage tanks for foam concentrates shall be of construction suitable for the liquid, solidly mounted, and permanently located.

2-7.2 Storage temperatures of foam concentrates shall be considered in locating storage tanks.

2-7.3 Storage tanks shall have capacities to accommodate only the needed quantities of foam concentrate plus adequate space for thermal expansion, the latter preferably to be accomplished by means of a vertical riser or expansion dome. Tanks meeting this requirement shall 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. Foam concentrate outlets from tanks shall be raised above the bottoms of the tanks to provide adequate sediment pockets.

2-7.4 In determining the quantity of foam concentrates, the volume of the sediment pocket shall be added to the quantity needed for system operation.

2-7.5 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.

2-7.6 Tanks shall be located to furnish a positive head on the pump suction.

2-7.7 Pressure proportioning tanks shall have means for filling, for gaging the level of concentrates, for drainage, and for cleaning and inspection of interior surfaces and of the concentrate holding bag, if provided.

2-8 Pressure on Foam Concentrate Lines. Where foam concentrate lines to the protective-system injection points are run underground or where they run aboveground for more than 50 ft (15 m), 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.

2-9 Temperature of Foam Concentrate Lines and Components. Temperature of foam concentrate lines and components shall be maintained within the storage temperature limits specified for the foam concentrate.

2-10 Location of System-Control Equipment.

2-10.1 Equipment items, such as storage tanks and proportioners for foam concentrates, pumps for water and foam concentrates, and control valves for water, concentrates, and 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.

2-10.2* 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.

2-11 Detection Equipment. Detection equipment shall be installed, tested, and maintained in accordance with NFPA 72E, *Standard on Automatic Fire Detectors*.

2-12 Alarms.

2-12.1* 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.

2-12.2* 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 Article 500, NFPA 70, National Electrical Code,® and other articles in Chapter 5 therefrom*).

2-12.3 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.

2-12.4 Alarm systems shall meet the applicable requirements of NFPA 72, *Standard for the Installation, Maintenance, and Use of Protective Signaling Systems.*

2-13 Strainers for Water and Foam Concentrates.

2-13.1 Strainers shall be listed for fire protection service and shall be capable of removing from the water all solids of sufficient size to obstruct the discharge devices. Strainers shall be installed so as to be accessible for cleaning during an emergency. Space shall be provided for basket removal.

2-13.2 Strainers shall be installed in the main water supply lines feeding orifices (or water passages) smaller than $^3/_8$ in. (9.6 mm). Strainers shall be installed on systems having larger orifices where water supply conditions warrant. Normally $^1/_8$-in. (3.2-mm) perforations are suitable.

2-13.3 Strainers shall be installed in liquid concentrate lines upstream of metering orifices or proportioning devices. 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 3 Water Supplies

3-1 Types of Water.

3-1.1* Water supplied to deluge foam-water sprinkler systems and foam-water spray systems shall be free of constituents not compatible with air foam concentrates.

3-2 Water Supply Capacity and Pressure.

3-2.1 Water supplies for deluge 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.

3-2.2 Where water supply is dependent on public water sources, attention shall be given to the pollution hazard introduced by the use of foam concentrate and any cross connections cleared with public health agencies concerned.

3-2.3 Water supplies shall be capable of supplying the systems at the design discharge capacity for at least 60 min.

Exception: For aircraft hangars, refer to NFPA 409, Standard on Aircraft Hangars.

Chapter 4 System Design and Installation

4-1 Plans and Specifications.

4-1.1 The designing and installation of deluge 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 4-1.1, plans and specifications shall indicate the quantity of foam concentrate to be stored, including the quantity in reserve, the concentration designation, and the minimum anticipated temperature of the concentrate at the point of proportioning.

(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.

4-2 Design Guides.

4-2.1* 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 Number
Low Expansion Foam and Combined Agent Systems	11
Sprinkler Systems	13
Standpipe and Hose Systems	14
Water Spray Fixed Systems for Fire Protection	15
Centrifugal Fire Pumps	20
Water Tanks for Private Fire Protection	22
Private Fire Service Mains	24
National Electrical Code	70
Central Station Protective Signaling Systems	71
Protective Signaling Systems	72
Automatic Fire Detectors	72E

NOTE: Refer to NFPA occupancy standards where applicable.

4-2.2 The design discharge rates for water or foam solution shall provide densities of not less than 0.16 gal per min per sq ft [6.5 (L/min)/m^2] of protected area. This minimum density is required because this is a dual-agent foam-water system.

Exception: For aircraft hangars refer to NFPA 409, Standard on Aircraft Hangars.

4-2.3 The foam discharge shall continue for a period of 10 min at the design rate specified in 4-2.2. If the system discharges at a rate above the minimum specified in 4-2.2,

then the operating time may be reduced proportionately, but shall not be less than 7 min.

4-3 Piping, Valves, Pipe Fittings, and Hangers.

4-3.1 Applicable parts of Chapter 3 of NFPA 13, *Standard for the Installation of Sprinkler Systems*, 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 covered herein are required to be hydraulically designed, the pipe-size tables of NFPA 13, *Standard for the Installation of Sprinkler Systems*, are not applicable.

4-3.2* Pipe and fittings carrying foam concentrate shall be of a material compatible with the particular foam concentrate to be used.

4-3.3* 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 (1207 kPa) 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.

4-3.3.1 Rubber gasketed fittings may be used to connect pipe in fire exposed areas when the foam-water deluge system is automatically controlled. Fire exposed areas in which these fittings are located shall be protected by automatic foam-water deluge systems or other approved means.

4-4 Operating-Means Design.

4-4.1* In automatic systems the detecting equipment shall be connected to means for tripping water deluge valves and other system-control equipment. Supplemental manual means for accomplishment of this purpose shall also be provided.

4-4.2 In automatic systems 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.

4-4.3 Automatic detection equipment, whether pneumatic, hydraulic, or electric, shall be provided with complete supervision so arranged that failure of equipment, loss of supervising air pressure, or loss of electric energy will result in positive notification of the abnormal condition.

4-4.4 Where used in a corrosive atmosphere, the devices shall be of materials not subject to corrosion or protected to resist corrosion.

4-4.5 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. (*See Article 500, NFPA 70, National Electrical Code, and other articles in Chapter 5 therefrom.)*

4-4.6 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 lb [178 newtons (force)] nor a movement of more than 14 in. (356 mm) to secure operation.

4-5 Drainage. 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.

4-6 Hydraulic Calculations.

4-6.1 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.

4-6.2 Pipe sizes shall be adjusted according to detailed friction-loss calculations. These calculations shall show the relation between the water supply and demand.

4-6.3 Hydraulic calculations for determining the foam solution and water-flow characteristics of systems covered by this standard shall be in accordance with NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*. Piping carrying foam solution shall be sized on the same basis as if it were carrying plain water.

4-6.4* The friction losses in piping carrying 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 A-1-3 for formula and Figures A-4-6.4(a)-(d) for charts*]. In calculating Reynolds number for selecting friction factors from the charts, the actual density (or specific gravity) of the foam concentrate to be used in the system shall be used. The viscosity used shall be the actual viscosity of the foam concentrate at the lowest anticipated storage temperature.

4-6.5 For purposes of computing friction loss in piping, the following "C" Factors shall be used for the Williams and Hazens formula:

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

Chapter 5 Acceptance Tests

5-1 Flushing of Supply Piping. Underground mains and lead-in connections to system risers shall be flushed thoroughly before connection is made to system piping, in order to remove foreign materials that may have entered the underground during the course of the installations or that may have been present in existing piping. The minimum rate of flow shall be not less than the water demand rate of the system, which is determined by the system design, or not less than that necessary to provide a velocity of 10 ft per sec (3 m/s), whichever is greater. For all systems the flushing operations shall be continued for a sufficient time to ensure thorough cleaning. When planning the flushing operations consideration shall be given to disposal of the water issuing from the test outlets.

Flow Rrequired to Produce a Velocity of 10 Ft per Second (3 m/s) in Pipes

Pipe Size	Flow	
(Inches)	(Gal per Minute)	(L/min)
4	390	1476
6	880	3331
8	1560	5905
10	2440	9235
12	3520	13 323

5-2 Hydrostatic Pressure Tests.

5-2.1 All piping, including yard piping, foam concentrate lines, and the system piping, shall be tested hydrostatically at not less than 200 psi (1379 kPa) pressure for 2 hr, or at 50 psi (345 kPa) in excess of the maximum static pressure when the maximum static pressure is in excess of 150 psi (10 bars).

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

5-2.2* 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 2 qt per hr (1.89 L/h) per 100 joints, irrespective of pipe diameter. See NFPA 24, *Standard on the Installation of Private Fire Service Mains and Their Appurtenances*, Chapter 8, "Rules for Laying Pipe."

5-2.3 Foam concentrate piping shall be shown to be leaktight during hydrostatic pressure tests.

5-3 System Tests Discharging Foam.

5-3.1* 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.

(c) Where full flow tests are not practical, adequate tests of system components to verify design capability shall be performed.

5-3.2 The discharge shall be continued for a sufficient time period to obtain stabilized discharge.

5-3.3* 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.

5-3.4 The concentration of foam in solution shall be determined. 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: 3 percent to 4 percent for nominal 3 percent concentrates and 5 percent to 7 percent for nominal 6 percent concentrates. The rate of solution discharge may be computed from hydraulic calculations utilizing recorded inlet and/or end-of-system operating pressure. The foam 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.

5-3.5 Systems shall be thoroughly flushed with water after operation with foam, except those portions normally containing foam concentrate when the system is not operating.

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

Chapter 6 Periodic Testing

6-1 Testing and Inspection of Foam Concentrate Injection Systems. Foam concentrate injection systems shall be so arranged that periodic tests and inspections are made at least annually without discharging 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 foam concentrate as practical.

6-2 Inspection of Foam Concentrates. Periodic inspection shall be made at least annually of foam concentrates and their containers for evidence of excessive sludging or deterioration. Inspection shall include a qualitative test of the foam concentrate normally conducted by the manufacturer. 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.

6-3 Tripping of Water-Control Valves. 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 foam from system discharge devices or diminishing or diluting the foam concentrate supply.

6-4 Testing and Inspection of Alarm and Detection Devices. Alarm and detection devices shall be tested and inspected in accordance with NFPA 72, *Standard for the Installation, Maintenance, and Use of Protective Signaling Systems*, and NFPA 72E, *Standard on Automatic Fire Detectors*.

Chapter 7 Maintenance

7-1 Deluge Foam-Water Sprinkler and Foam-Water Spray Systems.

7-1.1* Systems shall be serviced by personnel experienced in this work at periodic intervals, preferably semiannually, but at least annually.

7-1.2 Proportioning devices and strainers shall be thoroughly inspected and cleaned after each operation or flow test.

7-2 Operating and Maintenance Instructions and Layouts. Operating and maintenance instructions and layouts shall be readily available at the control equipment and at the plant fire headquarters. Selected plant personnel shall be trained and assigned the task of operating and maintaining the equipment.

Chapter 8 Referenced Publications

8-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is current as of the date of the NFPA issuance of this document.

8-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers*, 1990 edition

NFPA 11, *Standard for Low Expansion Foam and Combined Agent Systems*, 1988 edition

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1989 edition

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 1990 edition

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 1990 edition

NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps*, 1990 edition

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 1987 edition

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 1987 edition

NFPA 70, *National Electrical Code*, 1990 edition

NFPA 71, *Standard for the Installation, Maintenance, and Use of Signaling Systems for Central Station Service*, 1989 edition

NFPA 72, *Standard for the Installation, Maintenance, and Use of Protective Signaling Systems*, 1990 edition

NFPA 72E, *Standard on Automatic Fire Detectors*, 1990 edition

NFPA 409, *Standard on Aircraft Hangars*, 1990 edition

Appendix A

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

A-1-1.3 Reference is also made to NFPA 16A, *Recommended Practice for the Installation of Closed-Head Foam-Water Sprinkler Systems*.

A-1-3 Foam-Water Sprinklers. Foam-water sprinklers are open-type sprinklers designed:

(a) To receive foam solution (water plus liquid concentrate);

(b) 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;

(c) To provide mixing-chamber capacity for development of the air foam;

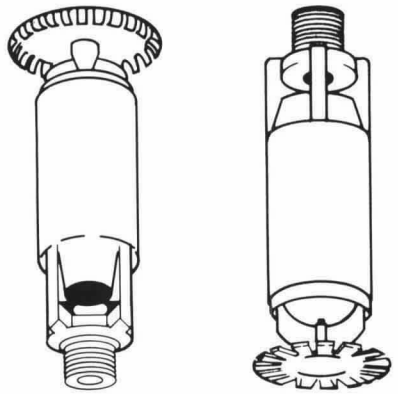
(d) To direct the formed foam discharging from the open end of the mixing tube against a deflector, shaped to distribute the foam in a pattern essentially comparable to the water-distribution pattern of present-day "standard" sprinklers (nomenclature from current edition of NFPA 13, *Standard for the Installation of Sprinkler Systems*), and to do this with essentially no impingement of the foam on the ceiling; and

(e) 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 position with the pattern of discharge in either case being downward. 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 Figure A-1-3(a).

A-1-3 Foam-Water Spray Nozzles. Foam-water spray nozzles combine a foam-maker with a body and a distributing deflector [for example, see Figure A-1-3(b)]. They will generate foam in the same manner described for foam-water sprinklers, when supplied with 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.



Upright Mounting Pendent Mounting

Figure A-1-3(a).

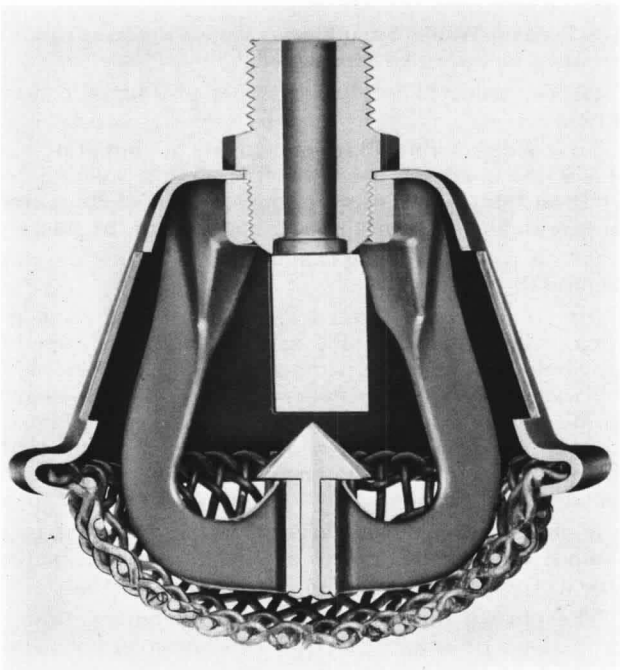


Figure A-1-3(b).

Darcy Formula

$$\Delta P = 0.000216 \frac{fL\ \rho\ Q^2}{d^5}$$

Reynolds Number

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

ΔP = Friction loss in psi
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-2-2 Table A-2.2(a) shows the range of the water discharge rates of listed foam-water sprinklers.

Table A-2-2(a)
Foam-Water Sprinkler* Water Discharge Rates

Pressure at Sprinkler Inlet (lb per sq in.)	Range of Discharge Rates (gal per min)
20	12-14
30	14-17
40	16-19
50	18-22
75	22-26
100	25-30

*Nominal 3/8 in. orifice.

Table A-2-2(b)
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
For SI Units 1 psi = 0.0689 bar; 1 gpm = 3.785 L/min

A-2-3.1 Foam concentrates meeting the requirements of 2-3.1 are available in 3 percent and 6 percent concentrations. Some foam concentrates are available for use as low as -20°F (-28°C).

A-2-4.2 Figures A-2-4.2(a), (b), (c), and (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.

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

$$Q_f = KCd^2 \sqrt{\Delta P}$$

K = Constant of particular foam liquid concentrate (available from the manufacturer)
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 that include orifice shape, viscosity of foam liquid, velocity, ratio of orifice diameter to pipe diameter, etc.

A-2-5 Foam concentrate pumps should have reliability equivalent to that of approved fire pumps.

A-2-10.2 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-2-12.1 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, the nearest fire department

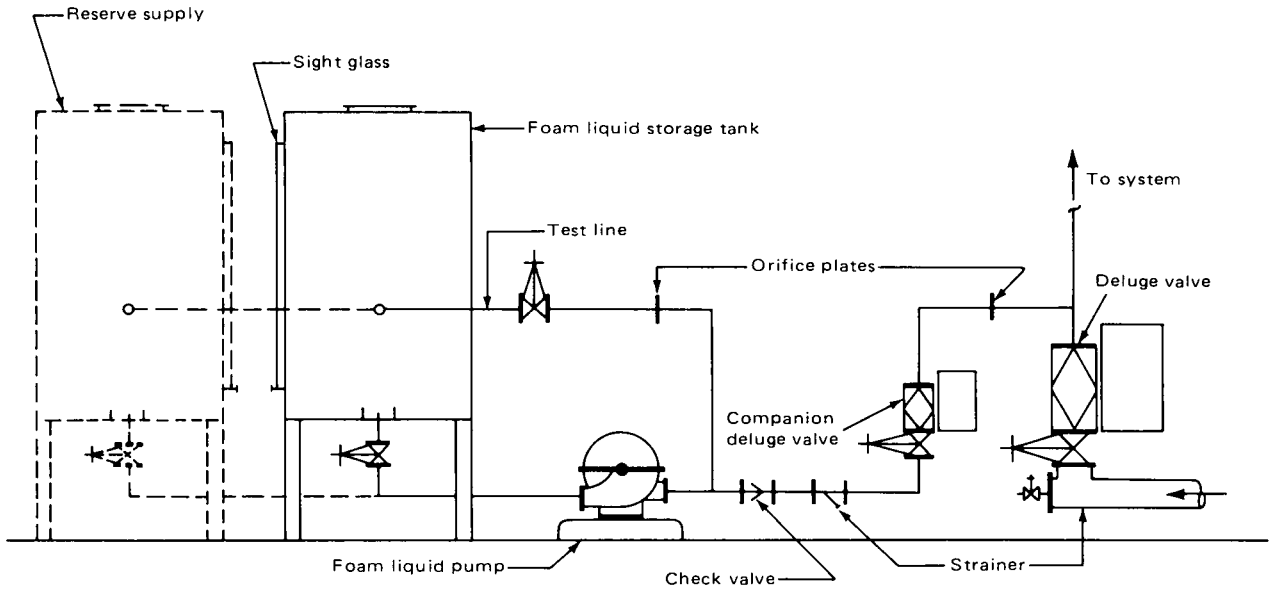


Figure A-2-4.2(a) Schematic arrangement of foam liquid-concentrate storage tank, liquid-concentrate pump, metering proportioners,and interconnecting piping.

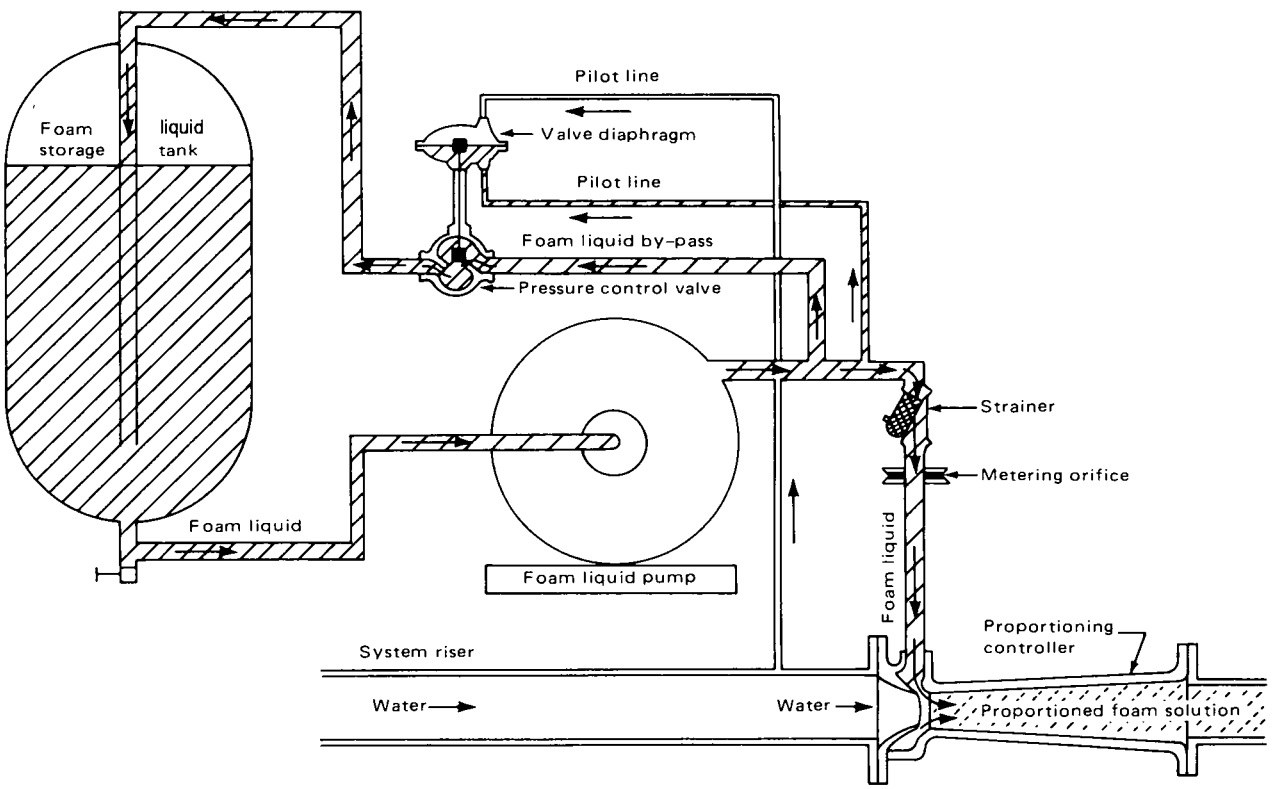


Figure A-2-4.2(b) Balanced-pressure proportioning system.

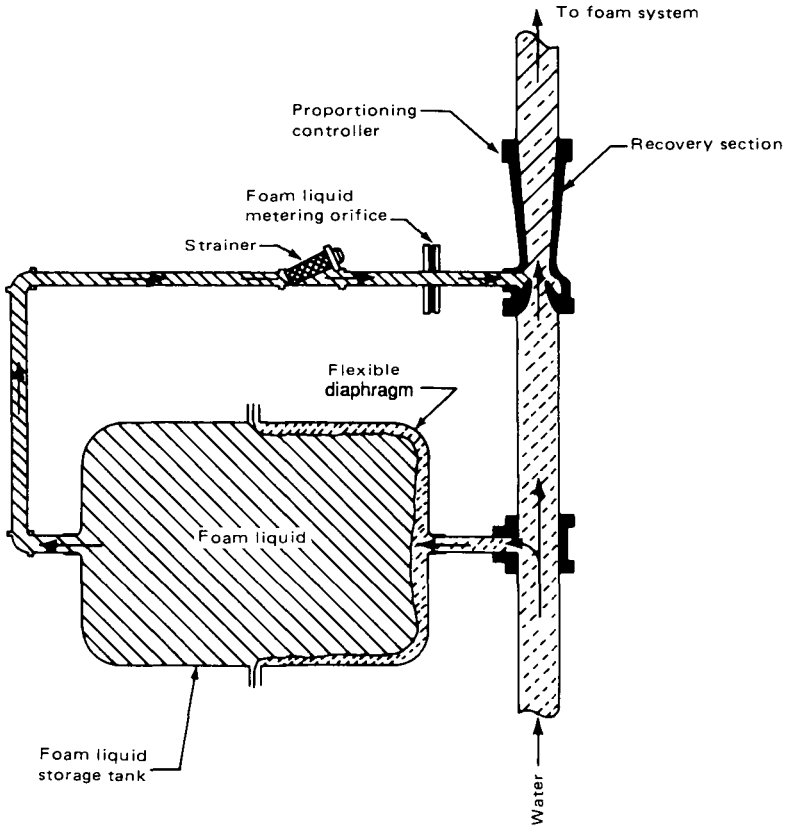


Figure A-2-4.2(c) Pressure-proportioning tank with diaphragm.

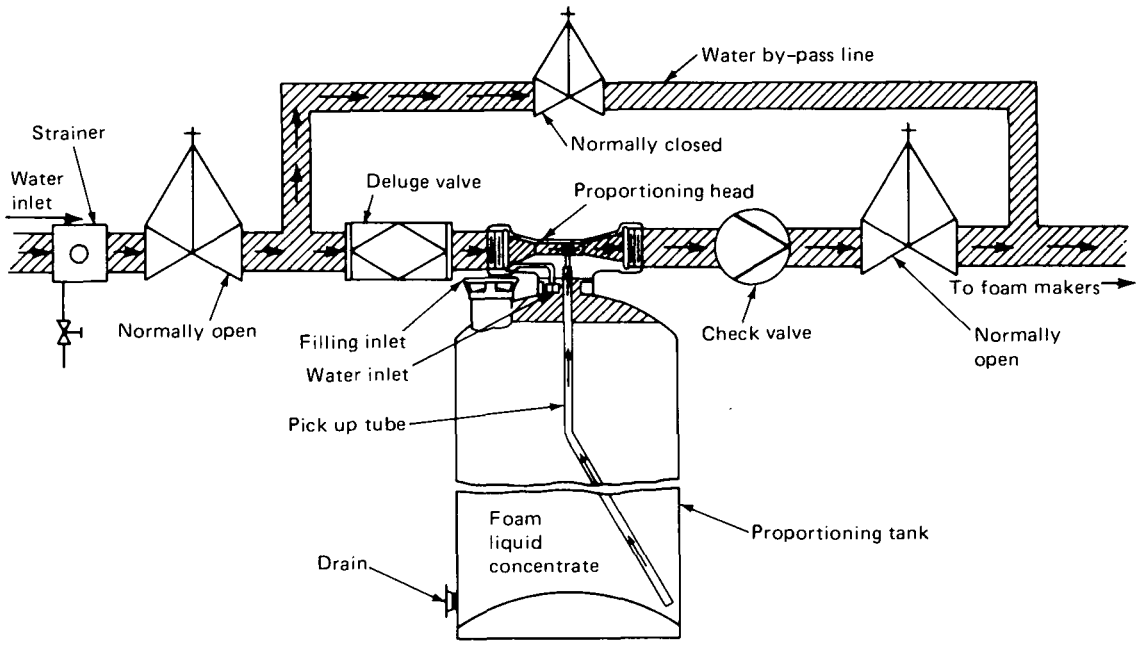


Figure A-2-4.2(d) Pressure-proportioning tank method (pressure-proportioning tank with diaphragm). The arrangement of these devices may take a variety of forms. A single tank or a battery of tanks manifolded together may be used.

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-2-12.2 See NFPA 71, *Standard for the Installation, Maintenance, and Use of Central Station Service*, and NFPA 72, *Standard for the Installation, Maintenance, and Use of Protective Signaling Systems*. Outdoor water-motor or electric-alarm gongs, responsive to system water flow, may be required.

A-3-1.1 Fire fighting efficiency of foams is not significantly affected when water temperature is below approximately 100°F (38°C), although some reduction in expansion occurs with very cold water. If the water temperature exceeds 100°F (38°C), however, foam stability and fire fighting efficiency usually is reduced.

A-4-2.1 For supervision of valves, refer to NFPA 26, *Recommended Practice for the Supervision of Valves Controlling Water Supplies for Fire Protection.*

A-4-3.2 It has been noted that galvanized piping is not compatible with most foam liquids.

A-4-3.3 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-4-4.1 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.

A-4-6.4 See Figures A-4-6.4(a), (b), (c), and (d).

A-5-2.2 To prevent the possibility of serious water damage in case of a break, pressure should be maintained during the 2-hr test period by a small-capacity pump, the main controlling gate being closed tight during this period.

A-5-3.1 Acceptance Test Suggestions.

(a) All tests should be made by the contractor in the presence of the inspector for the authority having jurisdiction.

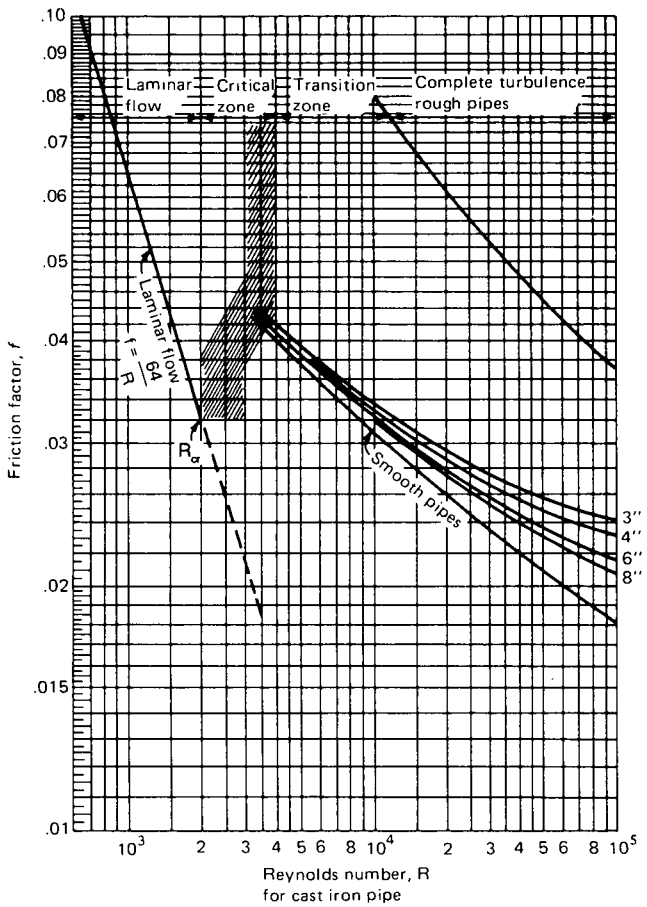


Figure A-4-6.4(a).

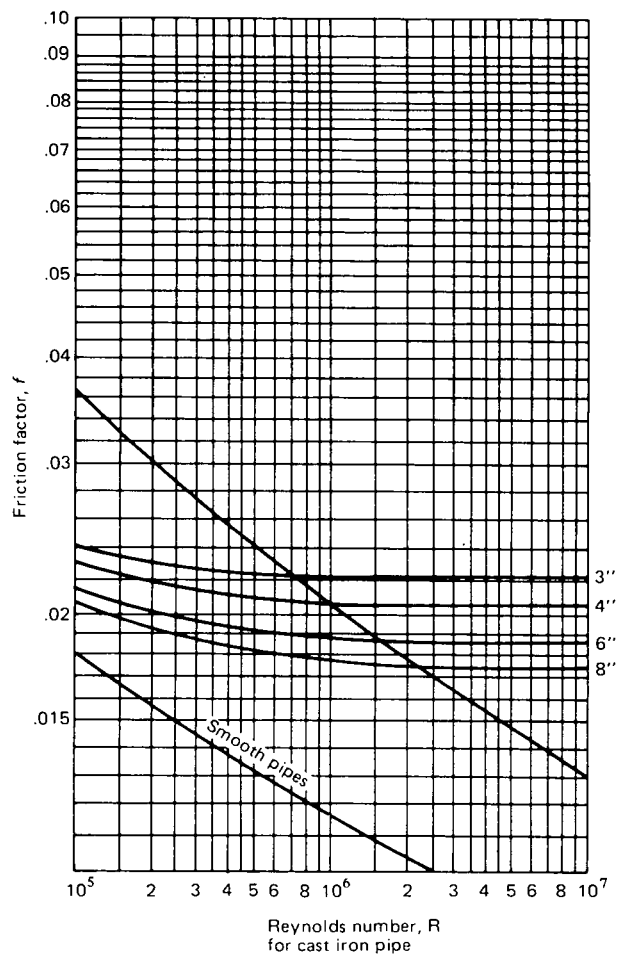


Figure A-4-6.4(b).

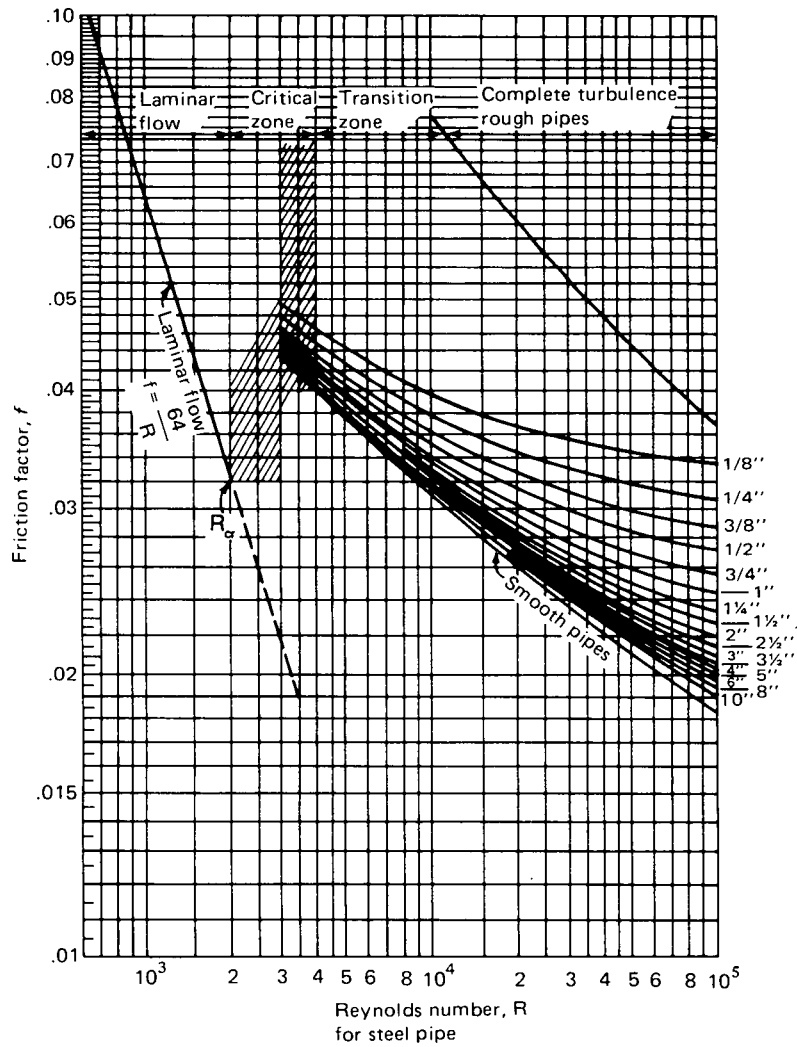


Figure A-4-6.4(c).

(b) Before asking final approval of the protective equipment by the authority having jurisdiction, installing companies should furnish a written statement to the effect that the work covered by its contract has been completed and all specified flushing of underground, lead-in, and system piping has been successfully completed, together with specified hydrostatic pressure tests and system-foam discharge tests.

(c) The samples of contractor's material and test certificates for aboveground and underground piping, appearing in Chapter 1 of NFPA 13, *Standard for the Installation of Sprinkler Systems*, will be useful to the contractor as a guide in filing written statements as called for in the foregoing.

A-5-3.3 Foams produced from foam-water discharge outlets are generally of lower expansion and faster drainage than from other foam producing devices. Laboratory listing and test data show that satisfactory fire control and extinguishment of petroleum fuels can be achieved using foam-water sprinklers producing foam characteristics as follows:

Protein foam and fluoroprotein foam

Expansion 3-8

25 percent D.T.: 15 sec min

NOTE: These data apply to foam characteristics determined by the method given in A-6-1.1.1 of NFPA 11.

Aqueous film forming foam

Expansion: 3-8

25 percent D.T.: 60 sec min

NOTE: These data apply to foam characteristics determined by the method given in A-6-1.1.2 in NFPA 11.

Numerical values developed by use of the two test methods referenced above are not directly comparable, so care must be taken to use the proper test method. In general, AFFF drains much more rapidly than protein and fluoroprotein foams, necessitating use of the different method.

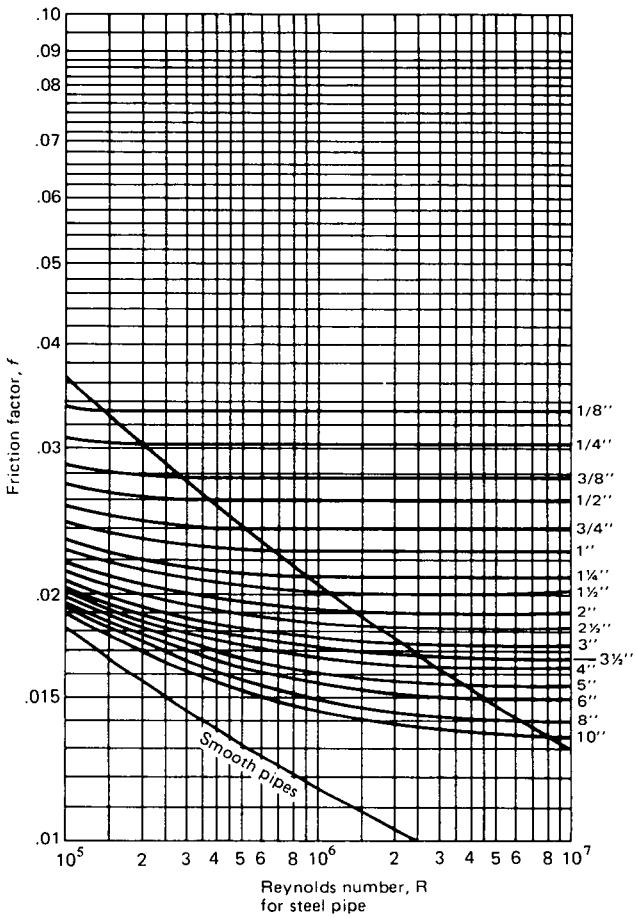


Figure A-4-6.4(d).

A-7-1.1 An inspection contract with the installer of the equipment for service tests and operation at regular intervals is recommended and may be required by the authority having jurisdiction.

Appendix B Referenced Publications

B-1 The following documents or portions thereof are referenced within this standard for informational purposes only and thus should not be considered part of the requirements of this document. The edition indicated for each reference is current as of the date of the NFPA issuance of this document.

B-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-1901.

NFPA 11, *Standard for Low Expansion Foam and Combined Agent Systems*, 1988 edition

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1989 edition

NFPA 16A, *Recommended Practice for the Installation of Closed-Head Foam-Water Sprinkler Systems*, 1988 edition

NFPA 26, *Recommended Practice for the Supervision of Valves Controlling Water Supplies for Fire Protection*, 1988 edition

NFPA 71, *Standard for the Installation, Maintenance, and Use of Signaling Systems for Central Station Service*, 1989 edition

NFPA 72, *Standard for the Installation, Maintenance, and Use of Protective Signaling Systems*, 1990 edition

NFPA 402M, *Manual for Aircraft Rescue and Fire Fighting Operations*, 1989 edition

NFPA 403, *Standard for Aircraft Rescue and Fire Fighting Services at Airports*, 1988 edition

NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire Fighting Foam Equipment*, 1987 edition

B-1-2 ASTM Publication. American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103.

ASTM E 380-1989, *Standard for Metric Practice*

Index