

NFPA®

11

Standard for
Low-, Medium-, and
High-Expansion Foam

2021



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NFPA® 11

Standard for

Low-, Medium-, and High-Expansion Foam

2021 Edition

This edition of NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, was prepared by the Technical Committee on Foam. It was issued by the Standards Council on November 2, 2020, with an effective date of November 22, 2020, and supersedes all previous editions.

This document has been amended by one or more Tentative Interim Amendments (TIAs) and/or Errata. See “Codes & Standards” at www.nfpa.org for more information.

This edition of NFPA 11 was approved as an American National Standard on November 22, 2020.

Origin and Development of NFPA 11

NFPA committee activity in this field dates from 1921, when the Committee on Manufacturing Risks and Special Hazards prepared standards on foam as a section of the general *Standard on Protection of Fire Hazards, Incident to the Use of Volatiles in Manufacturing Processes*. Subsequently the standards were successively under the jurisdiction of the Committee on Manufacturing Hazards and the Committee on Special Extinguishing Systems, prior to the present committee organization. The present text supersedes the prior editions adopted in 1922, 1926, 1931, 1936, 1942, 1950, 1954, 1959, 1960, 1963, 1969, 1970, 1972, 1973, 1974, 1975, 1976, and 1978. It also supersedes the 1977 edition of NFPA 11B.

The 1983 edition was completely rewritten to include all the material formerly contained in NFPA 11B, *Standard on Synthetic and Combined Agent Systems*. The standard was revised in 1988 and again in 1994 to state the requirements more clearly and to separate mandatory requirements from advisory text.

The standard was revised for the 1998 edition to include requirements for foam systems for marine applications and to provide guidance relating to the environmental impact of foam system discharges.

The 2002 edition was revised to address mixing of foam concentrates and to clarify requirements related to foam concentrate pumps. Requirements for medium- and high-expansion foam systems were included.

The 2005 edition was reorganized to provide the requirements for low-, medium-, and high-expansion foam, to better incorporate the requirements of NFPA 11A.

The 2010 edition added a new chapter to address compressed air foam systems. Unenforceable terms were removed to comply with the *Manual of Style for NFPA Technical Committee Documents*.

For the 2016 edition, the committee addressed several areas of concern. The piping requirements were reorganized and clarified, issues regarding acceptance criteria for annual foam concentrate testing were addressed, environmentally friendly methods of testing foam proportioners were recognized, and seal-only protection was permitted for composite roofs that meet specific criteria.

The 2021 edition contains multiple revisions to address the use of synthetic fluorine free foam (SFFF), including a new definition for SFFF. New definitions and explanatory annex material have been provided for cone roofs and external floating roofs. In Chapter 4, requirements that listed the types of foams permitted to be used on hydrocarbon fuels have been deleted, as the standard already requires foams to be listed for the flammable or combustible liquid they are protecting. Metric conversions throughout the standard have been updated as necessary to provide more usable numbers for metric users.

The 2021 edition also includes multiple new chapters and annexes. The requirements of NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, have been

consolidated into a new Chapter 6. A new Chapter 13 replaces the existing maintenance requirements with more comprehensive requirements for inspection, testing, and maintenance, including minimum requirements and frequency. A new Annex H provides summaries of current research and testing for the use of synthetic fluorine free foam (SFFF). A new Annex I outlines a testing protocol for a rim seal fire test for nonmetallic floating roof structures.

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Committee Scope: This Committee shall have primary responsibility for documents on the installation, maintenance, and use of foam systems for fire protection, including foam hose streams.

Contents

Chapter 1 Administration	11- 6	7.13 Local Application Systems.	11- 40
1.1 Scope.	11- 6	7.14 Foam Applications for Liquefied Natural Gas (LNG).	11- 41
1.2 Purpose.	11- 6	7.15 Portable Foam-Generating Devices.	11- 41
1.3 Application.	11- 6		
1.4 Retroactivity.	11- 6	Chapter 8 Compressed Air Foam Systems	11- 42
1.5 Equivalency.	11- 6	8.1 General.	11- 42
1.6 Units and Formulas.	11- 6	8.2 Water Supplies.	11- 42
Chapter 2 Referenced Publications	11- 6	8.3 Foam Concentrate.	11- 42
2.1 General.	11- 6	8.4 Air or Nitrogen Supply.	11- 42
2.2 NFPA Publications.	11- 6	8.5 Compressed Air Foam-Generating Method.	11- 43
2.3 Other Publications.	11- 7	8.6 Distribution Systems.	11- 43
2.4 References for Extracts in Mandatory Sections. ...	11- 8	8.7 Compressed Air Foam Discharge Devices.	11- 43
Chapter 3 Definitions	11- 8	8.8 Operation and Control of Systems.	11- 43
3.1 General.	11- 8	8.9 System Types.	11- 43
3.2 NFPA Official Definitions.	11- 8	8.10 Limitations.	11- 43
3.3 General Definitions.	11- 9	8.11 System Design.	11- 43
Chapter 4 System Components and System Types	11- 11	8.12 Installation of Piping and Fittings.	11- 43
4.1 General.	11- 11	8.13 Installation of Automatic Detection.	11- 43
4.2 Water Supplies.	11- 12	8.14 CAFS Discharge Device Choice and Location.	11- 43
4.3 Foam Concentrates.	11- 12	8.15 Discharge Density.	11- 43
4.4 Concentrate Compatibility.	11- 14	8.16 Discharge Duration.	11- 43
4.5 Foam Proportioning.	11- 14	8.17 System Flow Calculation.	11- 43
4.6 Foam Concentrate Pumps.	11- 14	8.18 Plans and Specifications.	11- 44
4.7 Piping.	11- 15	8.19 Testing and Acceptance.	11- 44
4.8 System Types.	11- 16	8.20 Maintenance.	11- 44
4.9 Operation and Control of Systems.	11- 16	Chapter 9 Specifications and Plans	11- 44
Chapter 5 Low-Expansion Foam Tank, Fueling, and Spill Area Systems	11- 17	9.1 Approval of Plans.	11- 44
5.1 Types of Hazards.	11- 17	9.2 Specifications.	11- 44
5.2 Outdoor Fixed-Roof (Cone) Tanks.	11- 17	9.3 Plans.	11- 44
5.3 Outdoor Open-Top Floating Roof Tanks.	11- 21	Chapter 10 Installation Requirements	11- 45
5.4 Outdoor Covered (Internal) Floating Roof Tanks.	11- 25	10.1 Foam Concentrate Pumps.	11- 45
5.5 Indoor Hazards.	11- 27	10.2 Flushing.	11- 45
5.6 Loading Racks.	11- 27	10.3 Power Supply.	11- 45
5.7 Diked Areas — Outdoor.	11- 28	10.4 Low-Expansion System Piping.	11- 45
5.8 Nondiked Spill Areas.	11- 29	10.5 Valves in Low-Expansion Systems.	11- 46
5.9 Supplementary Protection.	11- 29	10.6 Hangers, Supports, and Protection for Pipework.	11- 46
Chapter 6 Low-Expansion Foam Sprinkler and Spray Systems	11- 29	10.7 Hose Requirements.	11- 46
6.1 Administration.	11- 29	10.8 Test Connections.	11- 46
6.2 General System Requirements.	11- 30	Chapter 11 Low-Expansion Foam Systems for Marine Applications	11- 46
6.3 Working Plans.	11- 30	11.1 General.	11- 46
6.4 System Components.	11- 30	11.2 Fixed Low-Expansion Foam Systems for Machinery Spaces.	11- 47
6.5 System Design and Installation.	11- 32	11.3 Fixed Low-Expansion Foam Systems on Deck for Petroleum and Chemical Tankers.	11- 47
6.6 Acceptance Tests.	11- 35	11.4 Foam Outlet Devices.	11- 48
6.7 Inspection, Testing, and Maintenance.	11- 36	11.5 Monitors.	11- 48
Chapter 7 Medium- and High-Expansion Systems	11- 36	11.6 Hand Hoselines.	11- 48
7.1 General Information and Requirements.	11- 36	11.7 Hydraulic Calculations.	11- 49
7.2 Use and Limitations.	11- 36	11.8 Isolation Valves.	11- 49
7.3 Hazards Protected.	11- 36	11.9 Hangers, Supports, and Protection of Pipework. .	11- 49
7.4 Types of Systems.	11- 36	11.10 Testing and Inspection.	11- 49
7.5 Systems Protecting One or More Hazards.	11- 36	11.11 Foam System Concentrate Storage.	11- 49
7.6 Occupant Safety and Rescue Operations.	11- 36	11.12 Supply Arrangements.	11- 49
7.7 Operation and Control of Systems.	11- 37	11.13 Piping Materials.	11- 50
7.8 Foam Concentrate.	11- 37	Chapter 12 Acceptance Testing	11- 50
7.9 Air Supply.	11- 38	12.1 Inspection and Visual Examination.	11- 50
7.10 Foam-Generating Apparatus Location.	11- 38	12.2 Flushing after Installation.	11- 50
7.11 Distribution Systems.	11- 38	12.3 Acceptance Tests.	11- 50
7.12 Total Flooding Systems General Information.	11- 38	12.4 Pressure Tests.	11- 50
		12.5 Operating Tests.	11- 50

12.6	Discharge Tests.	11– 51	Annex D	Tests for Foam Systems	11– 115
12.7	Approval of Low-, Medium-, and High-Expansion Foam Systems.	11– 51	Annex E	Foam Health, Safety, and Environmental Issues	11– 129
12.8	System Restoration.	11– 51	Annex F	Test Method for Marine Firefighting Foam Concentrates Protecting Hydrocarbon Hazards	11– 132
12.9	Acceptance Tests of Foam-Water Deluge and Spray Systems.	11– 51	Annex G	Foam Concentrate Quality	11– 134
Chapter 13	Inspection, Testing, and Maintenance	11– 55	Annex H	Synthetic Fluorine-Free Foam (SFFF) Research Testing Summary	11– 137
13.1	General.	11– 55	Annex I	Rim Seal Fire Test Protocol	11– 148
13.2	Low-, Medium-, and High-Expansion Foam Systems.	11– 57	Annex J	Informational References	11– 158
13.3	Foam-Water Sprinkler Systems.	11– 57	Index		11– 160
Annex A	Explanatory Material	11– 62			
Annex B	Storage Tank Protection Summary	11– 112			
Annex C	Medium- and High-Expansion Foam	11– 115			

NFPA 11

Standard for

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2021 Edition

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

Chapter 1 Administration

1.1* Scope.

1.1.1 This standard covers the design, installation, operation, testing, and maintenance of low-, medium-, and high-expansion and compressed air foam systems for fire protection.

1.1.2* It is not the intent of this standard to specify where foam protection is required.

1.2 Purpose.

1.2.1 This standard is intended for the use and guidance of those responsible for designing, installing, testing, inspecting, approving, listing, operating, or maintaining fixed, semifixed, or portable low-, medium-, and high-expansion and compressed air foam fire-extinguishing systems for interior or exterior hazards.

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

1.2.3 Low-, medium-, and high-expansion foam and compressed air foam systems are intended to provide property protection and not life safety.

1.3 Application. This standard is not applicable to the following types of systems:

- (1) Chemical foams and systems (considered obsolete)
- (2) Combined agent systems
- (3) Mobile foam apparatus (See NFPA 1901.)
- (4) Class A foam and systems (See NFPA 1150.)

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

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

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

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

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

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

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

1.6 Units and Formulas. Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). The liter unit, which is not part of but is recognized by SI, is commonly used in international fire protection. Conversion factors for this unit are found in Table 1.6.

Chapter 2 Referenced Publications

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

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

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2019 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2017 edition.

N Table 1.6 Conversion Factors

	Name of Unit	Unit Symbol	Conversion Factor
Length	millimeter	mm	1 in. = 25 mm
	meter	m	1 ft = 0.3048 m
Area	square millimeters	mm ²	1 in. ² = 645.2 mm ²
	square meter	m ²	1 ft ² = 0.0929 m ²
Volume	milliliter	mL	1 fl oz = 29.57 mL
Fluid capacity	liter	l	1 fl oz = 0.02957 L
	liter	l	1 gal = 3.785 L
Flow	liter per minute	L/min	1 gpm = 3.7848 L/min
Pressure	bar	bar	1 psi = 0.0689 bar
Discharge Density	millimeter/minute	mm/min	1 gpm/ft ² = 40.746 mm/min
	liter/minute/m ²	(L/min)/m ²	1 gpm/ft ² = 40.746 (L/min)/m ²
Weight	kilogram	kg	1 lb = 0.4536 kg
Temperature	Fahrenheit	°F	°F = 9/5 x °C + 32
	Celsius	°C	°C = 5/9(°F - 32)
Velocity	meters per second	mps	1 fps = 0.3048 mps
Gauge (sheet steel)	millimeter	mm	10 gauge = 3.4 mm
			12 gauge = 2.8 mm
			14 gauge = 1.98 mm
			16 gauge = 1.57 mm
			22 gauge = 0.78 mm
			24 gauge = 0.63 mm

Note: For additional conversions and information, see IEEE/ASTM SI10.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, 2019 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2019 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 2018 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 2019 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2020 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2021 edition.

NFPA 70®, *National Electrical Code®*, 2020 edition.

NFPA 72®, *National Fire Alarm and Signaling Code®*, 2019 edition.

NFPA 220, *Standard on Types of Building Construction*, 2021 edition.

NFPA 409, *Standard on Aircraft Hangars*, 2021 edition.

NFPA 1150, *Standard on Foam Chemicals for Fires in Class A Fuels*, 2017 edition.

NFPA 1901, *Standard for Automotive Fire Apparatus*, 2021 edition.

NFPA 1961, *Standard on Fire Hose*, 2020 edition.

NFPA 1963, *Standard for Fire Hose Connections*, 2019 edition.

2.3 Other Publications.

2.3.1 API Publications. American Petroleum Institute, 1220 L Street, N.W., Washington, DC 20005-4070.

API STD 607, *Fire Test for Quarter-turn Valves and Valves Equipped with Nonmetallic Seats*, 7th edition, 2016.

API STD 650, *Welded Tanks for Oil Storage*, 12th edition, 2013, addendum 3, 2018.

2.3.2 ASME Publications. American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990.

ASME Boiler and Pressure Vessel Code, 2019.

ASME B1.20.1, *Standard for Pipe Threads, General Purpose (Inch)*, 2013.

ASME B16.1, *Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250*, 2015.

ASME B16.3, *Malleable Iron Threaded Fittings: Classes 150, and 300*, 2016.

ASME B16.4, *Gray Iron Threaded Fittings Classes 125, and 250*, 2016.

ASME B16.5, *Pipe Flanges and Flanged Fittings: NPS 1/2 Through 24 Metric/Inch Standard*, 2017.

ASME B16.9, *Factory-Made Wrought Butt Welding Fittings*, 2012.

ASME B16.11, *Forged Fittings, Socket-Welding and Threaded*, 2016, Errata, 2017.

ASME B16.15, *Cast Copper Alloy Threaded Fittings Classes 125, and 250*, 2013.

ASME B16.24, *Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves Classes 150, 300, 600, 900, 1500, and 2500*, 2016.

ASME B16.25, *Butt Welding Ends*, 2017.

ASME B31.1, *Power Piping*, 2018.

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

ASTM A53/A53M *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*, 2018.

Shaded text = Revisions. Δ = Text deletions and figure/table revisions.

• = Section deletions.

N = New material.



ASTM A135/A135M, *Standard Specification for Electric Resistance-Welded Steel Pipe*, 2009, reapproved 2014.

ASTM A234/A234M, *Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High-Temperature Service*, 2018.

ASTM A312/A312M, *Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes*, 2018.

ASTM A795/A795M, *Standard Specification for Black and Hot-Dipped-, Zinc-Coated-, (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use*, 2013.

ASTM B43, *Standard Specification for Seamless Red Brass Pipe, Standard Sizes*, 2015.

ASTM B315, *Standard Specification for Seamless Copper Alloy Pipe and Tube*, 2012.

ASTM C582, *Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment*, 2009, reapproved 2016.

ASTM D323, *Standard Test Method for Vapor Pressure of Petroleum Products (Reid Method)*, 2015a.

ASTM D1331, *Standard Test Methods for Surface and Interfacial Tension of Solutions of Paints, Solvents, Solutions of Surface-Active Agents, and Related Materials*, 2014.

ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 2019b.

IEEE/ASTM SI10, *American National Standard for the Use of the International System of Units: The Modern Metric System*, 2016.

2.3.4 AWS Publications. American Welding Society, 8669 NW 36 Street, #130, Miami, FL 33166-6672.

AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification*, 2014.

2.3.5 IEEE Publications. IEEE, Three Park Avenue, 17th Floor, New York, NY 10016-5997.

IEEE 45, *Recommended Practice for Electric Installations on Shipboard*, 2002.

2.3.6 IMO Publications. International Maritime Organization, 4 Albert Embankment, London SE1 7SR, United Kingdom.

Safety of Life at Sea, SOLAS Regulations II-2/4.3 and 4.3.5.

2.3.7 ISO Publications. International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland.

ISO 7-1, *Pipe Threads Where Pressure-Tight Joints Are Made on the Threads — Part 1: Dimensions, Tolerances and Designation*, 1994, technical corrigendum 1, 2007.

▲ **2.3.8 UL Publications.** Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 162, *Foam Equipment and Liquid Concentrates*, 2018.

2.3.9 Other Publications.

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

2.4 References for Extracts in Mandatory Sections.

NFPA 10, *Standard for Portable Fire Extinguishers*, 2018 edition.
NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2020 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2018 edition.

NFPA 820, *Standard for Fire Protection in Wastewater Treatment and Collection Facilities*, 2016 edition.

Chapter 3 Definitions

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

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

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

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

3.2.5 Shall. Indicates a mandatory requirement.

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

3.2.7 Standard. An NFPA Standard, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase "standards development process" or "standards development activities," the term "standards" includes all NFPA Standards,

including Codes, Standards, Recommended Practices, and Guides.

3.3 General Definitions.

3.3.1 Combustible Liquid. Any liquid that has a closed-cup flash point at or above 100°F (38°C), as determined by the test procedures and apparatus set forth in Section 4.4 of NFPA 30. [30, 2018]

3.3.1.1 Class II Liquid. A liquid that has a closed-cup flash point at or above 100°F (38°C) and below 140°F (60°C). [30, 2018]

3.3.1.2 Class IIIA Liquid. Any Liquid that has a closed-cup flash point at or above 140°F (60°C), but below 200°F (93°C). [30, 2018]

3.3.1.3 Class IIIB Liquid. Any liquid that has a closed-cup flash point at or above 200°F (93°C). [30, 2018]

3.3.2* Concentration. The percent of foam concentrate contained in a foam solution.

3.3.3* Discharge Devices. Devices designed to discharge water or foam-water solution in a predetermined, fixed, or adjustable pattern.

3.3.3.1 Air-Aspirating Discharge Devices. Devices specially designed to aspirate and mix air into the foam solution to generate foam, followed by foam discharge in a specific design pattern.

3.3.3.2 Compressed Air Foam Discharge Devices. Devices specifically designed to discharge compressed air foam in a predetermined pattern.

3.3.3.3* Non-Air-Aspirating Discharge Devices. Devices designed to provide a specific water discharge pattern.

3.3.4 Discharge Outlet.

3.3.4.1 Fixed Foam Discharge Outlet. A device permanently attached to a tank, dike, or other containment structure, designed to introduce foam.

3.3.4.2* Type I Discharge Outlet. An approved discharge outlet that conducts and delivers foam gently onto the liquid surface without submergence of the foam or agitation of the surface.

3.3.4.3 Type II Discharge Outlet. An approved discharge outlet that does not deliver foam gently onto the liquid surface but is designed to lessen submergence of the foam and agitation of the surface.

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

3.3.5.1* In-Line Eductor. A Venturi-type proportioning device that meters foam concentrate at a fixed or variable concentration into the water stream at a point between the water source and a nozzle or other discharge device.

3.3.6 Expansion. The ratio of final foam volume to original foam solution volume.

3.3.7 Film Formation. A property of aqueous film-forming foams and film-forming fluoroproteins characterized by a posi-

tive (>0.0 dynes/cm) spreading coefficient when measured according to ASTM D1331 using cyclohexane as the hydrocarbon substrate and distilled water to make the foam solution.

3.3.8 Fire.

3.3.8.1 Class A Fire. A fire in ordinary combustible materials, such as wood, cloth, paper, rubber, and many plastics. [10, 2018]

3.3.8.2 Class B Fire. A fire in flammable liquids, combustible liquids, petroleum greases, tars, oils, oil-based paints, solvents, lacquers, alcohols, and flammable gases.

3.3.9 Flammable (Class I) Liquid. Any liquid that has a closed-cup flash point that is below 100°F (38°C), as determined by the test procedures and apparatus set forth in Section 4.4 of NFPA 30, and a Reid vapor pressure that does not exceed an absolute pressure of 40 psi (3 bar) at 100°F (38°C), as determined by ASTM D323, *Standard Test Method for Vapor Pressure of Petroleum Products (Reid Method)*. [30, 2018]

3.3.9.1 Class IA Liquid. Any liquid that has a closed-cup flash point below 73°F (23°C) and a boiling point below 100°F (38°C). [30, 2018]

3.3.9.2 Class IB Liquid. Any liquid that has a closed-cup flash point below 73°F (23°C) and a boiling point at or above 100°F (38°C). [30, 2018]

3.3.9.3 Class IC Liquid. Any liquid that has a closed-cup flash point at or above 73°F (23°C) but below 100°F (38°C). [30, 2018]

3.3.10* Foam. A stable aggregation of bubbles of lower density than oil or water.

3.3.10.1 Compressed Air Foam (CAF). Homogeneous, micro-size foam bubbles produced by the combination of water, foam concentrate, and air or nitrogen under pressure.

3.3.11 Foam Chamber. See 3.3.4.1, Fixed Foam Discharge Outlet.

3.3.12* Foam Concentrate. A concentrated liquid foaming agent as received from the manufacturer.

3.3.12.1* Alcohol-Resistant Foam Concentrate. A concentrate used for fighting fires on water-soluble materials and other fuels destructive to regular, AFFF, SFFF, or FFFP foams, as well as for fires involving hydrocarbons.

3.3.12.2* Aqueous Film-Forming Foam Concentrate (AFFF). A concentrate based on fluorinated surfactants plus foam stabilizers to produce a fluid aqueous film for suppressing hydrocarbon fuel vapors and usually diluted with water to a 1 percent, 3 percent, or 6 percent solution.

3.3.12.3* Film-Forming Fluoroprotein Foam Concentrate (FFFP). A protein-foam concentrate that uses fluorinated surfactants to produce a fluid aqueous film for suppressing hydrocarbon fuel vapors.

3.3.12.4 Film-Forming Foam. A concentrate that when mixed at its nominal use concentration will form an aqueous film on hydrocarbon fuels.

3.3.12.5* Fluoroprotein Foam Concentrate. A concentrate very similar to protein-foam concentrate but with a synthetic fluorinated surfactant additive.

3.3.12.6* Medium- and High-Expansion Foam Concentrate. A concentrate, usually derived from hydrocarbon surfactants, used in specially designed equipment to produce foams having foam-to-solution volume ratios of 20:1 to approximately 1000:1.

3.3.12.7* Protein Foam Concentrate. Concentrate consisting primarily of products from a protein hydrolysate, plus stabilizing additives and inhibitors to protect against freezing, to prevent corrosion of equipment and containers, to resist bacterial decomposition, to control viscosity, and to otherwise ensure readiness for use under emergency conditions.

- N 3.3.12.8* Synthetic Fluorine-Free Foam (SFFF).** Foam concentrate based on a mixture of hydrocarbon surface active agents that is not formulated to contain per- or poly-fluoroalkyl substances (PFAS).

3.3.12.9 Synthetic Foam Concentrate. Concentrate based on foaming agents other than hydrolyzed proteins and including aqueous film-forming foam (AFFF) concentrates, medium- and high-expansion foam concentrates, and other synthetic foam concentrates.

3.3.12.9.1* Other Synthetic Foam Concentrate. A concentrate based on hydrocarbon surface active agents and listed as a wetting agent, foaming agent, or both.

3.3.13 Foam Concentrate Type. A classification of a foam concentrate that includes the chemical composition as defined under foam concentrate (*see 3.3.12*), including the use percentage, the minimum usable temperature, and the fuels on which the concentrate is effective.

3.3.14 Foam Generators.

3.3.14.1 Foam Generators — Aspirator Type. Foam generators, fixed or portable, in which jet streams of foam solution aspirate sufficient amounts of air that is then entrained on the screens to produce foam, and which usually produce foam with expansion ratios of not more than 250:1.

3.3.14.2* Foam Generators — Blower Type. Foam generators, fixed or portable, in which the foam solution is discharged as a spray onto screens through which an airstream developed by a fan or blower is passing.

3.3.15 Foam Injection.

3.3.15.1 Semisubsurface Foam Injection. Discharge of foam at the liquid surface within a storage tank from a floating hose that rises from a piped container near the tank bottom.

3.3.15.2 Subsurface Foam Injection. Discharge of foam into a storage tank from an outlet near the tank bottom.

3.3.16* Foam Solution. A homogeneous mixture of water and foam concentrate in the correct proportions.

3.3.16.1 Premixed Foam Solution. Solution produced by introducing a measured amount of foam concentrate into a given amount of water in a storage tank.

3.3.17 Foam System Types.

3.3.17.1* Compressed Air Foam System (CAFS). A system employing compressed air foam discharge nozzles, Type II and Type III applicators/devices, or hoses attached to a fixed piping system through which foam is transported from a mixing chamber.

3.3.17.2 Fixed Systems. A complete installation in which foam is piped from a central foam station, discharging through fixed delivery outlets to the hazard to be protected with permanently installed pumps where required.

- N 3.3.17.2.1* Foam-Water Sprinkler System.** A piping network employing automatic sprinklers, nozzles, or other discharge devices, connected to a source of foam concentrate and to a water supply.

- N 3.3.17.2.1.1* Foam-Water Deluge System.** A foam-water sprinkler system employing open discharge devices, which are attached to a piping system that is connected to a water supply through a valve that is opened by the operation of a detection system, which is installed in the same areas as the discharge devices.

- N 3.3.17.2.1.2* Foam-Water Dry Pipe System.** A foam-water sprinkler system employing automatic sprinklers or nozzles that are attached to a piping system that contains air or nitrogen under pressure, the release of which (as from the opening of a sprinkler) permits the water pressure to open a valve known as a dry pipe valve.

- N 3.3.17.2.1.3* Foam-Water Preaction System.** A foam-water sprinkler system employing automatic sprinklers or nozzles attached to a piping system containing air that might or might not be under pressure, with a supplemental detection system installed in the same area as the sprinklers.

- N 3.3.17.2.1.4* Foam-Water Spray System.** A foam-water sprinkler system designed to use nozzles rather than sprinklers.

- N 3.3.17.2.1.5* Preprimed System.** A wet pipe system containing foam solution.

3.3.17.3* Mobile System. Any type of foam-producing unit that is mounted on wheels and that is self-propelled or towed by a vehicle and can be connected to a water supply or can utilize a premixed foam solution.

3.3.17.4 Portable System. Foam-producing equipment, materials, hose, and so forth that are transported by hand.

3.3.17.5* Semifixed System. A system in which the hazard is equipped with fixed discharge outlets connected to piping that terminates at a safe distance.

3.3.18* Foam-Generating Methods. Methods of generation of air foam including hose stream, foam nozzle, and medium- and high-expansion generators, foam maker, pressure foam maker (high back pressure or forcing type), or foam monitor stream.

3.3.18.1* Compressed Air Foam-Generating Method. A method of generating compressed air foam recognized in this standard by using a mixing chamber to combine air or nitrogen under pressure, water, and foam concentrate in the correct proportions.

- N 3.3.19 Foam-Water Density.** The unit rate of foam-water solution application to an area, expressed in gpm/ft² (mm/min).

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

3.3.21 Inductor See 3.3.5.

N 3.3.22 Inspection, Testing, and Maintenance.

- N 3.3.22.1 Inspection.** A visual examination of a system or portion thereof to verify that it appears to be in operating condition and is free of physical damage. [820, 2016]
- N 3.3.22.2 Maintenance.** In water-based fire protection systems, work performed to keep equipment operable. [25, 2020]
- N 3.3.22.3 Test.** The operation of a device to verify that it is functioning correctly, or the measurement of a system characteristic to determine if it meets requirements. [25, 2020]
- N 3.3.22.4 Testing.** A procedure used to determine the operational status of a component or system by conducting periodic physical checks, such as waterflow tests, fire pump tests, alarm tests, and trip tests of dry pipe, deluge, or preaction valves. [25, 2020]

3.3.23 Monitor.

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

3.3.23.2 Portable Monitor (Cannon). A device that delivers a foam monitor stream and is mounted on a movable support or wheels so it can be transported to the fire scene.

3.3.24 Nozzle.

3.3.24.1* Foam Nozzle or Fixed Foam Maker. A specially designed hoseline nozzle or fixed foam maker designed to aspirate air that is connected to a supply of foam solution.

3.3.24.2* Self-Educting Nozzle. A device that incorporates a venturi to draw foam concentrate through a short length of pipe and/or flexible tubing connected to the foam supply.

3.3.25* Pressure Foam Maker (High Back Pressure or Forcing Type). A foam maker utilizing the Venturi principle for aspirating air into a stream of foam solution forms foam under pressure.

3.3.26 Proportioning. The continuous introduction of foam concentrate at the recommended ratio into the water stream to form foam solution.

3.3.26.1* Balanced Pressure Pump-Type Proportioning. A foam proportioning system that utilizes a foam pump and valve(s) to balance foam and water pressures at a modified venturi-type proportioner located in the foam solution delivery piping; a foam concentrate metering orifice is fitted in the foam inlet section of the proportioner.

3.3.26.1.1* In-Line Balanced Pressure Proportioning. A foam proportioning system utilizing a foam concentrate pump or a bladder tank in conjunction with a listed pressure reducing valve. At all design flow rates, the constant foam concentrate pressure is greater than the maximum water pressure at the inlet to the in-line balanced pressure proportioner. A pressure balancing valve integral to the in-line balanced pressure proportioner regulates the foam concentrate pressure to be balanced to incoming water pressure.

3.3.26.2* Coupled Water-Motor Driven Pump Proportioning. A correctly designed positive displacement water motor in the water supply line coupled to a positive displacement foam concentrate pump to provide proportioning.

3.3.26.3* Direct Injection Variable Pump Output Proportioning.

A direct injection proportioning system that utilizes flowmeters for foam concentrate and water in conjunction with a variable output foam pump control system.

3.3.27 Proportioning Methods for Foam Systems. The methods of proportioning used to create the correct solution of water and foam liquid concentrate.

3.3.28* Pump Proportioner (Around-the-Pump Proportioner).

A system that uses a venturi eductor installed in a bypass line between the discharge and suction side of a water pump and suitable variable or fixed orifices to induct foam concentrate from a tank or container into the pump suction line.

3.3.29 Stream.

3.3.29.1 Foam Hose Stream. A foam stream from a hand-line.

3.3.29.2 Foam Monitor Stream. A large capacity foam stream from a nozzle that is supported in position and can be directed by one person.

3.3.30* Spreading Coefficient. The measurement of a foam solution's potential to spread spontaneously across a hydrocarbon surface.

N 3.3.31 Storage Tank Roofs.

N 3.3.31.1* Cone Roof. A fixed structural steel conical or dome roof permanently attached to the exterior tank shell.

N 3.3.31.2* External Floating Roof. A roof system fitted to the inside diameter of a storage tank designed to automatically adjust to fluctuating liquid levels and is exposed to the atmosphere.

N 3.3.31.3* Internal Floating Roof. A roof system fitted to the inside diameter of a storage tank designed to automatically adjust to fluctuating liquid levels; covered completely by a permanently fixed structural steel cone or dome roof system attached to the exterior tank shell.

3.3.32 Tank.

3.3.32.1 Balanced Pressure Bladder Tank. A foam concentrate tank fitted with an internal bladder that uses waterflow through a modified venturi-type proportioner to control the foam concentrate injection rate by displacing the foam concentrate within the bladder with water outside the bladder.

3.3.32.2* Pressure Proportioning Tank. A foam concentrate tank with no bladder that uses waterflow through an orifice to displace a foam concentrate, having a specific gravity of at least 1.15, in the tank with water to add foam concentrate through an orifice into a water line at a specified rate.

Chapter 4 System Components and System Types

4.1* General. This chapter shall provide requirements for the correct use of foam system components.

4.1.1* All components shall be listed for their intended use.

N 4.1.2 Foam concentrate shall be listed for use with the proportioning equipment and discharge device(s).

4.1.3 Where listings for components do not exist, components shall be approved.

4.2 Water Supplies.

4.2.1 Water Supplies for Low-Expansion Foam Tank, Fueling, and Spill Area Systems.

4.2.1.1* Quality.

4.2.1.1.1 The water supply to foam systems shall be permitted to be hard or soft, fresh or salt, but shall be of a quality such that adverse effects on foam formation or foam stability do not occur.

4.2.1.1.2 No corrosion inhibitors, emulsion breaking chemicals, or any other additives shall be present without prior consultation with the foam concentrate supplier.

N 4.2.1.1.3 Water that contains solids likely to clog orifices in discharge devices but that is otherwise acceptable for making foam shall be permitted to be used after passing through line strainers.

4.2.1.2* Quantity. The water supply shall be of a quantity to supply all the devices that shall be permitted to be used simultaneously for the specified time.

4.2.1.2.1 This quantity shall include not only the volume required for the foam apparatus but also water that shall be permitted to be used in other firefighting operations, in addition to the normal plant requirements.

4.2.1.2.2 Premixed solution-type systems shall not be required to be provided with a continuous water supply.

4.2.1.3 Pressure. The pressure at the inlet to the foam system (e.g., foam generator, air foam maker) under required flow conditions shall be at least the minimum pressure for which the system has been designed.

4.2.1.4* Temperature. Optimum foam production shall be obtained by using water at temperatures between 40°F (4°C) and 100°F (38°C).

4.2.1.5 Design. The water supply system shall be designed and installed in accordance with NFPA 24.

4.2.1.5.1 Strainers shall be provided where solids of a size large enough to obstruct openings or damage equipment are present.

4.2.1.5.2 Hydrants furnishing the water supply for foam equipment shall be provided in the required number.

4.2.1.5.3 Hydrants shall be located as required by the authority having jurisdiction (AHJ).

4.2.1.6 Storage. Water supply or premixed solution shall be protected against freezing in climates where freezing temperatures are expected.

N 4.2.2 Water Supplies for Foam-Water Sprinkler and Spray Systems.

N 4.2.2.1 Water Quality.

N 4.2.2.1.1 Water supplied to foam-water systems shall be compatible with the foam concentrate to be used.

N 4.2.2.1.2 Water that contains solids likely to clog orifices in discharge devices but that is otherwise acceptable for making

foam shall be permitted to be used after passing through line strainers.

N 4.2.2.2 Water Supply Capacity, Pressure, and Duration.

N 4.2.2.2.1 Water supplies for deluge foam-water sprinkler systems and foam-water spray systems shall be automatic.

N 4.2.2.2.2 Water supplies shall have the capacity and a pressure to maintain foam and/or water discharge, or both, at the required design rate for the required duration over the area protected by the systems that are expected to operate simultaneously.

N 4.2.2.2.3* Where the water supply is dependent on public water sources, attention shall be given to the pollution hazard introduced by the use of foam concentrate.

N 4.2.2.2.4 Cross-connections shall be reviewed by public health agencies concerned.

N 4.2.2.3 Duration.

N 4.2.2.3.1* Water supplies shall be designed to meet the fixed fire protection demand plus 250 gpm (946 L/min) for inside and outside hose streams for at least 60 minutes, unless otherwise specified in the occupancy standards.

N 4.2.2.3.2 Water supplies for aircraft hangars shall be in accordance with NFPA 409.

N 4.2.3 Fire Department Connections.

N 4.2.3.1* Unless the requirements of 4.2.3.2 or 4.2.3.3 are met, the fire department connection(s) shall consist of two 2½ in. (65 mm) connections using NH internal threaded swivel fitting(s) with “2.5-7.5 NH standard thread,” as specified in NFPA 1963. [13:16.12.3.1]

N 4.2.3.2 Where local fire department connections do not conform to NFPA 1963, the authority having jurisdiction shall be permitted to designate the connection to be used. [13:16.12.3.1.1]

N 4.2.3.3 The use of threadless couplings shall be permitted where required by the authority having jurisdiction and where listed for such use. [13:16.12.3.1.2]

N 4.2.3.4 Fire department connections shall be equipped with listed plugs or caps, properly secured and arranged for easy removal by fire departments. [13:16.12.3.2]

N 4.2.3.5 Fire department connections shall be of an approved type. [13:16.12.3.3]

4.2.4 Water and Foam Concentrate Pumps.

4.2.4.1 When water or foam concentrate pumps are required for automatic or manual foam system operation, they shall be designed and installed in accordance with NFPA 20.

4.3 Foam Concentrates.

4.3.1 Types of Foam Concentrate.

4.3.1.1* Foam concentrate shall be listed for use with the foam concentrate proportioning equipment and with the discharge devices with which a given system is equipped.

N 4.3.1.1.1 Replacement supplies of foam concentrates shall be listed for use with system components.

N 4.3.1.1.2* Different types and/or brands of foam concentrates shall not be mixed for storage. Different brands of the same type of concentrate shall not be mixed unless data are provided by the manufacturer and accepted by the AHJ, to prove that the brands are compatible.

4.3.1.2* The concentrate used in a foam system shall be listed for use on the specific flammable or combustible liquid to be protected.

4.3.1.2.1 Water-miscible and polar flammable or combustible liquids shall be protected by alcohol-resistant concentrates listed for this purpose.

4.3.1.3 The limitations of the listing and the manufacturers' specifications shall be followed.

4.3.1.4 Acceptable ranges for the following physiochemical properties of the foam concentrate shall be published as part of the listing to determine compliance with 13.2.6.2:

- (1) Density or specific gravity
- (2) pH
- (3) Refractive index
- (4)* Viscosity

4.3.2 Concentrate Storage.

4.3.2.1 Storage Facilities.

4.3.2.1.1 Foam concentrates and equipment shall be stored in a location not exposed to the hazard they protect.

4.3.2.1.2 If housed, foam concentrates and equipment shall be in a noncombustible structure.

4.3.2.1.3 For outdoor nonautomatic systems, the AHJ shall be permitted to approve the storage of foam concentrate in a location off premises where these supplies are available at all times.

4.3.2.1.4 Loading and transportation facilities for foam concentrates shall be provided.

4.3.2.1.5 Off-premises supplies shall be of the type required for use in the systems of the given installation.

4.3.2.1.6 At the time of a fire, these off-premises supplies shall be accumulated in the required quantities, before the equipment is placed in operation, to ensure uninterrupted foam production at the design rate for the required period of time.

4.3.2.2* Quantity. The amount of concentrate shall meet the discharge requirements for the largest single hazard protected or group of hazards that are to be protected simultaneously.

4.3.2.3 Foam Concentrate Storage Tanks.

4.3.2.3.1 Bulk liquid storage tanks shall be fabricated from or be lined with materials compatible with the concentrate.

N 4.3.2.3.1.1 Storage tanks for foam concentrate shall be solidly mounted and shall be permanently located.

4.3.2.3.1.2 The storage tank shall be designed to minimize evaporation of foam concentrate.

4.3.2.3.1.3* Proportioning systems shall have signage to provide instruction on the proper sequence of system shut-down to prevent accidental loss of foam concentrate and/or system damage.

Δ 4.3.2.3.1.4 In atmospheric storage tanks, the suction inlet shall be located a minimum of 1 in. (25 mm) above the bottom of the tank.

4.3.2.3.1.5 Foam concentrate below the level of the suction inlet shall not be considered usable.

N 4.3.2.3.2 Atmospheric-Type Storage Tanks.

N 4.3.2.3.2.1 Storage tanks shall have capacities to accommodate the needed quantities of foam concentrate plus space for thermal expansion.

N 4.3.2.3.2.2 Foam concentrate outlets from the tanks shall be located to prevent sediment from being drawn into the system.

N 4.3.2.3.2.3 When determining the quantity of foam concentrates, the volume of the sediment pocket shall be added to the quantity needed for system operation.

N 4.3.2.3.2.4* Tanks shall be equipped with conservation-type vents, access handholes, or manholes that are located to provide for inspection of the following:

- (1) Interior tank surfaces
- (2) Connections for pump suction, relief, and testing lines
- (3) Protected sight gauges or other liquid level devices
- (4) Filling and draining connections

N 4.3.2.3.2.5 Tank discharge outlets shall be located to furnish a positive head on the pump suction.

N 4.3.2.3.3 Pressure-Type Storage Tanks.

N 4.3.2.3.3.1* Pressure-proportioning tanks shall have means for filling, for gauging the level of foam concentrates, and for drainage, cleaning, and inspection of interior surfaces and of the concentrate-holding bladder or diaphragm, if provided.

N 4.3.2.3.3.2 These tanks shall be stamped to be identified as meeting the requirements of ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1.

4.3.2.4 Storage Conditions.

4.3.2.4.1* In order to ensure the correct operation of any foam-producing system, the chemical and physical characteristics of the materials comprising the system shall be taken into consideration in design.

4.3.2.4.2* Foam concentrates shall be stored within the listed temperature limitations.

4.3.2.4.3 Markings shall be provided on storage vessels to identify the type of concentrate and its intended concentration in solution.

4.3.2.5 Foam Concentrate Supply.

4.3.2.5.1 Foam Concentrate Consumption Rates. The consumption rates shall be based on the percentage concentrate used in the system design (e.g., 3 percent or 6 percent or other, if so listed or approved by the AHJ).

4.3.2.5.2 Reserve Supply of Foam Concentrate.

4.3.2.5.2.1 There shall be a reserve supply of foam concentrate to meet design requirements in order to put the system back into service after operation.

4.3.2.5.2.2 The reserve supply shall be in separate tanks or compartments, in drums or cans on the premises, or shall be

able to be obtained from an approved outside source within 24 hours.

4.3.2.6 Auxiliary Supplies. Other equipment necessary to recommission the system, such as bottles of nitrogen or carbon dioxide for premixed systems, also shall be able to be secured.

4.4 Concentrate Compatibility.

4.4.1 Compatibility of Foam Concentrates.

4.4.1.1* Different types of foam concentrates shall not be mixed for storage.

4.4.1.2 Different brands of the same type of concentrate shall not be mixed unless data are provided by the manufacturer and accepted by the AHJ to prove that they are compatible.

4.4.1.3 Low-expansion foams generated separately from protein, fluoroprotein, FFFP, AFFF, SFFF, and alcohol-resistant concentrates shall be permitted to be applied to a fire in sequence or simultaneously.

4.4.2* Foam Compatibility with Dry Chemical Agents.

4.4.2.1 The manufacturers of the dry chemical and foam concentrate to be used in the system shall confirm that their products are mutually compatible.

4.4.2.2 Where used, limitations imposed on either of the agents alone shall be applied.

4.5 Foam Proportioning. The method of foam proportioning shall conform to one of the following:

- (1) Self-educing nozzle
- (2) In-line eductor
- (3) Pressure proportioners (with or without bladder)
- (4) Around-the-pump proportioners
- (5) Direct injection variable output foam pump system
- (6) Coupled water-motor driven pump proportioner
- (7) Balanced pressure pump-type proportioners

4.5.1* The proportioning system shall meet the listed minimum flow rate based on the minimum and maximum system discharge flow rate.

N 4.5.2 Fixed Foam Concentrate Proportioning Means.

N 4.5.2.1 Balanced-pressure or positive-pressure injection shall be the preferred methods for introduction of foam concentrates into the water flowing through the supply piping to the system.

N 4.5.2.2* Balanced-pressure injection methods shall be one of the following:

- (1) A balanced-pressure proportioning system utilizing a foam concentrate pump discharging through a metering orifice into a proportioning controller with the foam concentrate and water pressures automatically maintained as equal by the use of a pressure balancing valve.
- (2) A balanced-pressure proportioning system utilizing a pressure proportioning tank with a diaphragm or bladder to separate the water and foam concentrate discharging through a metering orifice into a proportioning controller.
- (3) An in-line balanced-pressure proportioning system utilizing a foam concentrate pump or bladder tank. A pressure regulating device placed in the pump return line shall maintain constant pressure in the foam concentrate

supply line at all design flow rates. This constant pressure shall be greater than the maximum water pressure under all operating conditions.

- (4) 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.

N 4.5.2.3 Other listed methods for foam proportioning shall be permitted as follows:

- (1) Balanced positive-pressure injection systems utilizing a foam concentrate pump and drive motor that vary the foam concentrate pump output to match water flow rates while maintaining the correct percentage of foam concentrate
- (2) Around-the-pump proportioners
- (3)* In-line eductors (inductors)

N 4.5.2.4* The exposed orifice plate indicator tab or nameplate shall have stamped, etched, engraved, or other permanent markings giving orifice diameters and an indication of the flow direction if flow characteristics vary with flow direction.

4.6* Foam Concentrate Pumps.

4.6.1* Materials. The design and materials of construction for foam concentrate pumps shall be approved for use with the type of foam concentrate used in the system.

N 4.6.2 Rated Capacities.

N 4.6.2.1 Foam concentrate pumps shall have rated capacities at or in excess of the maximum system demand.

4.6.2.2 To ensure positive injection of foam concentrate, the discharge pressure ratings of pumps at the design discharge capacity shall be in excess of the maximum water pressure available under any condition at the point of foam concentrate injection.

N 4.6.3 Overpressurization.

N 4.6.3.1* Foam concentrate pumps capable of overpressurizing the system shall be provided with means of pressure relief from the discharge to the supply side of the pump to prevent excessive pressure and temperature.

N 4.6.3.2 Overpressure shall not exceed the working pressure of the foam concentrate piping system.

N 4.6.4 Flushing.

N 4.6.4.1* Foam concentrate pumps shall have means for flushing.

N 4.6.4.2 Foam concentrate pumps shall be provided with a drain cock or valve.

N 4.6.5 Foam concentrate pumps shall be automatic-starting upon system actuation.

N 4.6.6 Pumps shall be listed for this service in accordance with NFPA 20.

Δ 4.6.7* Seals or packing shall be compatible with the foam concentrate.

4.6.8 A foam concentrate pump shall have the capacity to meet the actual maximum flow rate at the highest proportioning flow rate as permitted by 12.6.5 or the AHJ.

N 4.6.9 Foam concentrate pumps shall have rated capacities sufficient to meet the maximum system flow rate, as determined by 9.3.7.5.

4.7 Piping.

4.7.1* Foam Concentrate Pipe Materials.

4.7.1.1* Foam concentrate pipe and valves shall be made of one of the following materials:

- (1) Brass (red or naval)
- (2) Bronze
- (3) Stainless steel (304 or 316)
- (4) Copper nickel 90/10
- (5) Other material, in accordance with the foam concentrate manufacturer's certification of compatibility with the foam concentrate and as approved by the AHJ

4.7.1.2* Carbon steel pipe shall not be used.

4.7.1.3 Pipe carrying foam concentrate shall not be galvanized.

4.7.1.4 Foam concentrate pipe shall conform to one of the following standards:

- (1) ASTM A312/A312M
- (2) ASTM B43
- (3) ASTM B315
- (4) Other standards as allowed by 4.7.1.1(5), 4.7.1.2, and 4.7.1.3

4.7.1.5 In piping with dissimilar metals, dielectric components shall be used to insulate and reduce the possibility of galvanic corrosion.

4.7.1.6 Selection of pipe wall thickness shall conform to one of the following:

- (1) Schedule 40
- (2) ASME B31.1

4.7.1.7* For the purpose of computing friction loss in the foam concentrate piping, the following shall be used:

- (1) Darcy-Weisbach formula for (Newtonian) foam concentrates
- (2) Manufacturers' friction loss data for alcohol-resistant (non-Newtonian) foam concentrates

4.7.1.8 Flushing and drainage valves/connections for dry foam concentrate piping shall be installed in the standby condition.

Δ 4.7.1.9* Dry foam concentrate piping shall be pitched a minimum of $\frac{1}{2}$ in. over 10 ft (4 mm/m) to allow for drainage.

4.7.2* Foam Solution Pipe Materials.

4.7.2.1* Foam solution pipe shall be made of one of the following materials:

- (1) Galvanized steel
- (2) Stainless steel
- (3) Copper nickel 90/10
- (4) Internal/external corrosion-resistant pipe in accordance with the foam manufacturer's specification for compatibility and acceptable to the authority having jurisdiction
- (5) Unprotected carbon steel pipe when filled with foam solution or water and the discharge devices are closed to the atmosphere

4.7.2.2 Where exposed to corrosive influences, the piping shall be corrosion resistant or protected against corrosion.

4.7.2.3 Pipe within the hazard area shall be rated for the pressure and temperature involved.

4.7.2.4 Pipe within the hazard area shall be able to withstand the anticipated exposure to fire.

4.7.2.5 Nonmetallic foam solution piping shall be listed for the intended application.

4.7.2.6 Metallic foam solution pipe shall not be less than standard weight.

4.7.2.7 Foam solution pipe shall conform to one of the following standards:

- (1) ASTM A53/A53M
- (2) ASTM A135/A135M
- (3) ASTM A795/A795M
- (4) Other standards as allowed in 4.7.2.1(4)

4.7.2.8 Underground foam solution pipe shall be installed in accordance with NFPA 24.

N 4.7.2.8.1 Piping materials and specifications shall be in accordance with this standard.

4.7.2.9 For the purpose of computing friction loss in foam solution piping, the following C-values shall be used for the Hazen-Williams formula:

- (1) Galvanized steel pipe — 120
- (2) Other C-values for corrosion-resistant piping materials in accordance with NFPA 13

Δ 4.7.2.10 Foam solution distribution piping shall be pitched a minimum of $\frac{1}{2}$ in. over 10 ft (4 mm/m) to allow for drainage.

4.7.3 Fittings.

4.7.3.1* Foam Concentrate Fittings.

4.7.3.1.1 Foam concentrate piping shall use fittings made of the following materials, as appropriate to the foam concentrate pipe material:

- (1) Brass (red or naval)
- (2) Bronze
- (3) Stainless steel (304 or 316)
- (4) Other material, in accordance with the foam concentrate manufacturer's certification of compatibility, with approval from the AHJ, and as permitted by 4.7.3.1.2

4.7.3.1.2 Foam concentrate fittings shall not be carbon steel or galvanized.

4.7.3.1.3 Foam concentrate fittings shall not be less than standard class weight.

4.7.3.1.4 Foam concentrate fitting shall be in accordance with one of the following or as permitted by the AHJ:

- (1) ASME B16.5
- (2) ASME B16.11
- (3) ASME B16.15
- (4) ASME B16.24

4.7.3.2 Foam Solution Fittings.

4.7.3.2.1 Foam solution fittings shall be one of the following:

- (1) Galvanized steel

- (2) Stainless steel
- (3) Other material, in accordance with the manufacturer's certification of compatibility and with approval of the AHJ
- (4) Unprotected carbon steel pipe, when discharge devices are closed to the atmosphere
- (5) Internally/externally coated materials that are listed for the application

4.7.3.2.2 Foam solution fittings shall not be less than standard class weight.

4.7.3.2.3 Foam solution fittings shall be in accordance with one of the following or as permitted by the AHJ:

- (1) ASME B16.1
- (2) ASME B16.3
- (3) ASME B16.4
- (4) ASME B16.5
- (5) ASME B16.9
- (6) ASME B16.11
- (7) ASME B16.25
- (8) ASTM A234/A234M

4.7.3.2.4 Cast-iron fittings shall not be used where dry sections of piping are exposed to possible fire or where fittings are subject to stress in self-supporting systems.

4.7.3.2.5 Listed rubber or other elastomeric-gasketed fittings shall be permitted to be used in fire-exposed areas if the foam system is actuated automatically.

4.7.3.2.6 Listed rubber or other elastomeric-gasketed fittings shall be permitted to be used in fire-exposed areas if the foam system is actuated manually and high-temperature-rated extra-heavy-duty grooved fittings and gaskets have been tested in accordance with API STD 607 and meet these criteria within industry standards.

4.7.4 Joining of Pipes and Fittings.

4.7.4.1 Threaded Pipe.

4.7.4.1.1 Pipe threading shall be in conformance with ASME B1.20.1 or ISO 7-1.

4.7.4.1.2 PTFE tape or the foam concentrate manufacturer's compatible thread-locking compounds shall be used at pipe joints in the foam concentrate supply line.

4.7.4.2 Grooved Pipe. Dimensions of cut- and roll-grooves and outside diameters of piping materials shall conform to the manufacturers' recommendations and the listing laboratories' certifications.

4.7.4.3* Welded Pipe.

4.7.4.3.1 Field welding shall conform to the requirements of AWS B2.1/B2.1M or equivalent.

4.7.4.3.2 Shop welding shall conform to the requirements of Section 6.5 in NFPA 13.

4.7.4.3.3 Precautions shall be taken to ensure that the openings are fully cut out and that no obstructions remain in the waterway.

4.7.4.3.4 Precautions shall be taken to ensure that no galvanic corrosion occurs between piping and fittings.

4.7.5 Strainers.

4.7.5.1 Strainers shall be provided where solids of a size large enough to obstruct openings or damage equipment are present.

4.7.5.2 The ratio of the strainer's open basket area to its inlet pipe area shall be at least 10:1.

4.7.5.2.1 The net open area of the strainer shall be at least four times the area of the suction piping.

4.7.5.2.2 Strainer mesh size shall be in accordance with the pump manufacturer's recommendations based on foam concentrate viscosity.

4.7.6* Valves.

4.7.6.1 All valves for water and foam solution lines shall be of the indicator type, such as OS&Y or post indicator.

4.7.6.2 Automatic valves for foam concentrate lines shall be listed for this service.

4.7.6.3 Valve specifications for water use shall be permitted outside the hazard or diked area.

4.7.6.4 Inside the hazard or diked area, automatic control valves and shutoff valves shall be of steel or other alloy capable of withstanding exposure to fire temperatures.

Δ 4.7.6.5* Valve Supervision. All valves (main water, foam concentrate, and foam solution) required for automatic foam systems shall be supervised in their operating position by one of the following methods:

- (1) Central station, proprietary, or remote station signaling service in accordance with NFPA 72
- (2) Local signaling service that will cause the sounding of an audible signal at a constantly attended location in accordance with NFPA 72
- (3) Valves locked in the open position
- (4) Valves located within fenced enclosures under the control of the owner, sealed in the open position, and inspected weekly as part of an approved procedure

4.7.6.6 Where a pressure-reducing water deluge valve is used to control the discharge pressure, the set-pressure shall be recorded on a permanently marked weatherproof metal or rigid plastic sign secured with corrosion-resistant wire, chain, or other approved means.

4.8 System Types. The following four types of systems shall be permitted:

- (1) Fixed
- (2) Semifixed
- (3) Mobile
- (4) Portable

4.9 Operation and Control of Systems.

4.9.1 Methods of Actuation.

4.9.1.1 Systems shall be permitted to be actuated automatically or manually.

4.9.1.2 All systems shall have provisions for manual actuation.

4.9.2 Automatically Actuated Systems.

4.9.2.1 An automatic system shall be activated by automatic detection equipment.

4.9.2.2 Where operation is automatic, a reliable source of energy shall be used.

4.9.2.3 The need for an alternate power supply shall be determined by the AHJ.

4.9.2.4* Automatic Detection Equipment.

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

4.9.2.4.2 Where approved by the AHJ, small systems for localized hazards shall be permitted to be unsupervised.

4.9.2.5* Electric automatic detection equipment and any auxiliary electric equipment, if in hazardous areas, shall be designed expressly for use in such areas.

4.9.2.6 The system shall be permitted to be arranged to shut off automatically after a predetermined operating time.

4.9.2.6.1 Automatic shutdown and the predetermined operating time shall be approved by the AHJ.

4.9.2.6.2 Where automatic shutdown is required, an alarm condition shall remain until manually reset.

4.9.2.7 Detection System.

4.9.2.7.1 The detection system shall activate a local alarm as well as an alarm at a constantly attended location.

4.9.2.7.2 The detection system's alarms also shall be actuated when the system is operated manually.

4.9.3 Manually Actuated Systems.

4.9.3.1 Controls for manually actuated systems shall be located in a place removed from the hazard zone to permit them to be operated in an emergency, yet close enough to ensure operator knowledge of fire conditions.

4.9.3.2 The location and purposes of the controls shall be indicated and shall be related to the operating instructions.

4.9.4 Equipment.

4.9.4.1 All operating devices shall be designed for the service conditions they encounter.

4.9.4.2 Operating devices shall not be rendered inoperative, or be susceptible to inadvertent operation, by environmental factors such as high or low temperature, atmospheric humidity or pollution, or marine conditions.

4.9.4.3 Operating device systems shall have means for manual actuation.

Δ Chapter 5 Low-Expansion Foam Tank, Fueling, and Spill Area Systems

5.1* Types of Hazards. This chapter shall cover design information for the use of low-expansion foam to protect outdoor storage tanks, interior flammable liquid hazards, loading racks, diked areas, and nondiked spill areas.

5.2* Outdoor Fixed-Roof (Cone) Tanks. The following methods for protecting exterior fixed-roof tanks shall be included

within this section and shall not be considered to be in any order of preference:

- (1) Foam monitors and handlines, including those supplied by compressed air foam generation technology
- (2) Surface application with fixed foam discharge outlets, including those supplied by compressed air foam generation technology
- (3) Subsurface application
- (4) Semisubsurface injection methods

5.2.1 Supplementary Protection. In addition to the primary means of protection, supplementary protection shall be provided in accordance with the requirements found in Section 5.9.

5.2.2 Basis of Design. System design shall be based on protecting the tank requiring the largest foam solution flow, including supplementary hose streams.

5.2.3* Limitations. Fixed outlets shall not be used to protect horizontal or pressure tanks.

5.2.4 Design Criteria for Foam Monitors and Handlines.

5.2.4.1 Limitations.

5.2.4.1.1* Monitor nozzles shall be permitted to be used as the primary means of protection for cone roof tanks when part of a portable, mobile, or semi-fixed system (adequate fire water delivery, foam concentrate supply, and portable or fixed foam monitors), which can be put in service within 4 hours to protect the cone roof tank when the following requirements are met:

- (1) Risk assessment completed
- (2) Pre-incident contingency plan completed
- (3) Where approved by the AHJ

5.2.4.1.2 Foam handlines shall not be permitted to be used as the primary means of protection for fixed-roof tanks over 30 ft (9 m) in diameter or those over 20 ft (6.1 m) in height.

5.2.4.2 Foam Application Rates.

Δ 5.2.4.2.1* Flow Considerations.

N 5.2.4.2.1.1 To determine actual solution flow requirements, consideration shall be given to potential foam losses from wind, and other factors shall be included in the calculations.

N 5.2.4.2.1.2 A factor of 1.5 additional foam application rate shall be used as a minimum to compensate for these factors.

5.2.4.2.2* The design parameters for the use of monitors and handline nozzles to protect tanks containing hydrocarbons shall be in accordance with Table 5.2.4.2.2.

5.2.4.3* Tanks Containing Flammable and Combustible Liquids Requiring Alcohol-Resistant Foams.

5.2.4.3.1* Water-soluble and certain flammable and combustible liquids and polar solvents that are destructive to regular (non-alcohol-resistant) foams shall use alcohol-resistant foams.

5.2.4.3.2* For liquids in depths greater than 1 in. (25 mm), monitor and foam hose streams shall be limited for use with special alcohol-resistant foams listed and/or approved for the purpose.

Table 5.2.4.2.2 Foam Handline and Monitor Protection for Fixed-Roof Storage Tanks Containing Hydrocarbons

Hydrocarbon Type	Minimum Application Rate		Minimum Discharge Time (minutes)
	gpm/ft ²	mm/min*	
Flash point between 100°F and 140°F (38°C and 60°C)	0.16	6.5	50
Flash point below 100°F (38°C) or liquids heated above their flash points	0.16	6.5	65
Crude petroleum	0.16	6.5	65

Notes:

(1) Included in this table are gasohols and unleaded gasolines containing no more than 10 percent oxygenated additives by volume. Where oxygenated additives content exceeds 10 percent by volume, protection is normally in accordance with 5.2.4.3. Certain nonalcohol-resistant foams might be suitable for use with fuels containing oxygenated additives of more than 10 percent by volume. The manufacturer should be consulted for specific listings or approvals.

(2) Flammable liquids having a boiling point of less than 100°F (38°C) might require higher rates of application. Suitable rates of application should be determined by test. Flammable liquids with a wide range of boiling points might develop a heat layer after prolonged burning and then can require application rates of 0.2 gpm/ft² (8.2 mm/min) or more.

(3) Care should be taken in applying portable foam streams to high-viscosity materials heated above 200°F (93°C). Good judgment should be used in applying foam to tanks containing hot oils, burning asphalts, or burning liquids that have a boiling point above the boiling point of water. Although the comparatively low water content of foams can beneficially cool such fuels at a slow rate, it can also cause violent frothing and "slop-over" of the tank's contents.

(4) Testing by the LASTFIRE Group has confirmed that the use of compressed air foam delivery systems can extinguish tank fires using monitors, handlines, and fixed foam application appliances. The results of testing by listing agencies, other third-party research testing organizations, or manufacturer's data should be used to determine application rates for this type of hydrocarbon fire control.

(5) When using SFFF, the user should refer to Annex H and the manufacturer's recommendations to determine application rates.

* L/min·m² is equivalent to mm/min.

5.2.4.3.3 In all cases, the manufacturer of the foam concentrate and the foam-making equipment shall be consulted as to limitations and for recommendations based on listings or specific fire tests.

5.2.4.4* Design Parameters. Where monitors and handline nozzles are used to protect tanks containing flammable and combustible liquids requiring alcohol-resistant foams, the operation time shall be 65 minutes at listed application rates, unless the foam manufacturer has established, by fire test, that a shorter time shall be permitted.

5.2.5 Design Criteria for Surface Application with Fixed Foam Discharge Outlets.

5.2.5.1* Fixed Foam Discharge Outlets.

5.2.5.1.1 For the protection of a flammable liquid contained in a vertical fixed-roof (cone) atmospheric storage tank, discharge outlets shall be attached to the tank.

5.2.5.1.2 Where two or more discharge outlets are required, the outlets shall be spaced equally around the tank periphery.

5.2.5.1.2.1 Such outlets shall be individually piped and separately valved for isolation outside the dike area in accordance with 10.5.1.

5.2.5.1.2.2 Each outlet shall be sized to deliver foam at the minimum application rate or higher.

5.2.5.1.3 Fixed foam discharge outlets shall be attached at the top of the shell and shall be located or connected to preclude the possibility of the tank contents overflowing into the foam lines.

5.2.5.1.4 Fixed foam discharge outlets shall be attached so that displacement of the roof will not subject them to damage.

5.2.5.1.5 Fixed foam discharge outlets shall be provided with seal, frangible under low pressure, to prevent entrance of vapors into foam outlets and pipelines.

5.2.5.1.6 Fixed foam discharge outlets shall be provided with inspection means to allow maintenance and for inspection and replacement of vapor seals.

5.2.5.2 Design Criteria for Tanks Containing Hydrocarbons.

5.2.5.2.1* Fixed-roof (cone) tanks shall be provided with approved fixed foam discharge outlets as indicated in Table 5.2.5.2.1.

5.2.5.2.2* Minimum Discharge Times and Application Rates. Where fixed foam discharge outlets are used for fixed-roof (cone) tanks containing hydrocarbons, the minimum discharge times and application rates shall be in accordance with Table 5.2.5.2.2.

Table 5.2.5.2.1 Number of Fixed Foam Discharge Outlets for Fixed-Roof Tanks Containing Hydrocarbons or Flammable and Combustible Liquids Requiring Alcohol-Resistant Foams

Tank Diameter (or Equivalent Area)		Minimum Number of Discharge Outlets
ft	m	
Up to 80	Up to 24	1
Over 80 to 120	Over 24 to 37	2
Over 120 to 140	Over 37 to 43	3
Over 140 to 160	Over 43 to 49	4
Over 160 to 180	Over 49 to 55	5
Over 180 to 200	Over 55 to 61	6
Over 200	Over 61	6
		Plus 1 outlet for each additional 5000 ft ² (465 m ²)

5.2.5.2.3 If the apparatus available has a delivery rate higher than 0.1 gpm/ft² (4.1 mm/min), a proportionate reduction in the time figure shall be permitted to be made, provided that the time is not less than 70 percent of the minimum discharge times shown.

5.2.5.3* Design Criteria for Tanks Containing Flammable and Combustible Liquids Requiring Alcohol-Resistant Foams.

5.2.5.3.1 Water-soluble and certain flammable and combustible liquids and polar solvents that are destructive to nonalcohol-resistant foams shall require the use of alcohol-resistant foams.

5.2.5.3.2* In all cases, the manufacturers of the foam concentrate and the foam-making equipment shall be consulted as to limitations and for recommendations based on listings or specific fire tests.

5.2.5.3.3 Fixed-roof (cone) tanks shall be provided with approved fixed foam discharge outlets as indicated in Table 5.2.5.2.1.

5.2.5.3.4 Minimum Discharge Times and Application Rates. Minimum discharge times and application rates for fixed-roof (cone) tanks containing flammable and combustible liquids requiring alcohol-resistant foams shall be in accordance with Table 5.2.5.3.4.

Table 5.2.5.2.2 Minimum Discharge Times and Application Rates for Type II Fixed Foam Discharge Outlets on Fixed-Roof (Cone) Storage Tanks Containing Hydrocarbons

Hydrocarbon Type	Minimum Application Rate		Minimum Discharge Time (minutes)
	gpm/ft ²	mm/min*	
Flash point between 100°F and 140°F (38°C and 60°C)	0.10	4.1	30
Flash point below 100°F (38°C) or liquids heated above their flash points	0.10	4.1	55
Crude petroleum	0.10	4.1	55

Notes:

(1) Included in this table are gasohols and unleaded gasolines containing no more than 10 percent oxygenated additives by volume. Where oxygenated additives content exceeds 10 percent by volume, protection is normally in accordance with 5.2.5.3. Certain nonalcohol-resistant foams might be suitable for use with fuels containing oxygenated additives of more than 10 percent by volume. Consult manufacturer for specific listings or approvals.

(2) Flammable liquids having a boiling point of less than 100°F (38°C) might require higher rates of application. Suitable rates of application should be determined by test.

(3) For high-viscosity liquids heated above 200°F (93°C), lower initial rates of application might be desirable to minimize frothing and expulsion of the stored liquid. Good judgment should be used in applying foams to tanks containing hot oils, burning asphalts, or burning liquids that have boiling points above the boiling point of water. Although the comparatively low water content of foams can beneficially cool such liquids at a slow rate, it can also cause violent frothing and "slop-over" of the tank's contents.

(4) Type I discharge outlets are considered obsolete, and those currently installed become Type II outlets if damaged. Refer to A.5.2.5.2.2 for additional information and minimum discharge times for existing Type I outlets.

(5) Testing by the LASTFIRE Group has confirmed that the use of compressed air foam delivery systems can extinguish tank fires using monitors, handlines, and fixed foam application appliances. The results of testing by listing agencies, other third-party research testing organizations, or manufacturer's data should be used to determine application rates for this type of hydrocarbon fire control.

(6) When using SFFF, the user should refer to Annex H and the manufacturer's recommendations to determine application rates.

*L/min-m² is equivalent to mm/min.

Shaded text = Revisions. **Δ** = Text deletions and figure/table revisions. • = Section deletions. **N** = New material



Table 5.2.5.3.4 Minimum Application Rates and Discharge Times for Fixed-Roof (Cone) Tanks Containing Flammable and Combustible Liquids Requiring Alcohol-Resistant Foams

Application Rate for Specific Product Stored	Minimum Discharge Time (minutes) Type II Foam Discharge Outlet
Consult manufacturer for listings on specific products	55

Notes:

(1) Most currently manufactured alcohol-resistant foams are suitable for use with Type II fixed foam discharge outlets. However, some older alcohol-resistant foams require gentle surface application by Type I fixed foam discharge outlets. Consult manufacturers for listings on specific products.

(2) Type I discharge outlets are considered obsolete, and those currently installed become Type II outlets if damaged. Refer to A.5.2.5.2.2 for additional information and minimum discharge times for existing Type I outlets.

5.2.6 Design Criteria for Subsurface Application.

5.2.6.1* Subsurface foam injection systems shall be permitted for protection of liquid hydrocarbons in vertical fixed-roof atmospheric storage tanks.

5.2.6.1.1 Subsurface injection systems shall not be used for protection of Class IA hydrocarbon liquids or for the protection of alcohols, esters, ketones, aldehydes, anhydrides, or other products requiring the use of alcohol-resistant foams.

5.2.6.1.2* Foam concentrates and equipment for subsurface injection shall be listed for this purpose.

5.2.6.2* Foam Discharge Outlets.

5.2.6.2.1 The discharge outlet into the tank shall be permitted to be the open end of a foam delivery line or product line.

5.2.6.2.2 Outlets shall be sized so that foam generator discharge pressure and foam velocity limitations are not exceeded.

5.2.6.2.3 The foam velocity at the point of discharge into the tank contents shall not exceed 10 ft/sec (3 m/sec) for Class IB liquids or 20 ft/sec (6 m/sec) for other classes of liquids unless actual tests prove that higher velocities are satisfactory.

5.2.6.2.4* Where two or more outlets are required, they shall be located so that the foam travel on the surface cannot exceed 100 ft (30 m).

5.2.6.2.5 Each outlet shall be sized to deliver foam at the minimum application rate or higher.

5.2.6.2.6 For even foam distribution, outlets shall be permitted to be shell connections or shall be permitted to be fed through a pipe manifold within the tank from a single shell connection.

5.2.6.2.7 Rather than installing additional tank nozzles, shell connections shall be permitted to be made in manway covers.

5.2.6.2.8 Tanks shall be provided with subsurface foam discharge outlets as shown in Table 5.2.6.2.8.

5.2.6.3* Foam Discharge Outlet Elevation.

5.2.6.3.1* Foam discharge outlets shall be located so as not to discharge into a water bottom.

Table 5.2.6.2.8 Minimum Number of Subsurface Foam Discharge Outlets for Fixed-Roof Tanks Containing Hydrocarbons

Tank Diameter		Minimum Number of Discharge Outlets	
ft	m	Flash Point Below 100°F (38°C)	Flash Point 100°F (38°C) or Higher
Up to 80	Up to 24	1	1
Over 80 to 120	Over 24 to 37	2	1
Over 120 to 140	Over 37 to 43	3	2
Over 140 to 160	Over 43 to 49	4	2
Over 160 to 180	Over 49 to 55	5	2
Over 180 to 200	Over 55 to 61	6	3
Over 200	Over 61	6	3
		Plus 1 outlet for each additional 5000 ft ² (465 m ²)	Plus 1 outlet for each additional 7500 ft ² (700 m ²)

Notes:

(1) For Class IA liquids, see 5.2.6.1.1.

(2) Table 5.2.6.2.8 is based on extrapolation of fire test data on 25 ft (7.6 m), 93 ft (28 m), and 115 ft (35 m) diameter tanks containing gasoline, crude oil, and hexane, respectively.

(3) The most viscous fuel that has been extinguished by subsurface injection where stored at ambient conditions [60°F (16°C)] had a viscosity of 440 centistokes (2000 SSU) and a pour point of 15°F (−9°C). Subsurface injection of foam generally is not recommended for fuels that have a viscosity greater than 440 centistokes (2000 SSU) at their minimum anticipated storage temperature.

(4) In addition to the control provided by the smothering effect of the foam and the cooling effect of the water in the foam that reaches the surface, fire control and extinguishment can be enhanced further by the rolling of cool product to the surface.

5.2.6.3.2 The requirement of 5.2.6.3.1 shall be accomplished by having the outlets located at least 12 in. (300 mm) above the highest water level to prevent destruction of the foam.

5.2.6.4* Subsurface Injection Back-Pressure Limitations. The sizes and lengths of discharge pipe or lines used beyond the foam maker and the anticipated maximum depth of the fuel to be protected shall be such that the back pressure is within the range of pressures under which the device has been tested and listed by testing laboratories.

5.2.6.5 Minimum Discharge Times and Application Rates.

5.2.6.5.1 The minimum discharge times and application rates for subsurface application on fixed-roof storage tanks shall be in accordance with Table 5.2.6.5.1.

5.2.6.5.2* In cases where liquid hydrocarbons contain foam-destructive products, the manufacturer of the foam concentrate shall be consulted for recommendations based on listings and/or approvals.

Δ 5.2.6.5.3 If the apparatus available has a delivery rate higher than 0.1 gpm/ft² (4.1 mm/min), a proportionate reduction in the time figure shall be permitted to be made, provided that the time is not less than 70 percent of the minimum discharge time shown and that the maximum foam velocity is in accordance with 5.2.6.2.3.

5.2.7* Semisubsurface Systems. All equipment used in semi-subsurface systems shall be listed or approved for this purpose.

5.3* Outdoor Open-Top Floating Roof Tanks. Outdoor open-top floating roof tanks shall be as illustrated in Figure 5.3(a) through Figure 5.3(d).

Δ 5.3.1 Tank Protection Options.

N 5.3.1.1 Tanks shall be protected by seal area protection only (see 5.3.1.2) or by seal protection and full surface protection (see 5.3.1.3).

Δ Table 5.2.6.5.1 Minimum Discharge Times and Application Rates for Subsurface Application on Fixed-Roof Storage Tanks

Hydrocarbon Type	Minimum Application Rate		Minimum Discharge Time (minutes)
	gpm/ft ²	mm/min*	
Flash point between 100°F and 140°F (38°C and 60°C)	0.1	4.1	30
Flash point below 100°F (38°C) or liquids heated above their flash points	0.1	4.1	55
Crude petroleum	0.1	4.1	55

Notes:

(1) The maximum application rate shall be 0.20 gpm/ft² (8.1 mm/min).

(2) For high-viscosity liquids heated above 200°F (93°C), lower initial rates of application might be desirable to minimize frothing and expulsion of the stored liquid. Good judgment should be used in applying foams to tanks containing hot oils, burning asphalts, or burning liquids that are heated above the boiling point of water. Although the comparatively low water content of foams can beneficially cool such liquids at a slow rate, it can also cause violent frothing and "slop-over" of the tank's contents.

(3) When using SFFF, the user should refer to Annex H and the manufacturer's recommendations to determine application rates.

*L/min·m² is equivalent to mm/min.

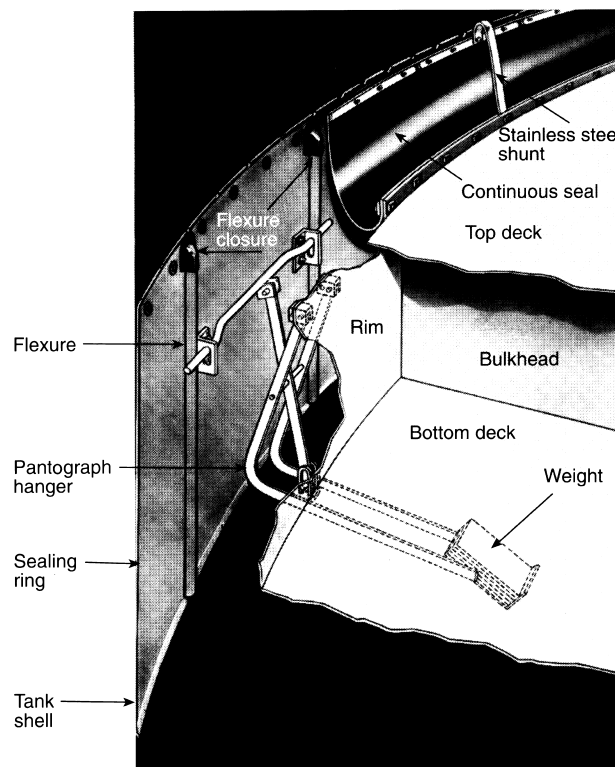


FIGURE 5.3(a) Pantograph-Type Seal Open-Top Floating Roof Tank.

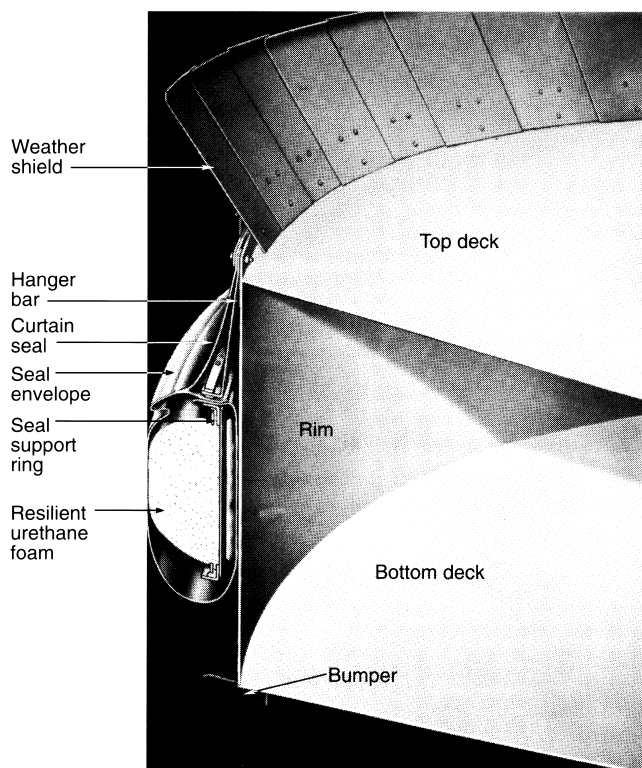


FIGURE 5.3(b) Tube Seal Open-Top Floating Roof Tank.

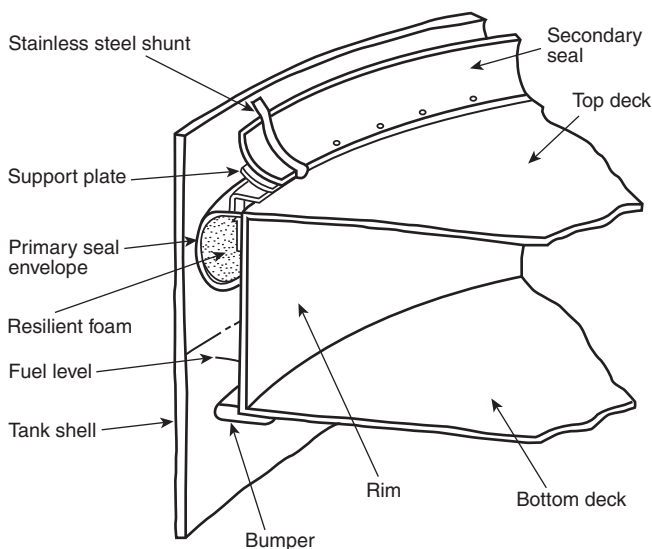


FIGURE 5.3(c) Double Seal System for Floating Roofs.

5.3.1.2 Seal area protection systems shall be permitted for the following types of roof construction:

- (1) Steel double deck
- (2) Steel pontoon
- (3)* Other tank construction that has passed external tank construction testing

5.3.1.3 The following tank construction types shall be protected with both seal area and full surface protection due to the

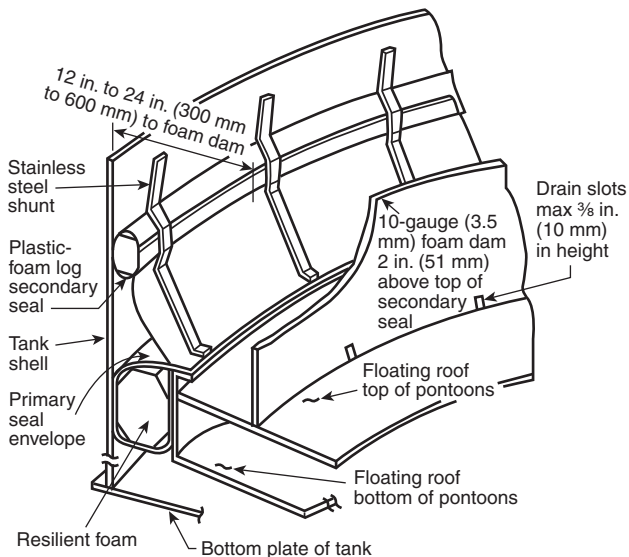


FIGURE 5.3(d) Double Seal System for Floating Roofs Using Plastic-Foam Log (Secondary Seal).

higher probability that the floating roof will be damaged and sink in a fire:

- (1) Roofs made from floating diaphragms
- (2) Roofs that rely on flotation device closures that are easily submerged if damaged
- (3) Pan roofs

5.3.1.4 Tanks equipped with the following floating roof types shall not be covered in Section 5.3:

- (1) Roofs made from floating diaphragms
- (2) Roofs that rely on flotation device closures that are easily submerged if damaged
- (3) Pan roofs

5.3.2 Systems for tanks so equipped shall be designed in accordance with 5.4.2.2.

5.3.3* Types of Fires Anticipated.

5.3.3.1 Subsurface and Semisubsurface Injection. Subsurface and semisubsurface injection shall not be used for protection of open-top or covered floating roof tanks because of the possibility of improper distribution of foam at the fuel surface caused by the floating roof, even if partially submerged.

5.3.3.2 Seal Area Protection. The foam protection facilities for an open-top floating roof tank seal area shall be based on 5.3.2 through 5.3.5.

5.3.4 Methods of Seal Fire Protection.

5.3.4.1 The following methods for fire protection of seals in open-top floating roof tanks shall be as required in 5.3.5 through 5.3.7:

- (1) Fixed discharge outlets
- (2) Foam handlines
- (3)* Small portable monitors [500 gpm (1900 L/min) or less] from the top platform

5.3.4.2 Supplementary Protection. In addition to the primary means of protection, supplementary protection shall be provided in accordance with the requirements of Section 5.9.

5.3.4.3* Basis of Design. System design shall be based on protecting the tank requiring the largest foam solution flow, including supplementary hose streams.

5.3.5 Fixed Discharge Outlets Design Criteria for Seal Area Protection.

5.3.5.1 Application of foam from fixed discharge outlets shall be permitted to be achieved by either of the following two methods:

- (1) The first method discharges foam above the mechanical shoe seal, a metal weather shield, or a secondary seal.
- (2) The second method discharges foam below a mechanical shoe seal directly onto the flammable liquid, behind a metal weather shield directly onto the tube seal envelope, or beneath a secondary seal onto the primary seal.

5.3.5.2* Top-of-Seal Method with Foam Dam.

5.3.5.2.1 Fixed foam discharge outlets located above a mechanical shoe seal, above a tube seal weather shield, or above a secondary seal shall be used in conjunction with a foam dam.

5.3.5.2.2 The following shall be permitted to be two methods of application of fixed foam discharge outlets:

- (1) Fixed foam discharge outlets (normally Type II) mounted above the top of the tank shell
- (2) Fixed foam discharge outlets mounted on the periphery of the floating roof

5.3.5.2.3* For this application, the fixed foam discharge outlets shall not be fitted with a frangible vapor seal device.

5.3.5.3 Top-of-Seal System Design.

5.3.5.3.1 The design parameters for the application of fixed foam discharge outlets on top of the seal to protect open-top floating roof tanks shall be in accordance with Table 5.3.5.3.1 and Figure 5.3.5.3.1.

5.3.5.3.2 The requirements specified in Table 5.3.5.3.1 apply to tanks containing hydrocarbons or flammable and combustible materials requiring alcohol-resistant foams.

5.3.5.3.3 The required minimum application rates specified in Table 5.3.5.3.1 shall apply, unless listings for specific products require higher application rates where Type II fixed foam discharge outlets are used.

5.3.5.3.4 If the application rate is higher than the minimum rate specified in Table 5.3.5.3.1, the discharge time shall be permitted to be reduced proportionately, provided that the reduced time is not less than 70 percent of the minimum discharge times specified.

5.3.5.3.5 Below Primary Seal or Weather Shield Method.

5.3.5.3.5.1 Fixed foam discharge outlets located below either a mechanical shoe seal, a metal weather shield, or a metal secondary seal shall use the designs that are illustrated in Figure 5.3.5.3.5.1.

5.3.5.3.5.2 A foam dam shall be installed if a tube seal is used and the top of the tube seal is less than 6 in. (152 mm) below the top of the pontoon.

5.3.5.3.6 Below-the-Seal or Weather Shield System.

5.3.5.3.6.1 The design parameters for the application of fixed foam discharge outlets below the seal (or weather shield) to protect open-top floating roof tanks shall be in accordance with Table 5.3.5.3.6.1.

5.3.5.3.6.2 The requirements shown in Table 5.3.5.3.6.1 shall apply to tanks containing hydrocarbons or flammable and combustible materials requiring alcohol-resistant foams.

5.3.5.3.6.3 The required minimum application rates shown in Table 5.3.5.3.6.1 shall apply unless listings for specific products require higher application rates when Type II fixed foam discharge outlets are used.

5.3.5.3.6.4 Below-the-seal (or shield) application shall not be used with combustible secondary seals.

Table 5.3.5.3.1 Top-of-Seal Fixed Foam Discharge Protection for Open-Top and Internal Floating Roof Tanks

	Applicable Illustration Detail	Minimum Application Rate		Minimum Discharge Time (minutes)	Maximum Spacing Between Discharge Outlets with			
					12 in. (305 mm) Foam Dam		24 in. (600 mm) Foam Dam	
		gpm/ft ²	mm/min*		ft	m	ft	m
Mechanical shoe seal	A	0.3	12.2	20	40	12	80	24
Tube seal with metal weather shield	B	0.3	12.2	20	40	12	80	24
Fully or partly combustible secondary seal	C	0.3	12.2	20	40	12	80	24
All metal secondary seal	D	0.3	12.2	20	40	12	80	24

Notes:

(1) Where the fixed foam discharge outlets are mounted above the top of the tank shell, a foam splashboard is necessary due to the effect of winds.

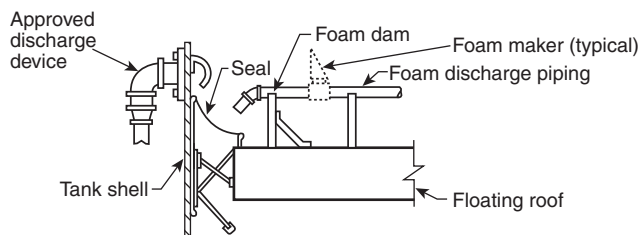
(2) When using SFFF, the user should refer to Annex H and the manufacturer's recommendations to determine application rates.

*L/min-m² is equivalent to mm/min.

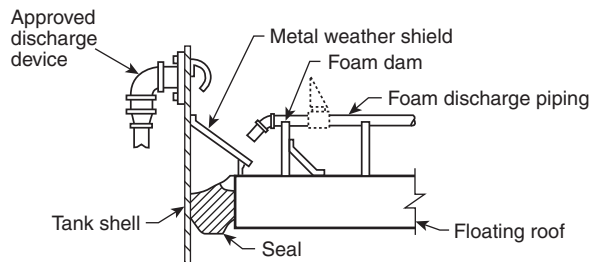
Shaded text = Revisions. **Δ** = Text deletions and figure/table revisions. • = Section deletions. **N** = New material



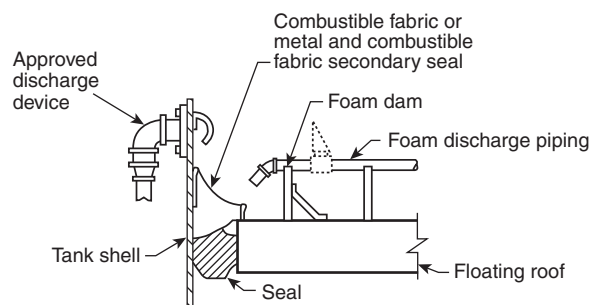
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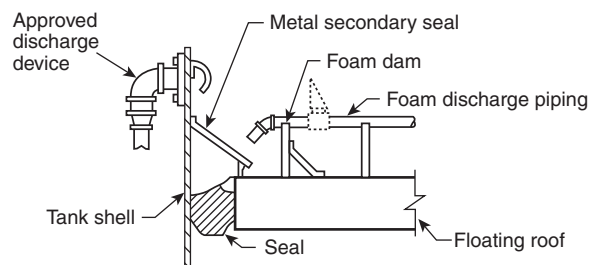
DETAIL A — Top-of-seal application
Foam discharge above mechanical shoe seal



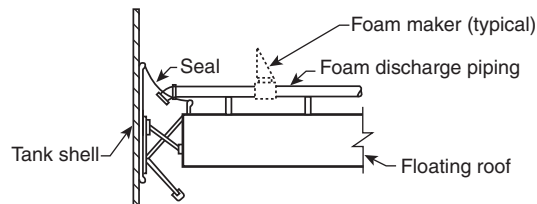
DETAIL B — Top-of-seal application
Foam discharge above metal weather seal



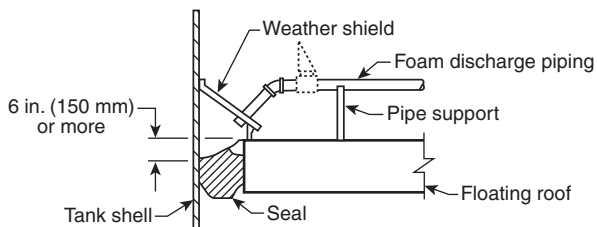
DETAIL C — Top-of-seal application
Foam discharge above secondary combustible fabric seal, or metal with combustible fabric sections



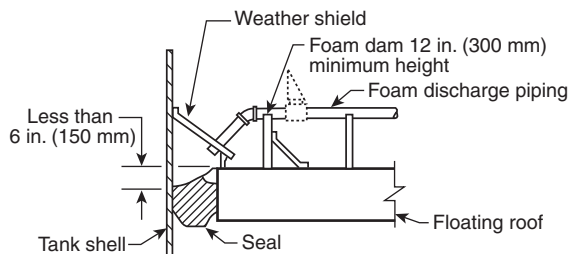
DETAIL D — Top-of-seal application
Foam discharge above metal secondary seal



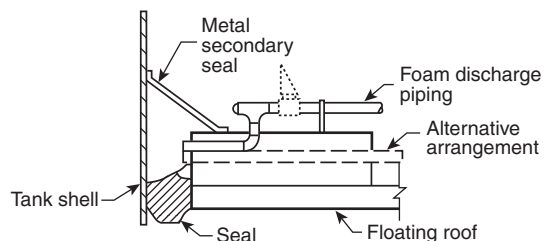
DETAIL A — Below-the-seal application
Foam discharge below mechanical shoe seal — no foam dam



DETAIL B — Below-the-shield application
Foam discharge below metal weather shield
Top of seal 6 in. (150 mm) or more below top of floating roof



DETAIL C — Below-the-shield application
Foam discharge below metal weather shield
Top of seal less than 6 in. (150 mm) below top of floating roof



DETAIL D — Below-the-seal application
Foam discharge below metal secondary seal
This foam application method is not acceptable if secondary seal is constructed of any combustible fabric sections.
(Refer to application above seal.)

FIGURE 5.3.5.3.1 Typical Foam System Illustrations for Top-of-Seal Fire Protection. Both fixed foam (wall-mounted) and roof-mounted discharge outlets are shown for illustrative purposes. Although both methods are shown, only one is needed.

FIGURE 5.3.5.3.5.1 Typical Foam System Arrangement Illustrations for Below-the-Seal (or Shield) Application.

Table 5.3.5.3.6.1 Below-the-Seal Fixed Foam Discharge Protection for Open-Top Floating Roof Tanks

Seal Type	Applicable Illustration Detail	Minimum Application Rate		Minimum Discharge Time (minutes)	Maximum Spacing Between Discharge Outlets
		gpm/ft ²	mm/min*		
Mechanical shoe seal	A	0.5	20.4	10	130 ft (40 m) — Foam dam not required
Tube seal with more than 6 in. (150 mm) between top of tube and top of pontoon	B	0.5	20.4	10	60 ft (18 m) — Foam dam not required
Tube seal with less than 6 in. (150 mm) between top of tube and top of pontoon	C	0.5	20.4	10	60 ft (18 m) — Foam dam required
Tube seal with foam discharge below metal secondary seal†	D	0.5	20.4	10	60 ft (18 m) — Foam dam not required

*L/min-m² is equivalent to mm/min.

†A metal secondary seal is equivalent to a foam dam.

5.3.5.4 Foam Dam Design Criteria.

5.3.5.4.1 The foam dam shall be circular and constructed of at least No. 10 U.S. standard gauge thickness [0.134 in. (3.4 mm)] steel plate.

5.3.5.4.2 The foam dam shall be welded or otherwise fastened to the floating roof.

5.3.5.4.3 The foam dam shall be designed to retain foam at the seal area, at a depth to cover the seal area while causing the foam to flow laterally to the point of seal rupture.

5.3.5.4.3.1 Dam height shall be at least 12 in. (300 mm) as measured from the connection between the seal and the roof.

5.3.5.4.3.2 The dam shall extend at least 2 in. (50 mm) above a metal secondary seal or a combustible secondary seal using a plastic-foam log.

5.3.5.4.3.3 Dam height shall be at least 2 in. (50 mm) higher than any burnout panels in metal secondary seals.

5.3.5.4.4 The foam dam shall be at least 12 in. (300 mm), but not more than 24 in. (600 mm), from the tank shell.

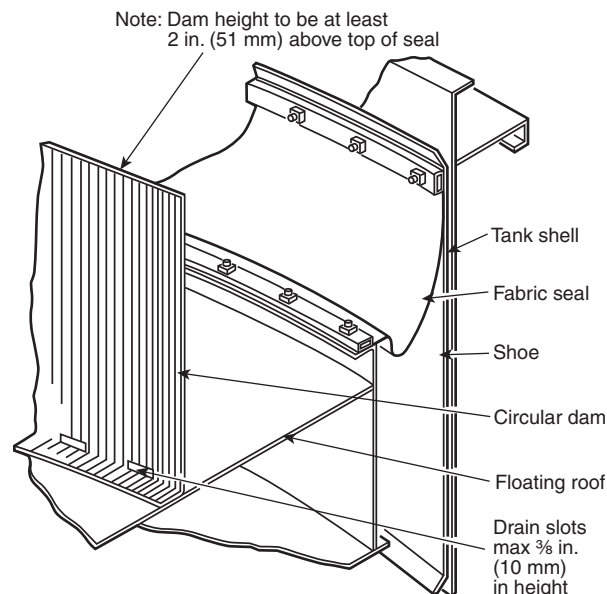
5.3.5.4.5* To allow drainage of rainwater, the foam dam bottom shall be slotted on the basis of 0.04 in² of slot area per ft² of dammed area (278 mm² of slot area per m² of dammed area), restricting drain slots to a maximum 3/8 in. (10 mm) in height, as shown in Figure 5.3.5.4.5.

5.3.6* Foam Handline Design Criteria for Seal Area Protection.

5.3.6.1 Foam handlines shall be permitted to be used from the wind girder for extinguishment of seal fires in open-top floating roof tanks.

5.3.6.2 Listed or approved equipment shall be used.

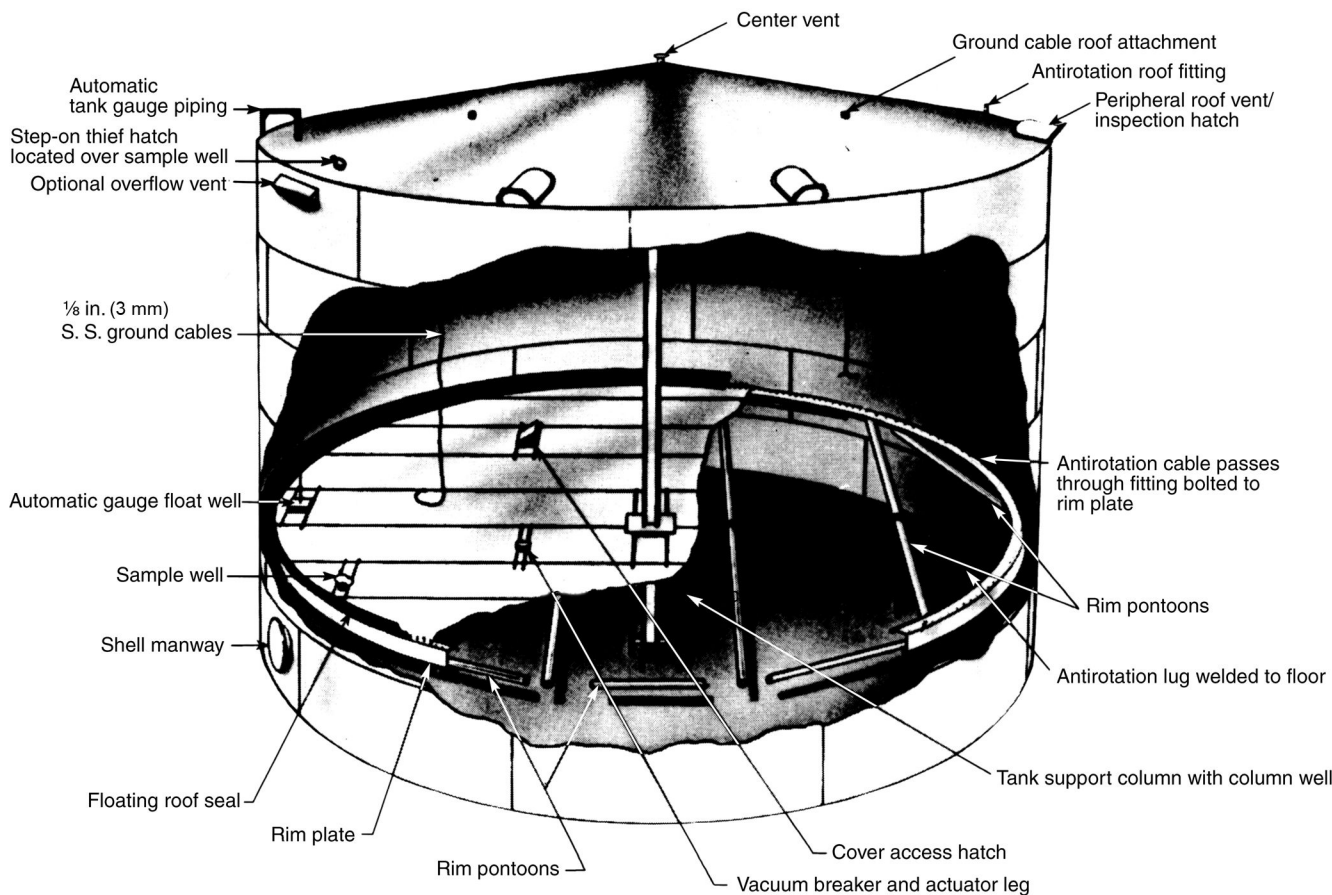
5.3.7 Foam Monitor Design Criteria for Seal Area Protection. Monitors shall not be used as the primary means of floating roof seal fire extinguishment because of the difficulty of directing foam into the annular space and the possibility of sinking the roof.

**FIGURE 5.3.5.4.5 Typical Foam Dam for Floating Roof Tank Protection.**

5.4* Outdoor Covered (Internal) Floating Roof Tanks. See Figure 5.4.

5.4.1 Requirements for tanks equipped with the following floating roof types shall not be covered in Section 5.4:

- (1) Roofs made from floating diaphragms
- (2) Roofs made from plastic blankets
- (3) Roofs made with plastic or other flotation material, even if encapsulated in metal or fiberglass, except as permitted in 5.4.2
- (4) Roofs that rely on flotation device closures that are easily submerged if damaged
- (5) Pan roofs



▲ FIGURE 5.4 Typical Covered Floating Roof Tank.

5.4.2* Seal area protection systems shall be permitted for the following types of roof construction:

- (1) Steel double deck
- (2) Steel pontoon
- (3) Full liquid surface contact, metallic sandwich panel, conforming to Appendix H, "Internal Floating Roofs," requirements of API STD 650
- (4)* Full liquid surface contact, composite sandwich roof/seal system, designed in accordance with the performance criteria in Appendix H, "Internal Floating Roofs," requirements of API STD 650 and the following:
 - (a) Fiberglass components shall be made from high-grade vinyl ester resin with a corrosion-resistant bottom surface and be compatible with the stored product.
 - (b) The top layer shall exhibit a flame spread index not exceeding 25 when tested in accordance with ASTM E84 (Class A).
 - (c) The structural laminate of the composite sandwich structure shall be in accordance with ASTM C582.
 - (d) Core material shall be of a closed-cell structure for inherent redundant buoyancy and shall be chemically compatible with the stored product.
 - (e) The roof surfaces shall be a seamless, one-piece construction that utilizes chemical bonds to join all components.

- (f) The perimeter seal system shall be gas-tight and utilize noncombustible material to cover the rim space.

5.4.2.1 All other types of roof construction shall require full surface protection.

5.4.2.2 Design for Full Surface Fire.

5.4.2.2.1 Where the basis for design is a full surface fire, the covered (internal) floating roof tank shall be treated as equivalent to a fixed-roof (cone) tank of the same diameter for the purpose of foam system design.

5.4.2.2.2 For a full surface fire, the foam facilities shall be designed in accordance with 5.2.5 and Section 5.9, except that separately valved laterals for each foam discharge shall not be required.

5.4.2.2.3 For this application, fixed foam discharge outlets shall not be fitted with a frangible vapor seal device.

5.4.2.2.4 Subsurface and semisubsurface injection shall not be used because of the possibility of improper distribution of foam.

5.4.2.3 Design for Seal Area Fire.

5.4.2.3.1 Where the basis for design is a seal fire, the covered (internal) floating roof tank shall be treated as equivalent to an

open-top floating roof tank of the same diameter for the purpose of foam system design.

5.4.2.3.2 For a seal fire, the foam discharge system shall be designed in accordance with the requirements specified in Table 5.3.5.3.1 utilizing fixed foam discharge outlets.

5.4.2.3.3 Supplementary Protection. In addition to the primary means of protection, there shall be provisions for supplementary protection in accordance with the requirements of Section 5.9.

5.4.2.3.4* Basis of Design.

5.4.2.3.4.1 System design shall be based on protecting the tank requiring the largest solution flow, including supplementary hose streams.

5.4.2.3.4.2 If the application rate is higher than the minimum rate specified in Table 5.2.6.5.1, the discharge time shall be permitted to be reduced proportionately, but shall not be less than 70 percent of the minimum discharge times specified.

5.5 Indoor Hazards.

5.5.1* This section shall address foam fire-extinguishing systems, which are intended to protect indoor storage tanks that have liquid surface areas of 400 ft² (37 m²) or greater.

5.5.2 Discharge Outlets. Tanks for storing liquid hydrocarbons shall be fitted with Type II, tank-mounted fixed foam discharge outlets as specified in Table 5.2.6.2.8.

5.5.3 Minimum Discharge Time and Application Rate.

Δ 5.5.3.1 The minimum application rate for indoor hydrocarbon storage tanks shall be 0.16 gpm/ft² (6.5 mm/min) of liquid surface area.

5.5.3.2 Minimum discharge time shall be as specified in Table 5.2.5.2.2 for Type II fixed foam discharge outlets.

5.5.3.3 If the application rate is higher than the minimum rate specified in 5.5.2, the discharge time shall be permitted to be reduced proportionately, but not to less than 70 percent of the minimum discharge times indicated.

5.5.4 Design Criteria for Indoor Storage Tanks Containing Flammable or Combustible Liquids Requiring Alcohol-Resistant Foams.

5.5.4.1* Water-soluble and certain flammable and combustible liquids and polar solvents that are destructive to nonalcohol-resistant foams shall require the use of alcohol-resistant foams.

5.5.4.2 In all cases, the manufacturers of the foam concentrate and the foam-making equipment shall be consulted as to limitations and for recommendations based on listings or specific fire tests.

5.6* Loading Racks.

5.6.1 Within the scope of this standard, loading racks shall be defined as being either truck or rail car types for the purpose of loading or unloading product.

5.6.2 Total rack size, flammable or combustible products involved, proximity of other hazards and exposures, drainage facilities, wind conditions, ambient temperatures, and available staff all shall be factored into the design of a loading rack foam system.

5.6.3 Methods of Protection. The following methods shall be permitted for protecting loading racks:

- (1) Foam-water sprinkler application utilizing air-aspirating foam-water sprinklers or nozzles or non-air-aspirating open standard sprinklers or foam nozzles using compressed air foam delivery systems
- (2) Foam monitors or foam monitors using compressed air foam delivery systems
- (3) Other devices approved by the AHJ

5.6.4 Design Criteria for Foam-Water Sprinkler Systems. The design criteria for sprinkler systems shall be in accordance with NFPA 16.

5.6.5 Design Criteria for Foam Monitor Protection Systems.

5.6.5.1* Areas to Be Protected by Monitor Nozzles. Monitor nozzle system design shall be based on the total ground area within the curb.

5.6.5.2 The intent of the design shall be to protect the canopy, pumps, meters, vehicles, and miscellaneous equipment associated with the loading and unloading operation in the event of a spill fire.

5.6.5.3 Minimum Application Rates and Discharge Times.

5.6.5.3.1 Minimum foam application rates and discharge times for loading racks protected by monitor nozzles shall be as specified in Table 5.6.5.3.1.

N 5.6.5.3.1.1 Foam types not included in Table 5.6.5.3.1 shall be permitted where used in accordance with their listing.

Δ 5.6.5.3.2 If a fuel depth of more than 1 in. (25 mm) can accumulate within the protected area, the application rate shall be increased to 0.16 gpm/ft² (6.5 mm/min).

Δ Table 5.6.5.3.1 Minimum Application Rates and Discharge Times for Loading Racks Protected by Foam Monitor Nozzle Systems

Foam Type	Minimum Application Rate		Minimum Discharge Time (minutes)	Product Being Loaded
	gpm/ft ²	mm/min*		
Protein and fluoroprotein	0.16	6.5	15	Hydrocarbons
AFFF, FFFP, and alcohol-resistant AFFF or FFFP	0.10	4.1	15	Hydrocarbons
Alcohol-resistant foams	Consult manufacturer for listings on specific products		15	Flammable and combustible liquids requiring alcohol-resistant foam

*L/min-m² is equivalent to mm/min.

Shaded text = Revisions. Δ = Text deletions and figure/table revisions. • = Section deletions. N = New material



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5.7* Diked Areas — Outdoor.

Δ 5.7.1 For the purpose of this standard, diked areas shall be areas bounded by contours of land or physical barriers that retain a fuel to a depth greater than 1 in. (25 mm).

5.7.2 Protection of these areas shall be achieved by either fixed discharge outlets, fixed or portable monitors, or foam hoselines.

5.7.3 **Methods of Application.** Where foam protection is used for a diked area, it shall be permitted to be accomplished by any of the following methods:

- (1) Low-level foam discharge outlets
- (2) Foam monitors or foam hoselines
- (3) Foam-water sprinklers or nozzles

5.7.3.1 This list of methods shall not be considered as being in the order of preference.

5.7.3.2* **Minimum Application Rates and Discharge Times for Fixed Discharge Outlets on Diked Areas Involving Liquid Hydrocarbons.** The minimum application rates and discharge times for fixed foam application on diked areas shall be as specified in Table 5.7.3.2.

5.7.3.3* Fixed Foam Discharge Outlets.

5.7.3.3.1 Fixed foam discharge outlets shall be sized and located to apply foam uniformly over the dike area at the application rate specified in Table 5.7.3.2.

5.7.3.3.2 Large dike areas shall be permitted to be subdivided to keep the total design solution within practical limits.

5.7.3.4 Fixed Foam-Water Sprinklers or Nozzles.

5.7.3.4.1 Where fixed foam-water sprinklers or nozzles are used, the system design shall be in accordance with NFPA 16.

5.7.3.4.2* Where foam-water sprinklers or nozzles are used as the primary protection, the design shall include the possibility that some of the foam discharge will be carried by the wind beyond the area of the fuel spill.

5.7.3.5 Fixed Low-Level Foam Discharge Outlets.

5.7.3.5.1 Fixed low-level foam discharge outlets shall be permitted to be open pipe fittings or directional flow nozzles

designed to discharge a compact, low-velocity foam stream onto the inner wall of the dike or, where necessary, directly onto the dike floor.

5.7.3.5.2 Fixed low-level foam discharge outlets shall be located around the dike wall, and, where necessary, inside the dike area, to apply foam uniformly over the dike area.

5.7.3.5.3* Limitations.

Δ 5.7.3.5.3.1 Where fixed discharge outlets installed at a low level are used as the primary protection, they shall be located so that no point in the dike area is more than 30 ft (9 m) from a discharge outlet where the discharge per outlet is 60 gpm (230 L/min) or less.

Δ 5.7.3.5.3.2 For outlets having discharge rates higher than 60 gpm (230 L/min), the maximum distance between discharge outlets shall be 60 ft (18 m).

5.7.3.5.4 **Foam Monitors.** Where monitors are used to discharge foam onto the dike area, they shall be located outside the dike area.

5.7.3.5.4.1 Where foam monitors are used as the primary protection, the design shall include the possibility that some of the foam discharge will be carried by the wind beyond the area of the fuel spill.

5.7.3.5.4.2 Where the monitor discharge is in the form of a compact, high-velocity foam stream, it shall be directed against the dike walls, tank surfaces, or other structures to prevent its plunging directly into the burning liquid surface.

5.7.4 Diked Areas Involving Flammable or Combustible Liquids Requiring Alcohol-Resistant Foams.

5.7.4.1 Water-soluble and certain flammable and combustible liquids and polar solvents that are destructive to nonalcohol-resistant foams shall require the use of alcohol-resistant foams.

5.7.4.2 Systems using these foams shall require special engineering consideration.

5.7.4.3 The design criteria for diked areas involving flammable or combustible liquids requiring alcohol-resistant foams shall be as stated in 5.7.4.3.1 through 5.7.4.3.3.

Δ Table 5.7.3.2 Minimum Application Rates and Discharge Times for Fixed Foam Application on Diked Areas Involving Hydrocarbon Liquids

Type of Foam Discharge Outlets	Minimum Application Rate		Minimum Discharge Time (minutes)	
	gpm/ft ²	mm/min*	Class I Hydrocarbon	Class II Hydrocarbon
Low-level foam discharge outlets	0.10	4.1	30	20
Foam monitors	0.16	6.5	30	20
Foam using compressed air foam technology	Consult manufacturer for listed minimum application rate	Consult manufacturer for listed minimum application rate	30	20

*L/min·m² is equivalent to mm/min.

Table 5.8.1.2 Minimum Application Rates and Discharge Times for Nondiked Spill Fire Protection Using Portable Foam Nozzles or Monitors

Foam Type	Minimum Application Rate		Minimum Discharge Time (minutes)	Anticipated Product Spill
	gpm/ft ²	mm/min*		
Protein and fluoroprotein	0.16	6.5	15	Hydrocarbon
AFFF, FFFP, and alcohol-resistant AFFF or FFFP	0.10	4.1	15	Hydrocarbon
Alcohol-resistant foams	Consult manufacturer for listings on specific products		15	Flammable and combustible liquids requiring alcohol-resistant foam

*L/min·m² is equivalent to mm/min.

5.7.4.3.1 Methods of fixed protection shall be the same as those described in 5.7.3.3 for hydrocarbon hazards.

5.7.4.3.2 Application rates shall be in accordance with manufacturer recommendations based on listings or approvals for specific products and corresponding foam-making devices.

5.7.4.3.3 The minimum discharge time shall be 30 minutes.

5.8* Nondiked Spill Areas.

5.8.1 Design Criteria for Protection of Spill Fires Involving Hydrocarbons or Flammable and Combustible Liquids Requiring Alcohol-Resistant Foams.

5.8.1.1 To determine protection for spill fires, the potential spill area shall be estimated.

5.8.1.2 Once this area has been determined, Table 5.8.1.2 shall be used to calculate requirements to be used as design criteria for portable nozzles or monitors.

5.8.1.2.1 Foam types not included in Table 5.8.1.2 shall be permitted where used in accordance with their listing.

5.9* Supplementary Protection.

5.9.1 Additional Protection. In addition to the primary means of protection, some types of hazards shall require provisions for supplemental means of protection.

5.9.2 Supplemental Foam Hose Stream Requirements.

5.9.2.1 Approved foam hose stream equipment shall be provided in addition to tank foam installations as supplementary protection for small spill fires.

5.9.2.2 The minimum number of fixed or portable hose streams required shall be as specified in Table 5.9.2.2 and shall provide protection of the area.

Table 5.9.2.2 Supplemental Foam Hose Stream Requirements Diameter of Largest Tank

Diameter of Largest Tank		Minimum Number of Hose Streams Required
ft	m	
Up to 65	Up to 20	1
65 to 120	20 to 36	2
Over 120	Over 36	3

5.9.2.3 The equipment for producing each foam stream shall have a solution application rate of at least 50 gpm (190 L/min), with the minimum number of hose streams shown in Table 5.9.2.2.

5.9.2.4 Additional foam-producing materials shall be provided to allow operation of the hose stream equipment simultaneously with tank foam installations as specified in Table 5.9.2.4.

Table 5.9.2.4 Hose Stream Operating Times, Supplementing Tank Foam Installations

Diameter of Largest Tank		Minimum Operating Time* (minutes)
ft	m	
Up to 35	Up to 11	10
35 to 95	11 to 29	20
Over 95	Over 29	30

*Based on simultaneous operation of the required minimum number of hose streams discharging at a rate of 50 gpm (190 L/min).

N Chapter 6 Low-Expansion Foam Sprinkler and Spray Systems

N 6.1 Administration.

N 6.1.1 Scope. The design, installation, and maintenance of foam-water sprinkler and spray systems shall be in accordance with this chapter. These systems shall be designed with the required density for either foam or water application as the controlling factor, depending on the design purpose of the system. It is not the intent of this standard to specify where foam-water sprinkler and spray protection is required. The determination of where foam-water sprinkler and spray systems are required shall be made in accordance with such applicable building and fire codes or standards such as NFPA 30 or NFPA 409.

N 6.1.2* Purpose. The purpose of these requirements is to provide a reasonable degree of protection for life and property from fire through installation requirements for foam-water sprinkler and spray systems based on sound engineering principles, test data, and field experience.

N 6.1.3 Application.

N 6.1.3.1* Because of the dual extinguishing agent discharge characteristic, these systems shall be selectively applicable to combination Class A and Class B hazards.

N 6.1.3.2 Foam-water deluge systems are applicable to the protection of two-dimensional flammable liquid hazards. They shall be permitted to be used for any of the purposes or combinations thereof detailed in 6.1.3.2.1 through 6.1.3.2.3.

N 6.1.3.2.1 Extinguishment. The primary purpose of such systems is the extinguishment of fire in the protected hazard. For this purpose, foam solution discharge densities shall be provided by system design, use of selected discharge devices, and provision of supplies of water at required pressures to accomplish the system design. Foam discharge rates shall be able to provide required rates of water discharge from the system until shut off during the design period and following depletion of foam concentrate supplies.

N 6.1.3.2.2 Prevention. Prevention of fire in the protected hazard is a supplemental feature of such systems. Manual operation of a system to discharge foam or water selectively 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 cleanup measures. In such cases, manual system operation provides foam coverage in the area with water discharge manually available.

N 6.1.3.2.3 Control and Exposure Protection. Control of fire to allow controlled burning of combustible materials where extinguishment is not possible and exposure protection to reduce heat transfer from an exposure fire can be accomplished by water spray or foam, or both, from these special systems. The degree of accomplishment is related strongly to the fixed discharge densities provided by the system design.

N 6.1.3.3 Foam of any type is not an effective extinguishing agent on fires involving liquefied or compressed gases (e.g., butane, butadiene, propane), 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 primary importance.

N 6.1.3.4* Only alcohol-type foam shall be used on fires in water-soluble solvents and polar solvents. Manufacturers of foam concentrates that are manufactured for the protection of such hazards shall be consulted for applicability.

N 6.1.3.5 Consideration shall be given to potential contamination of water supplies, treating systems, and effluent by foam concentrate, foam, or foam solution runoff. The foam concentrate manufacturer and the appropriate AHJ shall be consulted for guidance. (See Annex E.)

N 6.2 General System Requirements.

N 6.2.1 General System Information.

N 6.2.1.1 Foam-water deluge and preaction systems shall be provided with automatic and auxiliary manual tripping means in accordance with 6.4.10.

N 6.2.1.2 Manual operation only shall be permitted for foam-water deluge systems where acceptable to the AHJ.

N 6.2.2 Types of Systems. Foam-water systems shall be of the wet pipe, dry pipe, deluge, or preaction type.

N 6.2.3 Foam Discharge Duration.

N 6.2.3.1 Systems shall deliver foam to the hazards they protect for a specified period at given densities, either prior to water discharge or following water discharge, depending upon system design purpose.

N 6.2.3.2 Following completion of discharge of foam solution to the hazards protected, foam-water sprinkler and spray systems shall discharge water until manually shut off.

N 6.2.4* Reserve Supply of Foam.

N 6.2.4.1 The AHJ shall be consulted as to the means by which a reserve supply of foam concentrate shall be made available.

N 6.2.4.2 The reserve supply shall be listed for use with system components. (See 6.5.3.)

N 6.2.5* Preprimed Systems.

N 6.2.5.1 Wet pipe foam-water systems shall be preprimed with foam-water solution.

N 6.2.5.2 Systems shall not be required to be preprimed where recommended by the foam concentrate manufacturer and where approved by the AHJ.

N 6.2.6 Approvals.

N 6.2.6.1 Prior to designing a system for consideration, the AHJ shall be consulted.

N 6.2.6.2 All plans and specifications for the installation shall be approved by the AHJ prior to installation, and such authority shall be consulted as to devices and materials used in system construction and as to selection of the foam concentrate to be provided for system use.

N 6.2.6.3 All equipment and concentrates shall be approved for the particular application intended.

N 6.3 Working Plans. Working plans shall be in accordance with Chapter 9.

N 6.4 System Components.

N 6.4.1 Approved Devices and Materials.

N 6.4.1.1 All component parts, including foam concentrates, shall be listed for the use intended.

N 6.4.1.2 Where listed components are not manufactured, the components shall be of an approved type.

N 6.4.2 Discharge Devices.

N 6.4.2.1 Discharge devices and foam concentrates shall be listed for use together.

N 6.4.2.2 Discharge devices for foam-water deluge and spray shall be permitted to be air-aspirating, such as foam-water sprinkler and foam-water spray nozzles, or they shall be permitted to be non-air-aspirating, such as standard sprinklers.

N 6.4.2.3 Discharge devices for foam-water wet pipe, dry pipe, and preaction systems shall be automatic in operation and shall be non-air-aspirating.

N 6.4.3* Foam Concentrate. Foam concentrates shall be in accordance with the requirements of Section 4.3.

- N 6.4.4 Foam Concentrate Proportioning Means.** Foam concentrates shall be in accordance with the requirements of Section 4.5.
- N 6.4.5* Foam Concentrate Pumps.** Foam concentrate pumps shall be in accordance with the requirements of Section 4.6.
- N 6.4.6 Foam Concentrate Storage Tanks.** Storage tanks for foam concentrate shall be in accordance with Section 4.3.
- N 6.4.7 Piping, Valves, Pipe Fittings, and Hangers.**
- N 6.4.7.1** Piping, valves, pipe fittings, and hangers, including corrosion-protection coatings, shall be in accordance with NFPA 13.
- N 6.4.7.2*** Piping, fittings, and valves shall be of a material compatible with the foam concentrate, foam solution, or water used, as applicable.
- N 6.4.7.2.1*** Foam concentrate pipe and valves shall be made of one of the following materials:
- (1) Brass (red or naval)
 - (2) Bronze
 - (3) Stainless steel (304 or 316)
 - (4) Other material, in accordance with the foam concentrate manufacturer's certification of compatibility with the foam concentrate and as approved by the AHJ (See 4.7.1.1.)
- N 6.4.7.2.2*** Carbon steel pipe shall not be used. (See 4.7.1.2.)
- N 6.4.7.2.3** Pipe carrying foam concentrate shall not be galvanized. (See 4.7.1.3.)
- N 6.4.7.2.4** Foam concentrate pipe shall conform to one of the following standards:
- (1) ASTM A312
 - (2) ASTM B43
 - (3) ASTM B315
 - (4) Other standards as allowed by 4.7.1.4
- N 6.4.7.2.5*** Foam solution pipe shall be made of one of the following materials:
- (1) Galvanized steel
 - (2) Stainless steel
 - (3) Internal/external corrosion-resistant pipe in accordance with the foam manufacturer's specification for compatibility and acceptable to the AHJ
 - (4) Unprotected carbon steel pipe, when the discharge devices are closed to the atmosphere (See 4.7.2.1.)
- N 6.4.7.3*** Rubber-gasketed fittings shall be permitted to be used to connect pipe in fire-exposed areas where the foam-water system is automatically controlled.
- N 6.4.7.3.1** Fire-exposed areas in which these fittings are located shall be protected by automatic foam-water systems or other approved means.
- N 6.4.8 Strainers for Foam Concentrate.**
- N 6.4.8.1** Where listed strainers of the proper size are not available, strainers that have a ratio of open-basket area to inlet pipe size of at least 10:1 shall be used.
- N 6.4.8.2** Strainers shall be capable of removing all solids of a size that would obstruct system components.
- N 6.4.8.3** Perforations shall be no larger than the smallest orifice in the system and no less than $\frac{1}{8}$ in. (3 mm).
- N 6.4.9 Automatic System Detection.**
- N 6.4.9.1** Detection required for foam-water deluge systems shall be in accordance with NFPA 15.
- N 6.4.9.2** Detection required for foam-water preaction systems shall be in accordance with NFPA 13.
- N 6.4.9.3** Detection and actuation circuitry shall be supervised through a listed panel in accordance with NFPA 72.
- N 6.4.10* Test Connections.** System test connections shall be sized to accommodate both the low flow of the proportioner and the maximum anticipated flow through the proportioner.
- N 6.4.11 Stock of Spare Sprinklers.**
- N 6.4.11.1*** A supply of at least six spare sprinklers shall be maintained on the premises so that any sprinklers that have operated or been damaged in any way can be promptly replaced. [13:16.2.7.1]
- N 6.4.11.2** The sprinklers shall correspond to the types and temperature ratings of the sprinklers in the property. [13:16.2.7.2]
- N 6.4.11.3** The sprinklers shall be kept in a cabinet located where the temperature to which they are subjected will at no time exceed the maximum ceiling temperatures specified in Table 6.4.11.3 for each of the sprinklers within the cabinet. [13:16.2.7.3]
- N 6.4.11.4** Where dry sprinklers of different lengths are installed, spare dry sprinklers shall not be required, provided that a means of returning the system to service is furnished. [13:16.2.7.4]
- N 6.4.11.5** The stock of spare sprinklers shall include all types and ratings installed and shall be as follows:
- (1) For protected facilities having under 300 sprinklers — no fewer than six sprinklers
 - (2) For protected facilities having 300 to 1000 sprinklers — no fewer than 12 sprinklers
 - (3) For protected facilities having over 1000 sprinklers — no fewer than 24 sprinklers
- [13:16.2.7.4]
- N 6.4.11.6*** One sprinkler wrench as specified by the sprinkler manufacturer shall be provided in the cabinet for each type of sprinkler installed to be used for the removal and installation of sprinklers in the system. [13:16.2.7.6]
- N 6.4.11.7** A list of the sprinklers installed in the property shall be posted in the sprinkler cabinet. [13:16.2.7.7]
- N 6.4.11.7.1*** The list shall include the following:
- (1) Sprinkler Identification Number (SIN) if equipped; or the manufacturer, model, K-factor, deflector type, thermal sensitivity, and pressure rating
 - (2) General description
 - (3) Quantity of each type to be contained in the cabinet
 - (4) Issue or revision date of the list
- [13:16.2.7.7.1]

N 6.5 System Design and Installation.**N 6.5.1 General.**

N 6.5.1.1 Foam-water sprinkler systems shall meet the minimum design criteria as presented in this chapter.

N 6.5.1.2 Except as allowed by 6.5.2.6.2, 6.5.2.2.1(B), and 6.5.6.2, where occupancy standards specify more stringent criteria, they shall take precedence.

N 6.5.1.3 The design and installation of foam-water systems shall be entrusted to experienced and responsible persons.

N 6.5.2 Design Criteria.

N 6.5.2.1* Referenced Standards. System designs shall conform to all the applicable requirements of the following standards unless otherwise specified in this standard:

- (1) NFPA 13
- (2) NFPA 14
- (3) NFPA 15
- (4) NFPA 20
- (5) NFPA 22
- (6) NFPA 24
- (7) NFPA 30
- (8) NFPA 70
- (9) NFPA 72

N 6.5.2.2* Design Approach.

N 6.5.2.2.1 The design discharge density shall be in accordance with the applicable occupancy standard for water or foam-water systems but in no case less than 0.16 gpm/ft² (6.5 mm/m²).

N 6.5.2.2.1.1 When using SFFF, the user shall refer to Annex H and the manufacturer's recommendations to determine application rates.

N 6.5.2.2.2 Foam-Water Wet Pipe, Dry Pipe, and Preaction Systems.**N 6.5.2.2.2.1 Total Design Area.**

N (A)* The total design area shall be 5000 ft² (465 m²).

N (B) Where applicable occupancy standards specify design areas different from that specified in 6.5.2.2.1(A), the occupancy standards shall take precedence.

N 6.5.2.2.3 For the purposes of hydraulic calculations, the water supply shall meet the requirements of 6.2.3.

N 6.5.2.3 Foam Solution Discharge Duration.

N 6.5.2.3.1 The foam solution shall be designed to discharge for a period of 10 minutes (based on the density as specified in 6.5.2.2.1) over the entire system area for deluge and spray foam-water systems and over the design area for wet pipe, dry pipe, and preaction foam-water systems.

N 6.5.2.3.2 Where actual system discharge exceeds the minimum as specified in 6.5.2.2.1, a proportionate reduction in the duration of the foam discharge time shall be permitted, but in no case shall the duration be less than 7 minutes.

N 6.5.2.4 Proportioning System. The proportioning system selected shall be in accordance with Section 4.5.

N 6.5.2.4.1 Foam concentrate pumps shall be designed and installed in accordance with Section 4.6.

N 6.5.2.4.2 Power Supply and Controller. The power supply and controllers for the drivers of foam concentrate pumps shall be installed in accordance with NFPA 20 and NFPA 70.

N 6.5.2.5 Foam Concentrate Lines.

N 6.5.2.5.1* Where foam concentrate lines are run underground or where they run aboveground for more than 50 ft (15 m), these lines shall be maintained full, and a means of checking the tightness of the system shall be provided.

N 6.5.2.5.2 The temperature of the foam concentrate lines and components shall be maintained within the storage temperature limits specified for the foam concentrate.

N 6.5.2.6 Containment, Drainage, and Spill Control.

N 6.5.2.6.1* 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.

Table 6.4.11.3 Temperature Ratings, Classifications, and Color Codings

Maximum Ceiling Temperature		Temperature Rating		Temperature Classification	Color Code	Glass Bulb Colors
°F	°C	°F	°C			
100	38	135–170	57–77	Ordinary	Uncolored or black	Orange or red
150	66	175–225	79–107	Intermediate	White	Yellow or green
225	107	250–300	121–149	High	Blue	Blue
300	149	325–375	163–191	Extra high	Red	Purple
375	191	400–475	204–246	Very extra high	Green	Black
475	246	500–575	260–302	Ultra high	Orange	Black
625	329	650	343	Ultra high	Orange	Black

[13:Table 7.2.4.1]

N 6.5.2.6.2 Where applicable occupancy standards specify containment or drainage that differs from that specified in 6.5.2.6.1, the occupancy standard shall take precedence.

N 6.5.3 Equipment Location. Equipment items, such as storage tanks and proportioners for foam concentrates; pumps for water and foam concentrates; and control valves for water, foam concentrates, and foam solution, shall be located as near as possible to the hazard or hazards they protect but shall not be exposed to a fire in a manner that is likely to impair system performance.

N 6.5.4 Alarms. Alarms shall be provided in accordance with the requirements of NFPA 13.

N 6.5.5 Strainers.

N 6.5.5.1 Strainers shall be installed so that they are accessible for cleaning or flushing.

N 6.5.5.2 Strainers shall be installed so as to be accessible for cleaning (flushing) while maintaining system discharge during an emergency.

N 6.5.6 Sprinkler Spacing and Location.

N 6.5.6.1 Sprinkler spacing shall not exceed 100 ft² (9.3 m²) per sprinkler or exceed 12 ft (3.7 m) spacing between sprinklers on a branch line or between branch lines. Except in buildings where the primary structural members are 25 ft (7.6 m) apart, the line-to-line distance shall be permitted to be 12 ft 6 in. (3.8 m) where the system has a density of ≥ 0.25 .

N 6.5.6.2 Where applicable occupancy standards specify a sprinkler spacing different from that specified in 6.5.6.1, the occupancy standards shall take precedence.

N 6.5.6.3 For foam-water preaction systems, the requirements of 6.5.8 shall also take precedence.

N 6.5.7 Temperature Rating.

N 6.5.7.1 The temperature rating of sprinklers shall be within the range of 250°F to 300°F (121°C to 149°C) where they are located at the roof or ceiling.

N 6.5.7.2 Where sprinklers are located at an intermediate level, the temperature rating shall be within the range of 135°F to 170°F (57°C to 77°C), unless ambient conditions require a higher rating.

N 6.5.8 Foam-Water Deluge Systems.

N 6.5.8.1 Tripping.

N 6.5.8.1.1* In automatic systems, the detection equipment shall be connected to a means for tripping water deluge valves and other system-control equipment.

N 6.5.8.1.2 Supplemental manual means for this purpose also shall be provided.

N 6.5.8.2 Foam Concentrate Injection.

N 6.5.8.2.1 In automatic systems, foam concentrate injection shall be activated automatically by, or concurrently with, activation of the main water supply control valve.

N 6.5.8.2.2 Manual operating means shall be designed for this same purpose.

N 6.5.8.3 Automatic detection equipment, whether pneumatic, hydraulic, or electric, shall be provided with complete supervi-

sion arranged so that failure of equipment, loss of supervising air pressure, or loss of electric energy results in clear notification of the abnormal condition.

N 6.5.8.4 Where used in a corrosive atmosphere, the detection devices shall be of materials not subject to corrosion or of materials protected to resist corrosion.

N 6.5.8.5* Automatic detection equipment of the electric type and any auxiliary equipment of the electric type, if in hazardous areas, shall be designed specifically for use in such areas.

N 6.5.8.6 In automatic systems, manually operated tripping devices shall actuate the automatic control valve by mechanical, pneumatic, electric, or other approved means.

N 6.5.8.6.1 The manual device shall be strong enough to prevent breakage.

N 6.5.8.6.2 Manual controls shall not necessitate a pull of more than 40 lb (force) [178 N] or a movement of more than 14 in. (356 mm) to secure operation.

N 6.5.9 Fire Department Connection.

N 6.5.9.1* When a fire department connection is required, it shall be installed on the supply side of the proportioner.

N 6.5.9.2 Where a fire department connection is provided, the following items shall be evaluated before installation or use:

- (1) Overpressurizing of system components
- (2) Imbalance of proportioning equipment
- (3) Dilution of proportioned foam solution
- (4) Disturbance of system accessory devices including, but not limited to, the following:
 - (a) Pressure switches
 - (b) Hydraulic control valves
 - (c) Main control valve trim
- (5) Pressures and flows exceeding the foam system design capability

N 6.5.9.3 A sign that states the following shall be placed at the fire department connection:

FIRE DEPARTMENT CONNECTION
THIS CONNECTION FEEDS A FOAM-WATER SPRINKLER
SYSTEM.
DO NOT PUMP AT PRESSURES
EXCEEDING [*insert design pressure*] UNTIL FOAM
LIQUID SUPPLY IS EXHAUSTED.
IF INCIDENT IS CONTROLLED BY FOAM BLANKET, DO
NOT DESTROY FOAM BLANKET BY EXCESSIVE APPLICATION
OF WATER.

N 6.5.10 Hydraulic Calculations.

N 6.5.10.1 Foam-Water Deluge Systems.

N 6.5.10.1.1 System piping shall be hydraulically designed to obtain uniform foam and water distribution and to allow for loss of head in water supply piping.

N 6.5.10.1.1.1 The adjustment in pipe sizes shall be based on a maximum variation of 20 percent above the specified discharge rate per sprinkler or nozzle.

N 6.5.10.1.2 Pipe sizes shall be adjusted according to detailed friction-loss calculations.

N 6.5.10.1.2.1 These calculations shall show the relationship between the water supply and the water demand.

N 6.5.10.1.3 Hydraulic calculations for piping carrying water or foam solution shall be in accordance with NFPA 13.

N 6.5.10.1.3.1 Piping carrying foam solution shall be sized as if carrying plain water.

N 6.5.10.1.4* The friction losses in piping carrying foam concentrate shall be calculated using the Darcy-Weisbach formula.

N 6.5.10.1.4.1 Friction factors for use with the Darcy-Weisbach formula shall be selected from the graphs shown in Figure 6.5.10.1.4.1(a) through Figure 6.5.10.1.4.1(d).

N 6.5.10.1.4.2 In calculating the Reynolds number for selecting friction factors from the graphs, the actual density (or specific gravity) of the foam concentrate to be employed in the system shall be used.

N 6.5.10.1.4.3 The viscosity used shall be the actual viscosity of the foam concentrate at the lowest anticipated storage temperature.

N 6.5.10.1.4.4* For purposes of computing friction loss in piping using alcohol-resistant foam concentrate, the designer shall consult the foam concentrate manufacturer for friction characteristics.

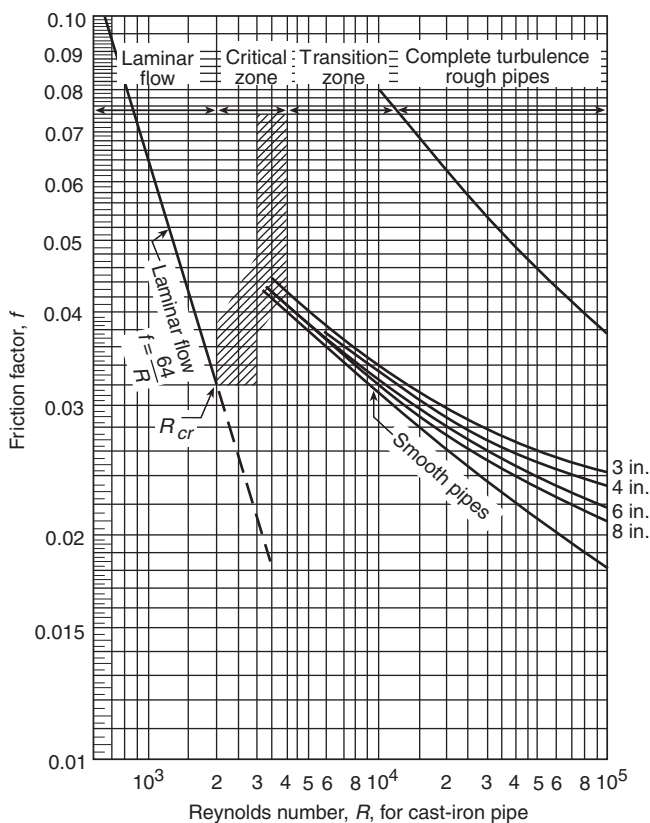


FIGURE 6.5.10.1.4.1(a) Moody Diagram for Cast-Iron Pipe, $R \leq 10^5$.

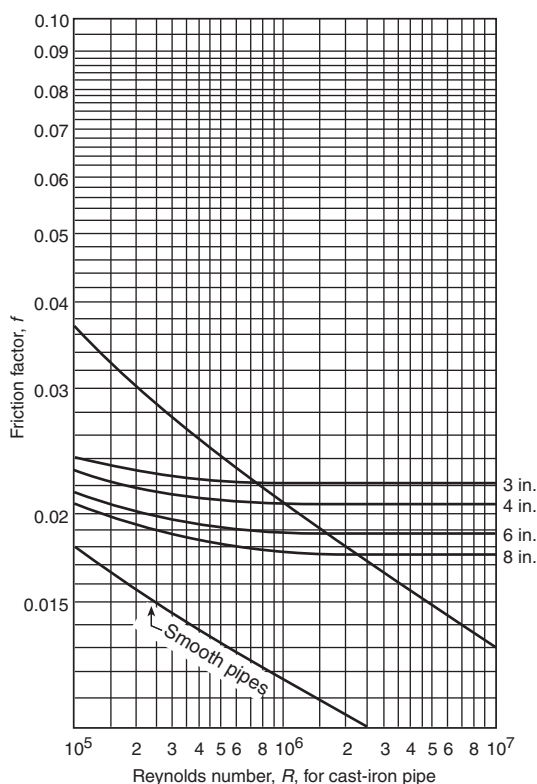


FIGURE 6.5.10.1.4.1(b) Moody Diagram for Cast-Iron Pipe, $R \geq 10^5$.

N 6.5.10.1.5 For purposes of computing friction loss in piping, the C values shall be used for the Hazen-Williams formula in accordance with Table 6.5.10.1.5.

N 6.5.10.2 Foam-Water Wet Pipe, Dry Pipe, and Preaction Systems.

N 6.5.10.2.1 System piping shall be hydraulically designed to obtain uniform foam and water distribution and to allow for loss of head in system piping.

N 6.5.10.2.2* Two sets of hydraulic calculations shall be provided, as follows:

- (1) Actual calculated demand flow and pressure based on the most hydraulically demanding condition, balanced to the available water supply
- (2) Actual calculated demand flow and pressure based on the least hydraulically demanding design area, balanced to the available water supply

N 6.5.10.2.3* Hydraulic balance to, and comparison with, the available water supply shall verify that the actual system discharge will not exceed the capability of the foam concentrate supply to provide foam solution discharge as specified in 6.5.2.3.1 and 6.5.2.3.2.

N 6.5.10.2.4 Pipe sizes shall be adjusted according to detailed friction-loss calculations.

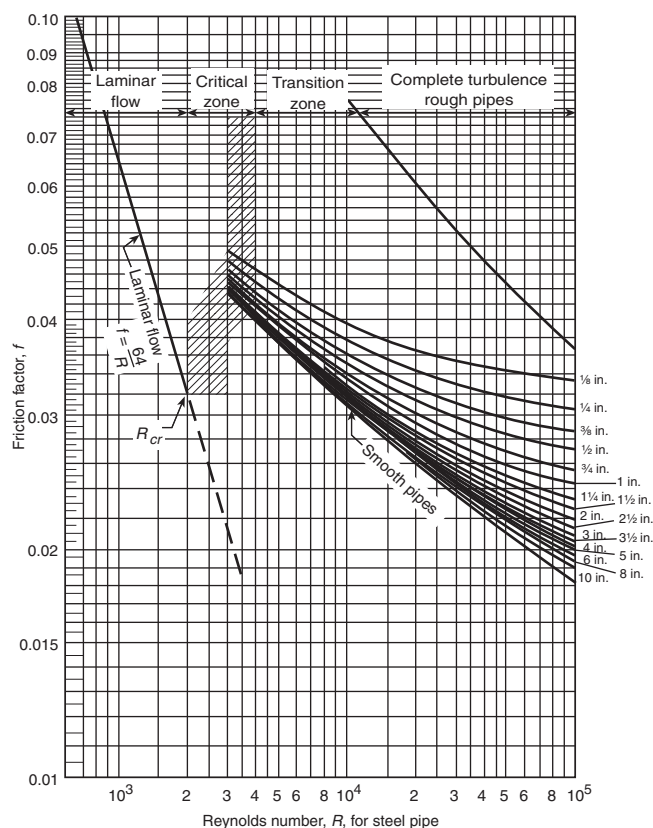


FIGURE 6.5.10.1.4.1(c) Moody Diagram for Steel Pipe, $R \leq 10^5$.

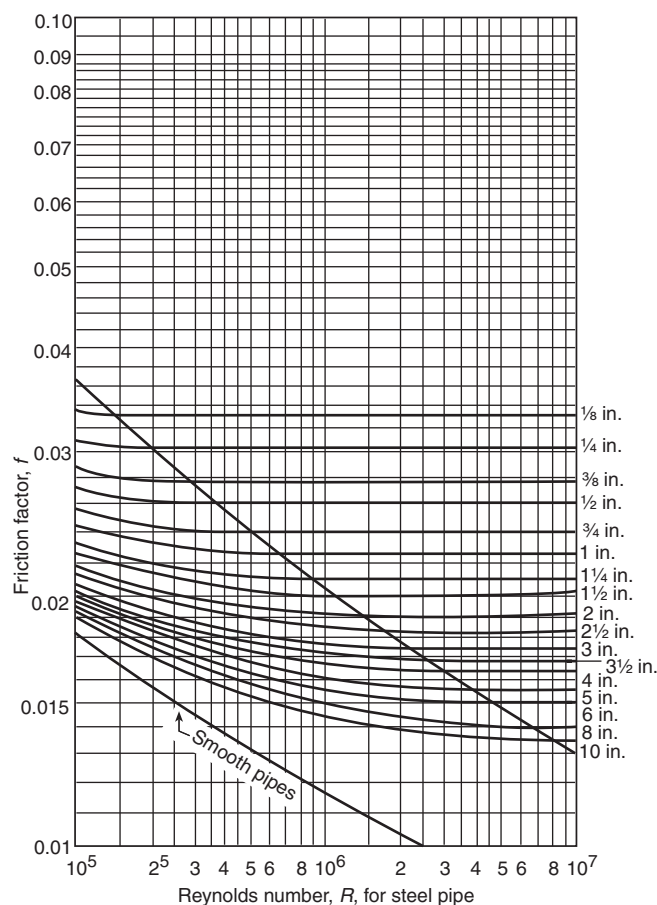


FIGURE 6.5.10.1.4.1(d) Moody Diagram for Steel Pipe, $R \geq 10^5$.

6.5.10.2.4.1 Friction-loss calculations shall show the relationship between the water supply and system demand.

6.5.10.2.5 Hydraulic calculations for determining the foam solution and water flow characteristics of systems covered by this standard shall be in accordance with NFPA 13.

6.5.10.2.5.1 Friction-loss characteristics for foam solution piping shall be considered the same as if the piping were carrying water.

6.5.10.2.6 For purposes of computing friction loss in piping, the C values in Table 6.5.10.1.5 shall be used in the Hazen-Williams formula.

6.5.10.3 Friction Loss.

6.5.10.3.1 The friction loss in piping carrying foam concentrate shall be calculated in accordance with the requirements of 6.5.10.1.4.

6.5.10.3.2 For purposes of computing friction loss in piping using alcohol-resistant foam concentrate, the designer shall consult the foam concentrate manufacturer for friction characteristics.

6.6 Acceptance Tests. Acceptance tests shall be in accordance with Section 12.9.

Table 6.5.10.1.5 Hazen-Williams C Values

Pipe or Tube	C Value*
Unlined cast or ductile iron	100
Black steel (dry systems including preaction)	100
Black steel (wet systems including deluge)	120
Galvanized steel (dry systems including preaction)	100
Galvanized steel (wet systems including deluge)	120
Plastic (listed) all	150
Cement-lined cast or ductile iron	140
Copper tube, brass or stainless steel	150
Asbestos cement	140
Concrete	140

*The authority having jurisdiction is permitted to allow other C values.
[13:Table 27.2.4.8.1]

N 6.7 Inspection, Testing, and Maintenance. Inspection, testing, and maintenance shall be in accordance with Chapter 13.

Chapter 7 Medium- and High-Expansion Systems

7.1* General Information and Requirements. This chapter shall apply to requirements for a design of medium- and high-expansion foam systems.

7.2 Use and Limitations.

7.2.1 Medium- and high-expansion foams shall be specifically evaluated to verify the applicability of medium- or high-expansion foam as a fire control agent for the type of hazard.

7.3* Hazards Protected. Hazards that medium- and high-expansion foam systems shall be permitted to protect include the following:

- (1) Ordinary combustibles
- (2) Flammable and combustible liquids
- (3) Combinations of (1) and (2)
- (4) Liquefied natural gas (high-expansion foam only)

7.3.1 Susceptibility of the protected hazard to water damage shall be evaluated.

7.3.2* Medium- and high-expansion foam systems shall not be used on fires in the following hazards except where component evaluation, including tests, indicates acceptability:

- (1) Chemicals, such as cellulose nitrate, that release oxygen or other oxidizing agents to sustain combustion
- (2) Energized unenclosed electrical equipment
- (3) Water-reactive metals such as sodium, potassium, and NaK (sodium-potassium alloys)
- (4) Hazardous water-reactive materials, such as triethyl-aluminum and phosphorus pentoxide
- (5) Liquefied flammable gas

7.4 Types of Systems. The types of systems within the scope of this standard shall be provided as follows:

- (1) Total flooding systems
- (2) Local application systems
- (3) Portable foam-generating devices

7.5 Systems Protecting One or More Hazards.

7.5.1 Systems shall be permitted to be used to protect one or more hazards or groups of hazards by means of the same supply of foam concentrate and water.

7.5.2 Where, in the opinion of the AHJ, two or more hazards can be simultaneously involved in fire by reason of their proximity, each hazard shall be protected with an individual system, or the system shall be arranged to discharge on all potentially involved hazards simultaneously.

7.6* Occupant Safety and Rescue Operations.

Δ 7.6.1* Occupant Evacuation.

7.6.1.1 Facility occupants shall be briefed on system operation (activation and emergency shutdown) and evacuation procedures.

7.6.1.2 Upon system activation, occupants shall evacuate the facility and assemble in a predetermined location to conduct a count of personnel.

7.6.1.3 Foam discharge points relative to building exits shall not inhibit evacuation where possible.

N 7.6.2* Rescue Operations.

N 7.6.2.1 Upon notification of entrapped occupant(s), only trained rescue personnel wearing full personal protective equipment with self-contained breathing apparatus shall enter the foam-filled facility.

N 7.6.2.2* To facilitate rescue operations, facility doors shall be fully opened and a blended attack of coarse water and industrial silicone-based de-foaming agent shall be utilized.

N 7.6.2.2.1 Facility foam generators shall remain operational (water only) to aid in foam dispersion.

N 7.6.2.3* Rescue personnel shall use a straight-line search pattern and search wands to effectively cover large floor spaces.

N 7.6.2.3.1* To ensure effective communications, rescue personnel shall remain within line-of-sight of each other.

7.6.3* Electrical Clearances.

7.6.3.1 All system components shall be located to maintain minimum clearances from live parts as shown in Table 7.6.3.1.

7.6.3.2 The clearances given are for altitudes of 3281 ft (1000 m) or less.

7.6.3.2.1* At altitudes in excess of 3281 ft (1000 m), the clearance shall be increased at the rate of 1 percent for each 328 ft (100 m) increase in altitude above 3281 ft (1000 m).

7.6.3.2.2 To coordinate the required clearance with the electrical design, the design BIL of the equipment being protected

Δ Table 7.6.3.1 Clearance from Medium- and High-Expansion Foam Equipment to Live Uninsulated Electrical Components

Nominal Line Voltage (kV)	Nominal Voltage to Ground (kV)	Design BIL* (kV)	Minimum Clearance	
			in.	mm
To 15	To 9	110	7	178
23	13	150	10	254
34.5	20	200	13	330
46	27	250	17	432
69	40	350	25	635
115	66	550	37	940
138	80	650	44	1118
161	93	750	52	1321
196–230	114–132	900	63	1600
		1050	76	1930
		1175	87	2210
		1300	98	2489
287–380	166–220	1425	109	2769
		1550	120	3048
500	290	1675	131	3327
		1800	142	3607
		1925	153	3886
500–700	290–400	2100	168	4267
		2300	184	4674

*Basic insulation level (BIL) values are expressed as kilovolts (kV), the number being the crest value of the full wave impulse test that the electrical equipment is designed to withstand.

shall be used as a basis, although this is not material at nominal line voltages of 161 kV or less.

7.6.3.2.3 At voltages higher than 161 kV, uniformity in the relationship between design BIL kV and the various electrical system voltages has not been established in practice and is dependent on several variables; thus, the required clearances to ground shall be based on the design BIL used rather than on the nominal line or ground voltage.

7.6.3.2.4 The clearance between uninsulated energized parts of the electrical system equipment and any portion of the medium- or high-expansion foam system shall not be less than the minimum clearance provided elsewhere for electrical system insulations on any individual component.

7.7 Operation and Control of Systems.

7.7.1* Detection of Fires.

7.7.1.1 Automatic detection shall be used for fixed systems.

7.7.1.1.1* Removal of automatic detection shall be permitted when approved by the AHJ.

7.7.1.2* Automatic detection shall be by listed or approved methods or devices capable of detection and indicating heat, smoke, or flame. Automatic detection devices shall be installed in accordance with *NFPA 72*.

7.7.1.3 Detection by the use of combustible vapor detectors or an abnormal condition in the hazard, such as process trouble, shall be arranged using approved industrial practices as specified by an engineering study.

7.7.1.4* A reliable source of energy shall be used in detection systems.

7.7.1.4.1 The power supply for electrical detection systems shall be independent of the supply for the protected area.

7.7.1.4.2 Arrangement of the power supply shall be in accordance with requirements of *NFPA 72* for continuity of power supplies.

7.7.2 Supervision. Supervision of automatic detection and actuation equipment shall be provided and arranged so that there will be an immediate indication of failure, preferably at a constantly attended location.

7.7.3 Alarms.

7.7.3.1 Audible alarms shall be installed to indicate the operation of the system, to alert personnel, and to indicate failure of any supervised device or equipment.

7.7.3.2 Such devices shall be of such a type and shall be provided in such numbers and at such locations as are necessary to accomplish their purpose satisfactorily.

7.7.3.3 An alarm shall be provided to show that the system has operated.

7.7.3.4 Alarms shall be provided to give ample warning of discharge where hazard(s) to personnel exist.

7.7.3.5 Alarms indicating failure of supervised devices or equipment shall give prompt and positive indication of any failure and shall be distinctive from alarms indicating operation or hazardous conditions.

7.7.4* Operating Devices.

7.7.4.1 Operating devices shall include foam generators, valves, proportioners, eductors, discharge controls, and shut-down equipment.

7.7.4.1.1 Operation shall be controlled by listed or approved mechanical, electrical, hydraulic, or pneumatic means.

7.7.4.1.2 A reliable source of energy shall be used.

7.7.4.1.3 The electrical power supply for an electrically operated medium- or high-expansion foam system shall be as reliable as a fire pump circuit in accordance with *NFPA 20*.

7.7.4.2 All operating devices shall be approved for the service they will encounter and shall not be rendered inoperative or susceptible to accidental operation.

7.7.4.2.1 Provision shall be made to protect piping that is normally filled with liquid from freezing.

7.7.4.3 All devices shall be located, installed, or suitably protected so that they are not subject to mechanical, chemical, climatic, or other conditions that will render them inoperative.

7.7.4.4 Manual controls for actuation and shutdown shall be conveniently located and accessible at all times, including the time of fire and system operation.

7.7.4.4.1 Remote control stations for manual actuation shall be considered where the area is large, where egress is difficult, or where required by the AHJ.

7.7.4.4.2 Manual controls for actuation shall operate the system to the same extent as the automatic control.

7.7.4.5 All automatically operated equipment controlling the generation and distribution of foam shall be provided with approved independent means for emergency manual operation.

7.7.4.5.1 If the means for manual actuation of the system required in **7.7.1** provide approved positive operation independent of the automatic actuation, it shall be permitted to be used as the emergency means.

7.7.4.5.2 The emergency means, preferably mechanical, shall be accessible and located close to the equipment controlled.

7.7.4.5.3 If possible, the system shall be designed so that complete emergency actuation shall be permitted to be accomplished from one location.

7.7.4.6 All required door and window closers, vent openers, and electrical equipment shutdown devices shall be considered integral parts of the system and shall function simultaneously with the system operation.

7.7.4.7 All manual operating devices shall be identified with signs as to the hazards they protect.

7.8 Foam Concentrate.

7.8.1 Quality. See Annex G.

7.8.1.1 The foam concentrate used in the system shall be listed for use with the equipment.

7.8.1.2 The quality of the concentrate for performance under the installation requirements of this standard shall be determined by tests.

7.9 Air Supply.

7.9.1 Air from outside the hazard area shall be used for foam generation unless data is provided to show that air from inside the hazard can be successfully employed.

7.9.2 The data shall be specific for the products of combustion to be encountered and shall provide factors for increasing foam discharge rates over those given in 7.12.8 if fire tests indicate that need.

7.9.3 Vents from the fire area shall be located to prevent recirculation of combustion products or other materials deleterious to the formation of foam into foam generator air inlets.

7.10 Foam-Generating Apparatus Location.

7.10.1 Accessibility for Inspection and Maintenance. Foam-generating apparatus shall be located and arranged so that inspection, testing, recharging, and other maintenance is facilitated and interruption of protection is held to a minimum.

7.10.2* Protection Against Exposure.

7.10.2.1 Foam-generating equipment shall be located as close as possible to the hazard(s) it protects, but not where it will be unduly exposed to a fire or explosion.

7.10.2.2 Foam generators installed inside the hazard area shall be listed to resist or be protected against fire exposure for the duration of the fire.

7.10.2.3 Such protection shall be permitted to be in the form of insulation, water spray or sprinklers, or other method as determined by an engineering study.

7.10.2.4 In certain applications, additional generators shall be permitted to be substituted for fire exposure protection based on results of fire tests.

7.11 Distribution Systems.

7.11.1 Piping and Fittings. Piping and fittings shall conform to the requirements of Chapter 4.

7.11.2 Arrangement and Installation of Piping and Fittings.

7.11.2.1 A listed strainer for use with the proportioner and foam generator shall be provided in the water line upstream of the water valve.

7.11.2.2 Supplemental strainers shall be permitted to be used as recommended by the foam equipment manufacturer.

7.11.3 Ducts.

7.11.3.1 Foam distribution and air inlet ducts shall be designed, located, installed, and suitably protected so that they are not subject to undue mechanical, chemical, or other damage.

7.11.3.2 Duct closures such as selector valves, gates, or doors shall be of the quick-opening type, so as to allow free passage of the foam.

7.11.3.2.1 When duct closures are located where they are subjected to fire or heat exposure, either inside or outside the area to be protected, special care shall be taken to ensure positive operation.

7.11.3.3 Ducts shall be designed and installed so that undue turbulence is avoided, and the actual foam discharge rate shall be determined by test or other method acceptable to the AHJ.

7.12 Total Flooding Systems General Information.

7.12.1 Description. A total flooding system shall consist of fixed foam-generating apparatus complete with a piped supply of foam concentrate and water, arranged to discharge into an enclosed space or enclosure around the hazard.

7.12.2* Applications. Total flooding systems shall be permitted to be used where a permanent enclosure is provided around the hazard to enable the required amount of fire-extinguishing medium to accumulate at the proper depth and to be maintained for a period of time required to ensure fire control or extinguishment in a specific combustible material.

7.12.3 General Requirements.

7.12.3.1 Total flooding systems shall be designed, installed, tested, and maintained in accordance with the applicable requirements of this standard.

7.12.3.2 Only listed or approved equipment and devices shall be used in these systems.

7.12.4 Total Flooding Enclosure Specifications.

7.12.4.1* Leakage.

7.12.4.1.1 Openings. Openings below design filling depth, such as doorways and windows, shall be arranged to close automatically before, or simultaneously with, the start of the foam discharge, with due consideration for evacuation of personnel.

7.12.4.1.1.1 Openings shall be designed to maintain closure during a fire and shall be capable of withstanding pressures of foam and sprinkler water discharge.

7.12.4.1.1.2 Where openings cannot be protected by automatic closing devices, the total flooding system shall be designed to compensate for the probable loss of foam.

(A) The system design shall be tested to ensure proper performance.

(B) If the foam system is permitted to start prior to complete closure of the space to be filled, additional foam output shall be allowed to compensate for the losses.

(C) This shall be verified by test based on the individual site conditions.

7.12.4.1.2 Ventilation.

7.12.4.1.2.1 Where outside air is used for foam generation, high-level venting shall be provided for air that is displaced by the foam.

7.12.4.1.2.2 Venting velocity shall not exceed 1000 ft/min (305 m/min) in free air.

7.12.4.1.2.3 The required venting shall consist of openings, either normally open or normally closed and arranged to open automatically when the system operates.

7.12.4.1.2.4 Where design criteria demand exhaust fans, they shall be approved for high-temperature operation and installed with consideration for protection of switches, wiring, and other electrical devices to ensure equal reliability of exhaust fan performance. Operation of the fans shall not compromise foam generator operations.

7.12.4.1.2.5 Where forced-air ventilating systems interfere with the proper buildup of foam, they shall be automatically shut down or closed.

7.12.5 Foam Requirements.

7.12.5.1 General. Total flooding medium- or high-expansion foam shall be discharged at a rate required to fill the enclosure to a depth above the hazard before an unacceptable degree of damage occurs.

7.12.5.2 Foam Depth.

7.12.5.2.1 High-Expansion Foam.

7.12.5.2.1.1 The minimum total depth of foam shall be not less than 1.1 times the height of the highest hazard but in no case less than 24 in. (600 mm) over this hazard.

7.12.5.2.1.2 For flammable or combustible liquids, the required depth over the hazard shall be permitted to be considerably greater than the requirement of 7.12.5.2.1.1 and shall be no less than the depth determined by tests. Tests shall duplicate the anticipated fire event in the protected area.

7.12.5.2.2 Medium-Expansion Foam.

7.12.5.2.2.1 Required depth over the hazard shall vary with expansion.

7.12.5.2.2.2 Depth shall be determined by tests. (See 7.12.6.3 and Annex G.)

7.12.6 Submergence Volume for High-Expansion Foams.

7.12.6.1 Submergence volume for sprinkler protected areas shall be defined as the depth as specified in 7.12.5.2.2.2 multiplied by the floor area of the space to be protected in accordance with 7.12.3.

7.12.6.2 Submergence volume for unsprinklered rooms of combustible construction or finish shall be based on the entire volume, including concealed spaces.

7.12.6.3 The volume occupied by vessels, machinery, or other permanently located equipment shall be permitted to be deducted when determining the submergence volume.

7.12.6.4 The volume occupied by stored material shall not be deducted when determining the submergence volume.

7.12.7 Submergence Time for High-Expansion Foams.

7.12.7.1* Recommended times to achieve submergence volume for various types of hazards and building construction shall be as shown in Table 7.12.7.1 and in accordance with NFPA 220, Table 4.1.1.

7.12.7.2 Shorter submergence times shall be permitted to be required depending on the factors included in 7.12.8.

7.12.7.3 The submergence time shall be based on a maximum of 30 seconds delay between fire detection and start of foam discharge.

7.12.7.4 Any delays in excess of 30 seconds shall be deducted from the submergence times in Table 7.12.7.1.

7.12.7.5 Where use of high-expansion foam on polar solvents is contemplated, the foam equipment supplier shall substantiate suitability for the intended use.

7.12.8* Rate of Discharge.

7.12.8.1 Medium-Expansion Foam. The rate of discharge for medium-expansion foam shall be determined by tests.

7.12.8.2 High-Expansion Foam.

7.12.8.2.1* The rate of foam discharge necessary for extinguishment or control to permit overhaul shall be dependent on the strength of sprinkler protection, the nature and configuration of the hazard, the vulnerability of the structure and contents to fire, and the loss potential to life, property, and production.

7.12.8.2.2 The foam discharge rate shall meet the foam depth requirements and submergence times of Table 7.12.7.1, with

▲ Table 7.12.7.1 Maximum Submergence Time for High-Expansion Foam Measured from Start of Foam Discharge in Minutes

Hazard	Construction Type			
	Type II (000), Type III (200), Type V (000)		Type I (all), Type II (222, 111), Type IV (2HH), Type V (111)	
	Sprinklered	Not Sprinklered	Sprinklered	Not Sprinklered
Flammable liquids [flash points below 100°F (38°C)] having a vapor pressure not exceeding 40 psia (276 kPa)	3	2	5	3
Combustible liquids [flash points of 100°F (38°C) and above]*	4	3	5	3
Low-density combustibles (i.e., foam rubber, foam plastics, rolled tissue, or crepe paper)	4	3 [†]	6	4 [†]
High-density combustibles (i.e., rolled paper kraft or coated banded)	7	5 [†]	8	6 [†]
High-density combustibles (i.e., rolled paper kraft or coated unbanded)	5	4 [†]	6	5 [†]
Rubber tires	7	5 [†]	8	6 [†]
Combustibles in cartons, bags, or fiber drums	7	5 [†]	8	6 [†]

*Polar solvents are not included in this table. Flammable liquids having boiling points lower than 100°F (38°C) might require higher application rates. See NFPA 30.

[†]These submergence times might not be directly applicable to storage piled above 15 ft (4.6 m) or where fire spread through combustible contents is very rapid.

Shaded text = Revisions. ▲ = Text deletions and figure/table revisions. • = Section deletions. N = New material



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compensation for normal foam shrinkage, foam leakage, and breakdown effects of sprinkler discharge.

7.12.8.2.3 Calculation.

7.12.8.2.3.1* The minimum rate of discharge or total generator capacity shall be calculated from the following formula:

[7.12.8.2.3.1]

$$R = \left(\frac{V}{T} + R_s \right) \times C_N \times C_L$$

where:

R = rate of discharge in ft^3/min (m^3/min)

V = submergence volume in ft^3/min (m^3/min)

T = submergence time in minutes

R_s = rate of foam breakdown by sprinklers in ft^3/min (m^3/min)

C_N = compensation for normal foam shrinkage

C_L = compensation for leakage

Δ 7.12.8.2.3.2* The factor (R_s) for compensation for breakdown by sprinkler discharge shall be determined either by test or, in the absence of specific test data, by the following formula:

[7.12.8.2.3.2]

$$R_s = S \times Q$$

where:

S = foam breakdown in $\text{ft}^3/\text{min} \cdot \text{gpm}$ ($\text{m}^3/\text{min} \cdot \text{L}/\text{min}$) of sprinkler discharge. S shall be $10 \text{ ft}^3/\text{min} \cdot \text{gpm}$ ($0.0748 \text{ m}^3/\text{min} \cdot \text{L}/\text{min}$).

Q = estimated total discharge from maximum number of sprinklers expected to operate in gpm (L/min).

7.12.8.2.3.3 The factor (C_N) for compensation for normal foam shrinkage shall be 1.15, which is an empirical factor based on average reduction in foam quantity from solution drainage, fire, wetting of surfaces, absorbency of stock, and so forth.

7.12.8.2.3.4* The factor (C_L) for compensation for loss of foam due to leakage around doors and windows and through unclosable openings shall be determined by the design engineer after evaluation of the structure. This factor shall not be permitted to be less than 1.0 even for a structure completely tight below the design filling depth. This factor shall be permitted to be as high as 1.2 for a building with all openings normally closed, depending on foam expansion ratio, sprinkler operation, and foam depth.

7.12.9 Quantity.

7.12.9.1 High-expansion foam concentrate and water shall be provided to permit continuous operation of the entire system for 25 minutes or to generate four times the submergence volume, whichever is less, but in no case less than enough for 15 minutes of full operation.

7.12.9.2 The quantity for medium-expansion foam shall be determined by tests developed by an independent testing laboratory.

7.12.9.3 Reserve supplies shall be provided in accordance with 7.12.9.

7.12.10* Maintenance of Submergence Volume for High-Expansion Foam.

7.12.10.1 To ensure control or extinguishment, the submergence volume shall be maintained for at least 60 minutes for unsprinklered locations and 30 minutes for sprinklered locations.

7.12.10.2 Where the hazard consists of flammable or combustible liquids in noncombustible containers, the time in 7.12.10.1 shall be permitted to be reduced.

7.12.10.3 Method.

7.12.10.3.1 The submergence volume shall be permitted to be maintained by continuous or intermittent operation of any or all of the generators provided.

7.12.10.3.2* Arrangements and procedures shall be provided to maintain the submergence volume without waste of foam concentrate.

7.12.10.4* Overhaul. Overhaul procedures shall be preplanned to prevent loss of control by submergence of the hazard.

7.12.10.5 Distribution. The medium- and high-expansion foam generators shall be located such that a relatively even buildup of foam will take place throughout the protected area during the discharge period.

7.13 Local Application Systems.

7.13.1 General Information.

7.13.1.1 Description. A local application system shall consist of fixed foam-generating apparatus complete with a piped supply of foam concentrate and water that is arranged to discharge foam directly onto a fire or spill hazard.

7.13.1.2* Uses.

7.13.1.2.1 Local application systems shall be permitted to be used for the extinguishment or control of fires in flammable or combustible liquids, liquefied natural gas (LNG), and ordinary Class A combustibles where the hazard is not totally enclosed.

7.13.1.2.2 For multiple-level or three-dimensional fire hazards where total building flooding is impractical, the individual hazard shall be provided with containment facilities.

7.13.2 General Requirements.

7.13.2.1 Local application systems shall be designed, installed, tested, and maintained in accordance with the applicable requirements in this standard.

7.13.2.2 Only listed or approved equipment, devices, and agents shall be used in these systems.

7.13.3 Hazard Specifications.

7.13.3.1 Extent of Hazard. The hazard shall include all areas to or from which fire shall spread.

7.13.3.2* Location of Hazard.

7.13.3.2.1 Local application medium- and high-expansion foam systems shall be permitted to be used to protect hazards located indoors, under partial shelter, or completely outdoors.

7.13.3.2.2 Provisions shall be made to compensate for winds and other effects of weather.

7.13.3.3 Foam Requirements for Flammable and Combustible Liquids and Solids.

7.13.3.3.1 General. Foam shall be discharged at a rate to cover the hazard to a depth of at least 24 in. (600 mm) within 2 minutes.

7.13.3.3.2 Quantity.

7.13.3.3.2.1 Foam concentrate and water shall be provided to permit continuous operation of the entire system for at least 12 minutes.

7.13.3.3.2.2 Reserve supplies shall be provided in accordance with 7.12.9.

7.13.3.3.3 Arrangement.

7.13.3.3.3.1 Discharge outlets shall be arranged to ensure that foam is delivered over all areas that constitute the hazard.

7.13.3.3.3.2 Where parts of the hazard are elevated or raised up from the ground or floor line, the arrangement of the system shall be such that foam will be delivered to, and retained on, such parts in the required depth to ensure prompt and final extinguishment.

7.14* Foam Applications for Liquefied Natural Gas (LNG).

7.14.1* System Design Considerations.

7.14.1.1 The determination of the high-expansion foam system design shall depend on an analysis specific to the individual site.

7.14.1.2 The analysis shall include effects of heat exposure on adjacent plant equipment.

7.14.1.3 Automatic alarms and actuation shall be required for fixed systems.

7.14.1.3.1 Where an engineering study shows that automatic protection is not required, the system shall be permitted to be activated manually.

7.14.2* Foam Discharge Rate per Unit Area.

7.14.2.1 The discharge rate per unit area shall be established by tests and shall be able to achieve a positive and progressive reduction in radiation within the time limitations established in the analysis.

7.14.2.2 The discharge rate per unit area determined by the test in Section G.4 shall be increased by the necessary factor to account for the initial vaporization rate and the configuration of the hazard.

7.14.2.3 After steady-state control conditions have been reached, the discharge rate per unit area established in the test for maintenance of fire control shall be used to maintain control.

7.14.3 Quantity.

7.14.3.1 The initial quantity of foam concentrate shall permit a continuous application at the initial design rate for fire control to reach steady-state conditions.

7.14.3.2 Additional foam concentrate supplies shall be on hand to provide control maintenance for the calculated fire duration.

7.14.3.3* Foam System Arrangement. The foam system shall have foam outlets arranged to supply foam to cover the design fire area within the specified time.

7.15 Portable Foam-Generating Devices.

7.15.1 General Information.

7.15.1.1 Description.

7.15.1.1.1 Portable foam-generating devices consist of a foam generator, manually operable and transportable, connected by means of hose, or piping and hose, to a supply of water and foam concentrate.

7.15.1.1.2 The proportioning equipment shall be integral to or separate from the foam generator.

7.15.1.1.3 A separate foam concentrate supply shall be permitted to be provided for each unit, or solution shall be permitted to be piped from central proportioning equipment.

7.15.1.2 General Requirements.

7.15.1.2.1 Portable foam-generating devices and associated equipment shall be used and maintained in accordance with the applicable requirements in this standard.

7.15.1.2.2 Only listed or approved equipment and devices shall be used.

7.15.2 Hazard Specifications. Portable foam-generating devices shall be permitted to be used to combat fires in all hazards covered in this chapter.

7.15.3 Location and Spacing.

7.15.3.1 Portable foam-generating devices that are preconnected to a water or solution supply shall be placed where they are accessible and shall have enough hose to reach the most distant hazard they are expected to protect.

7.15.3.2 Foam concentrate shall be accessible for immediate use.

7.15.3.3 Portable foam generators shall be located such that they are not exposed to the hazard.

7.15.3.4 When portable foam generators are not preconnected to a water or solution supply, their associated equipment shall be located and arranged for immediate transport to all designated hazards.

7.15.4 Foam Requirements.

7.15.4.1 Rate and Duration of Discharge.

7.15.4.1.1 The rate and duration of discharge, and consequently the quantity of foam concentrate and water, shall be determined by the type and potential size of hazard.

7.15.4.1.2 To the extent that the specific hazards are identified, the applicable requirements of this chapter shall apply.

7.15.4.1.3 Simultaneous Use of Portable Foam-Generating Devices. Where simultaneous use of two or more devices is possible, supplies of foam concentrate and water shall be accessible to supply the maximum number of devices that are physically possible to be used at any one time.

7.15.5 Equipment Specifications.

7.15.5.1 Hose.

7.15.5.1.1 Hose used to connect the generator to the water or solution supplies shall be listed lined hose meeting requirements of NFPA 1961.

7.15.5.1.2 The hose size and length shall be selected with consideration to the hydraulics of the entire system.

7.15.5.1.3 Hose shall be stored in an arrangement that will permit immediate use and shall be protected against the weather.

7.15.5.2 Electric Power Supply and Connections.

7.15.5.2.1 Power supply and connections needed for operation of the generator shall be capable of transmitting the required power and shall be selected for the intended use.

7.15.5.2.2 All power cables shall be sufficiently rugged to withstand abuse in service, shall be impervious to water, and shall contain a ground wire.

7.15.5.2.3 Electrical connectors shall be waterproof.

7.15.6* Training. All personnel shall be properly trained in the operation of portable foam-generating equipment and in the necessary firefighting techniques.

Chapter 8 Compressed Air Foam Systems

8.1 General.

8.1.1 This chapter shall provide requirements for the correct use of compressed air foam system components.

8.1.2 All components shall be listed for their intended use.

8.1.2.1 Where listings for components do not exist, components shall be approved.

8.2 Water Supplies.

8.2.1 Quality.

8.2.1.1 The water supply to compressed air foam systems shall be permitted to be hard or soft, fresh or salt, but shall be of a quality so that adverse effects on foam formation or foam stability do not occur.

8.2.1.2 No corrosion inhibitors, emulsion breaking chemicals, or any other additives shall be present without prior consultation with the foam concentrate supplier.

8.2.2 Quantity.

8.2.2.1 The water supply shall be of a quantity to supply all the discharge devices and compressed air foam hoses that shall be permitted to be used simultaneously for the specified time.

8.2.2.2 This quantity of water shall include not only the volume required for the compressed air foam apparatus but also water that shall be permitted to be used in other firefighting operations, in addition to the normal plant requirements.

8.2.3 Pressure. The pressure available at the inlet to the compressed air foam system under required flow conditions shall be at least the minimum pressure for which the system has been designed.

8.2.4 Temperature. Water temperatures shall be between 40°F (4°C) and 100°F (38°C).

8.2.5 Design. The water system shall be designed and installed in accordance with NFPA 24.

8.2.6 Storage. Water supply shall be protected against freezing in climates where freezing temperatures are expected.

8.3 Foam Concentrate.

8.3.1 Quality.

8.3.1.1 Foam concentrate shall be listed.

8.3.1.2 The foam concentrate used in a compressed air foam system shall be that listed for use with the equipment.

8.3.1.2.1 The performance of the system shall be dependent on the composition of the foam concentrate as listed with associated fuels and protection storage arrangement (consult applicable standard for storage arrangement protection).

8.3.1.2.2 The quality of the concentrate for proper performance under the installation requirements of this standard shall be determined by suitable tests.

8.3.2 Quantity. The amount of foam concentrate in the system shall be at least sufficient for the largest single hazard protected, or a group of hazards that are to be protected simultaneously.

8.3.3 Storage Tanks.

8.3.3.1 Storage tanks shall be of corrosion-resisting materials and construction compatible with the foam concentrate.

8.3.3.1.1 Consideration shall be given to design of the storage tanks to minimize evaporation of concentrate.

8.3.3.2 Markings shall be provided on storage tanks to identify the type of concentrate and its intended concentration in solution.

8.3.4 Storage Conditions. Foam concentrate shall be stored within the listed temperature limitations.

8.3.5 Reserve Supply of Foam Concentrate.

8.3.5.1 A reserve supply of foam concentrate sufficient to meet system design requirements shall be provided in order to put the system back into service after operation.

8.3.5.2 The reserve supply shall be in separate tanks or compartments, in drums or cans on the premises, or available from an approved outside source within 24 hours.

8.3.6 Compatibility of Foam Concentrate.

8.3.6.1 Different types of foam concentrates shall not be mixed for storage.

8.3.6.2 Different brands of the same type of concentrate shall not be mixed unless data are provided by the manufacturer to prove that they are compatible and are accepted by the AHJ.

8.4 Air or Nitrogen Supply.

8.4.1 Quantity.

8.4.1.1 Primary Supply. The amount of air or nitrogen shall be at least sufficient for the largest single hazard protected, or a group of hazards that are to be protected simultaneously.

8.4.1.2 Reserve Supply. A reserve supply of air or nitrogen sufficient to meet system design requirements shall be provided in order to put the system back into service after operation or available from an approved outside source within 24 hours.

8.4.2 Storage Containers.

8.4.2.1 Storage containers shall be listed.

8.4.2.2 Pressurized storage containers shall be designed to comply with all transportation requirements from the point of origin to the destination.

8.4.2.2.1 Containers shall be designed, fabricated, inspected, certified, and stamped in accordance with Section VIII of ASME *Boiler and Pressure Vessel Code*.

8.4.2.3 Pressurized storage containers shall not be located where they are subject to severe weather conditions or to mechanical, chemical, or other damage.

8.4.2.4 Each pressurized storage container shall be provided with a releasing device.

8.4.3 Supervision. Air or nitrogen pressure shall be supervised for high and low pressure.

8.4.4 Regulators. Regulators controlling the air or nitrogen pressure for compressed air foam systems shall be listed for the intended purpose.

8.4.5 Plant Air. Plant air shall be permitted to be utilized where the facility has an air supply that complies with the requirements of a dedicated main and reserve air supply, including the quality, quantity, pressure, and reliability requirements of the listing, and shall be subject to the approval of the AHJ.

8.4.6 Air Compressor. Air compressors used as a dedicated source of air supply shall be listed for use on fire protection systems.

8.5 Compressed Air Foam-Generating Method. The method used to generate compressed air foam shall be listed.

8.6 Distribution Systems.

8.6.1 Piping. Pipe shall be in accordance with 4.7.2.3.

8.6.2 Fittings. All pipe fittings shall be in accordance with 4.7.3.

8.7 Compressed Air Foam Discharge Devices.

8.7.1 Compressed air foam discharge devices shall be listed for the intended purpose.

8.7.2 Discharge devices shall be located and installed so that they are not subject to mechanical, chemical, climatic, or other conditions that would render them inoperative.

8.8 Operation and Control of Systems.

8.8.1 Operation and control of systems shall be in accordance with Section 4.9.

8.9 System Types.

8.9.1 Compressed air foam systems conforming to this chapter shall be fixed deluge-type systems, fixed spray-type systems, or fixed or semi-fixed pipe Type II and Type III applications, wherein compressed air foam shall discharge simultaneously from all nozzles or devices upon system activation.

8.9.2 The system shall be permitted to be designed to protect a single zone or multiple zones.

8.10 Limitations.

8.10.1 Compressed air foam systems shall be designed and installed in accordance with their listing for the specific hazards and protection objectives specified in the listing.

8.10.2 These limitations are described in the manufacturer's listed design manual, which shall be part of the listing of the system.

8.11 System Design. The system shall be designed in accordance with the manufacturer's design manual, which shall be part of the listing.

8.12 Installation of Piping and Fittings. Piping for compressed air foam systems shall be installed in accordance with NFPA 13.

8.13 Installation of Automatic Detection. Automatic detection devices shall be installed in accordance with NFPA 72.

8.14 CAFS Discharge Device Choice and Location.

8.14.1 Discharge devices shall be of the type listed for the intended purpose.

8.14.2 Discharge devices shall be located in accordance with listing limitations on spacing, floor coverage, and alignment.

Δ 8.15 Discharge Density. The design discharge density shall be in accordance with the applicable occupancy standards and in accordance with the manufacturer's listing but in no case less than 0.04 gpm/ft² (1.63 mm/min) for hydrocarbon fuel applications and 0.06 gpm/ft² (2.3 mm/min) for alcohol and ketone applications.

8.15.1 Where fixed spray-type systems are used to protect three-dimensional equipment, the minimum density shall be applied over the projected area of rectangular prism envelope for the equipment and its appurtenances.

8.16 Discharge Duration.

8.16.1 The system shall be designed to discharge compressed air foam for a minimum period of 10 minutes over the entire area for deluge-type systems and a minimum of 5 minutes for fixed spray-type systems and shall be in accordance with the manufacturer's listing.

8.16.2 Back-up fire sprinkler protection shall be permitted to be applied as required by the AHJ.

8.17 System Flow Calculation.

8.17.1 General. Compressed air foam flow involves a mixture of both hydraulic and pneumatic elements, which shall be addressed together in the system design to preserve the foam bubble structure until foam is discharged on a hazard.

8.17.2 System flow calculations shall be performed using a calculation method for compressed air foam within the limitations of the manufacturer's design manual.

■ 8.17.3 No calculations shall be required for a listed pre-engineered system design using the manufacturer's listed design manual.

8.17.4 Compressed air foam piping lengths and configurations of fittings and nozzles shall be in accordance with the manufacturer's listed limitations.

8.18 Plans and Specifications. Plans and specifications shall be in accordance with Chapter 9.

8.19 Testing and Acceptance. Compressed air foam systems shall be tested in accordance with Chapter 12.

8.20 Maintenance. Compressed air foam systems shall be maintained in accordance with Chapter 13.

Chapter 9 Specifications and Plans

9.1* Approval of Plans. Plans shall be submitted to the AHJ for approval before installation or modification to an existing system.

N 9.1.1 Deviation from approved plans shall require permission of the AHJ.

9.2 Specifications. Specifications for foam systems shall be developed and shall include the requirements of 9.2.1 through 9.2.3.

9.2.1 The specifications shall designate the AHJ and shall indicate whether submission of plans is required.

9.2.2 The specifications shall state that the installation shall conform to this standard and shall meet the approval of the AHJ.

9.2.3* The specifications shall include the specific tests required to meet the approval of the AHJ.

9.3 Plans.

9.3.1 Preparation of plans shall be entrusted only to fully experienced and responsible persons.

9.3.2 These plans shall be drawn to an indicated scale or shall be dimensioned.

9.3.3 The plans shall include or be accompanied by the following information, where applicable:

- (1) Name of owner and occupant
- (2) Location, including street address
- (3) Point of compass
- (4) Full height cross section, or schematic diagram, including structural member information construction of dike and tank
- (5) Size of supply main and whether dead end or circulating — if dead end, direction and distance to nearest circulating main — and water flow test results and system elevation relative to test hydrant
- (6) Other sources of water supply with pressure or elevation
- (7) Make, type, model, and model number of discharge devices
- (8) Pipe type and schedule of wall thickness
- (9) Nominal pipe size and cutting lengths of pipe (or center-to-center dimensions).
- (10) Types of fittings and joints, and locations of all welds and bends. The contractor shall specify on drawing any sections to be shop welded and types of fittings or formations to be used.

- (11) Types and locations of hangers, sleeves, braces, and methods of securing foam chambers or other discharge devices when applicable
- (12) All control valves, check valves, drain pipes, and test connections
- (13) Piping provisions for flushing
- (14) For hydraulically designed systems, the information on the hydraulic data nameplate
- (15) Graphic representations of the scale used on all plans
- (16) Name and address of contractor
- (17) Hydraulic reference points shown on the plan that correspond with comparable reference points on the hydraulic calculation sheets
- (18) Information about backflow preventers (manufacturer, size, type)
- (19) Sizes and locations of hydrants, showing sizes and numbers of outlets and whether outlets are to be equipped with independent gate valves. Whether hose houses and equipment are to be provided, and by whom, shall be indicated. Static and residual hydrants that were used in flow tests shall be shown
- (20) Sizes, locations, and piping arrangements of fire department connections
- (21) Physical details of the hazard, including the location, arrangement, and hazardous materials involved
- (22) Type and percentage of foam concentrate
- (23) Required solution application rate
- (24) Submergence volume calculations
- (25) Water requirements
- (26) Calculations specifying required amount of concentrate
- (27)* Hydraulic calculations
- (28) Calculation specifying required amount of air
- (29) CAFS flow calculations report
- (30) Identification and capacity of all equipment and devices
- (31) Location of piping, detection devices, operating devices, generators, discharge outlets, and auxiliary equipment
- (32) Schematic wiring diagram
- (33) Explanations of any special features

9.3.4 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 AHJ for approval before installation.

9.3.5 Where field conditions necessitate any change affecting system performance from the approved plan, revised "as installed" plans shall be supplied for approval to the AHJ.

9.3.6 Charts that specify head, delivery, efficiency, and brake horsepower curves of pumps shall be furnished by the contractor.

9.3.7 Hydraulic Calculations.

9.3.7.1 General. Hydraulic calculations shall be prepared on forms that include a summary sheet, detailed worksheets, and a graph sheet.

Δ 9.3.7.2 Summary Sheet. The summary sheet shall contain the following information, where applicable:

- (1) Date
- (2) Location
- (3) Name of owner and occupant
- (4) Building number or other identification
- (5) Description of hazard
- (6) Name and address of contractor or designer

- (7) Name of approving authority
- (8) System design requirements, as follows:
 - (a) Design area of foam application, ft² (m²)
 - (b) Minimum rate of foam
 - (c) Application, gpm/ft² [mm/min or gpm (L/m)] per outlet
 - (d) Protected area per foam chamber or discharge device, ft² (m²)
 - (e) Duration of foam application (min)
- (9) Total foam requirements as calculated, including allowance for inside hose, outside hydrants, and exposure protection (such as dike area protection)
- (10)* Actual discharge conditions, as follows:
 - (a) Total actual foam application, gpm (L/min)
 - (b) Duration of foam application (min)
- (11) Allowable flow range of each proportioner

9.3.7.3 Detailed Worksheets. Detailed worksheets or computer printouts shall contain the following information:

- (1) Sheet number
- (2) Foam chamber or discharge device description and discharge constant (*K*)
- (3) Hydraulic reference points
- (4) Flow in L/min (gpm)
- (5) Pipe size
- (6) Pipe lengths, center-to-center of fittings
- (7) Equivalent pipe lengths for fittings and devices
- (8) Friction loss in psi/ft (bar/m) of pipe
- (9) Total friction loss between reference points
- (10) Elevation head in psi (bar) between reference points
- (11) Required pressure in psi (bar) at each reference point
 - Velocity pressure and normal pressure if included in calculations
- (12) Notes to indicate starting points or reference to other sheets or to clarify data shown

9.3.7.4 Graph Sheet. A graphic representation of the complete hydraulic calculation shall be plotted on semi-exponential graph paper ($Q^{1.85}$) and shall include the following:

- (1) Water supply curve
- (2) Foam system demand
- (3) Hose allowance, where applicable

9.3.7.5 Water Supply Analysis. Summarized information regarding the available water supply shall include the following information:

- (1) Node tag at the source
- (2) Static pressure [psi (bar)] available at the source
- (3) Residual pressure [psi (bar)] available at the source
- (4) Total flow [gpm (bar)] available at the source
- (5) Available water pressure [psi (bar)] at the source when the total calculated demand is flowing
- (6) Total calculated water demand [gpm (L/m)] at the source
- (7) Required pressure [psi (bar)] at the source when flowing total calculated demand
- (8) Total water flow rate [gpm (L/m)] at the source, balanced to the available water supply
- (9) Balanced pressure [psi (bar)] at the source when flowing total water flow rate.

Chapter 10 Installation Requirements

10.1 Foam Concentrate Pumps.

10.1.1 Foam concentrate pump discharge pressure shall not exceed the working pressure of the concentrate piping or components in the system.

10.1.2 Positive displacement pumps and centrifugal pumps are capable of overpressuring the system and shall be provided with means of pressure relief from the discharge to the supply side of the circuit to prevent excessive pressure and temperature.

10.2 Flushing.

10.2.1 Pumps shall be provided with a means for flushing with water.

10.2.2 Foam concentrate piping systems shall be provided with flush inlet and outlet connections.

10.3 Power Supply.

10.3.1 Power supply for the drivers of foam concentrate pumps shall be installed in accordance with NFPA 20 and NFPA 70.

10.3.2 Power supplies shall be arranged such that disconnecting power from the protected facility during a fire does not disconnect the power supply to the foam concentrate pump feeder circuit.

10.3.3 Controller.

10.3.3.1 A controller governing the start-up of foam concentrate pumps with electric drivers of 30 horsepower or less shall be listed as a limited service controller.

10.3.3.2 A controller governing the start-up of foam concentrate pumps with electric drivers of greater than 30 horsepower shall be listed as a full service fire pump controller.

10.3.3.3 A controller governing the start-up of foam concentrate pumps with diesel engine drivers shall be listed as a diesel engine fire pump controller.

10.3.4* Service Disconnecting Means.

10.3.4.1 A service disconnecting means in the feeder circuits to limited service controllers shall be permitted, where allowed by the AHJ, provided the disconnecting means is supervised for the correct position.

10.3.4.2 Supervision for correct position shall be performed by one of the following:

- (1) Central station, proprietary, or remote station signaling electrical supervision service
- (2) Local electrical supervision through use of a signaling service that will cause the sounding of an audible signal at a constantly attended point
- (3) Locking the disconnect in the correct position with monthly recorded inspections

10.4 Low-Expansion System Piping.

10.4.1 All piping inside of dikes or within 50 ft (15 m) of tanks not diked shall be buried under at least 12 in. (300 mm) of earth or, if aboveground, shall be supported and protected against mechanical injury.

10.4.2* For systems that apply foam to a tank's liquid surface from the top side, all piping within the dike or within **50 ft (15 m)** of tanks not diked shall be designed to absorb the upward force and shock caused by a tank roof rupture.

10.4.3* One flange or union joint shall be provided in each riser at a convenient location, preferably directly below the foam maker, to permit hydrostatic testing of the piping system up to this joint.

10.4.4 Hose connections for semi-fixed foam systems on fixed-roof (cone) tanks shall terminate outside the dike area at least one tank diameter from the tank but in no case less than **50 ft (15 m)**.

10.4.5 The inlets to the piping shall be fitted with corrosion-resistant metal connections, compatible with the equipment supplying foam solution to the system, and provided with plugs or caps.

10.5 Valves in Low-Expansion Systems.

10.5.1 The laterals to each foam discharge outlet on fixed roof tanks shall be separately valved outside the dike in the following circumstances:

- (1) All fixed systems
- (2) Any laterals of a semi-fixed system not supplied by an individual hose connection

10.5.1.1 Valves shall be located either in the central foam station or at points where the laterals branch from the common supply line.

10.5.1.2 These valves shall not be located within the dike.

10.5.1.3 Valves shall be located at a distance of at least one tank diameter from the tank but in no case less than **50 ft (15 m)**.

10.5.1.4 Shutoff valves shall be permitted to be located at shorter distances where remotely operated, subject to the approval of the AHJ.

10.5.2 Where two or more foam proportioners are installed in parallel and discharge into the same outlet header, valves shall be provided between the outlet of each device and the header.

10.5.3 The water line to each proportioner inlet shall be separately valved.

10.5.4 For subsurface applications, each foam delivery line shall be provided with a valve and a check valve unless the latter is an integral part of the high back-pressure foam maker or pressure generator to be connected at the time of use.

10.5.5 Where product lines are used for foam, product valving shall be arranged to ensure that foam enters only the tank to be protected.

10.5.6 Drain valves that are accessible shall be provided for low points in underground and aboveground piping.

10.5.7* Bladder Tank Valves.

10.5.7.1 For bladder tank systems with multiple risers, the water supply feed to the bladder tank shall be arranged to prevent the discharge of foam concentrate into risers that have been isolated, to prevent further discharge into the hazard.

10.5.7.2 For single-riser systems, the water feed to the bladder tank shall be located above the system control valve.

10.6 Hangers, Supports, and Protection for Pipework.

10.6.1 Where protecting hazards where there is a possibility of explosion, pipework shall be routed to afford the best protection against damage.

10.6.2 The supply piping to foam outlets that protect a given hazard in a fire area shall not pass over another hazard in the same fire area.

10.6.3 All hangers shall be of approved types.

10.6.4 Tapping or drilling of load-bearing structural members shall not be permitted where unacceptable weakening of the structure would occur.

10.6.5 Attachments shall be made to existing steel or concrete structures and equipment supports.

10.6.6 Where systems are of such a design that the standard method of supporting pipe for protection purposes cannot be used, the piping shall be supported in such a manner as to produce the strength equivalent to that afforded by the standard means of support.

10.7 Hose Requirements. Unlined fabric hose shall not be used with foam equipment.

10.8 Test Connections. Valves and hose connections shall be installed to facilitate testing of proportioning equipment.

N 10.8.1 A $\frac{1}{2}$ in. (15 mm) female National Pipe Thread (FNPT) threaded connection for a pressure gauge shall be provided at the most remote fixed foam discharge outlet.

N 10.8.2 The $\frac{1}{2}$ in. (15 mm) connection for foam makers and foam chambers shall be installed 2 to 4 pipe diameters upstream of the discharge device inlet.

N 10.8.3 Where galvanized piping is used in accordance with 4.7.2.2, the threaded connection shall be installed on the spool piece prior to being treated to prevent localized corrosion at the connection.

Chapter 11 Low-Expansion Foam Systems for Marine Applications

11.1* General.

11.1.1 This chapter shall cover design information for the use of low-expansion foam systems that are necessary for marine applications where required by the AHJ.

11.1.2 The provisions of Chapters 4, 5, 7, and 9 of this standard shall not be applicable unless specifically referenced.

11.1.3* Components.

11.1.3.1 All components shall be listed or approved for their intended application and shall be approved for use in a marine environment.

11.1.3.2 Each manufacturer shall maintain a system design manual describing basic system design arrangements and denoting each of the manufacturers' products within the system.

11.1.4 Foam concentrates shall be approved.

11.1.4.1 The concentrate used in a foam system for protecting a flammable or combustible liquid shall be approved for hydro-

carbons in accordance with a test method equivalent to the 100 ft² (9.3 m²) hydrocarbon method given in Annex F.

11.1.4.2 Four consecutive fire tests shall be completed — two using sea water and two using freshwater.

11.1.4.3* Concentrates intended for use on polar solvent systems shall be approved for hydrocarbons in accordance with 11.1.4.1 and approved for use on polar solvents in accordance with a method comparable to UL 162.

11.1.5 The foam supply shall conform to the requirement of 4.3.2.2.

11.1.6 The water supply shall conform to the requirements of 4.2.1.1 through 4.2.1.3.

11.1.7 The foam system shall be capable of being actuated, including introduction of foam solution into the foam main within 3 minutes of notification of a fire.

11.2 Fixed Low-Expansion Foam Systems for Machinery Spaces.

11.2.1* Where installed, systems protecting machinery spaces shall be capable of discharging the required quantity of expanded foam to provide a foam depth of at least 6 in. (150 mm) over the largest area over which oil is expected to spread.

Δ 11.2.2 The foam solution application rate shall be in accordance with either of the following:

- (1) Product listing
- (2) Approval by the AHJ

N 11.2.2.1 The minimum foam solution application rate shall be 0.16 gpm/ft² (6.5 mm/min) for a minimum of 5 minutes.

11.2.3 The system shall be capable of generating foam for extinguishing hydrocarbon fires.

11.2.4 Means shall be provided for effective distribution of the foam through a permanent system of piping and control valves to discharge outlets and for foam to be directed by fixed foam outlets.

11.2.5 The foam expansion ratio shall not exceed 12:1.

11.2.6 Where a deck foam system is also installed, the foam supply and proportioning system shall not be required to be separate.

11.2.7 The quantity of foam concentrate shall be that required to meet the single largest system demand.

11.2.8 Controls.

11.2.8.1 System controls shall be simple to operate and grouped together in a location accessible during fire conditions in the protected area.

11.2.8.2 Instructions in permanent lettering shall be affixed to the equipment or in a position adjacent thereto.

11.2.8.3 Remotely controlled devices shall have local mechanical override.

11.3 Fixed Low-Expansion Foam Systems on Deck for Petroleum and Chemical Tankers.

11.3.1* Purpose. The purpose of this section shall be to provide guidance for the design and arrangement of deck

foam systems that are expected to provide the following performance:

- (1) Extinguish deck spill fires and maintain a foam blanket while hot metal cools.
- (2) Control or suppress cargo manifold fires except those involving three-dimensional pressurized liquid fires.
- (3) Suppress or control tank fires involving a portion of the cargo area, assuming that the top of the tank(s) within the design area is open to weather and that the trajectory of the foam is not obstructed.
- (4) Provide protection for the crew while arrangements are being made to abandon ship.
- (5) During lightering operations, the deck foam system flowing water shall protect the exposed vessel from fire on an adjacent ship while preparations are made to get the exposed vessel under way.
- (6) The deck foam system is not intended to provide extinguishment, suppression, or control of incidents resulting from major explosions or collisions that cause the fire to exceed the area of the single largest tank.
- (7) The deck foam system shall be designed and arranged to withstand the effects of weather, vibration, corrosion, strain, and impact expected during the ship's operation.
- (8) Suppress vapors from an unignited spill on deck.

11.3.2 Control Station.

11.3.2.1 The main control station for the system shall be located aft of the cargo area and be operable in the event of fire in the main area protected.

11.3.2.2* Operating instructions and diagrams of piping systems and valves shall be provided in clear and permanent lettering and shall be affixed to the equipment or in a position visible thereto.

11.3.2.2.1 The diagrams shall show which valves are to be opened in the event the system must be activated.

11.3.2.2.2 The diagrams shall explain thoroughly and clearly all the steps necessary to put the system into operation.

11.3.2.2.3 Each valve shall be labeled describing its function.

11.3.2.3 The control station shall be provided with emergency lighting.

11.3.3* Fire Main Capacity. Operation of a deck foam system at its required foam solution flow rate shall still permit the simultaneous use of the required number of streams of water and other services provided by the fire main system.

11.3.4* Rate of Application. The rate of application of foam solution for fires on deck shall not be less than the greatest of 11.3.4.1 or 11.3.4.2.

Δ 11.3.4.1 Rate of application for hydrocarbon fuels shall be in accordance with the product listing or approved by the AHJ but in no case less than the following:

- (1) Deck spill calculation: 0.16 gpm/ft² (6.50 mm/min) over 10 percent of the cargo block deck area, where the cargo block deck area is the maximum breadth of the ship multiplied by the total longitudinal extent of the cargo tank spaces
- (2) Largest tank calculation: 0.24 gpm/ft² (9.78 mm/min) of the horizontal sectional area of the single largest tank
- (3) Largest monitor calculation: 0.074 gpm/ft² (3.0 mm/min) of the area protected by the largest monitor, such