Report of the Committee on Foam

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Nonvoting
Donald M. Johnson, San Bruno, CA
Rep. T/C Fla & Combust Liquids
Richard L. Tuve, Consultant, Fire Technology, MD
Member Emeritus

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

Committee Scope: The installation, maintenance, and use of foam systems for fire protection, including foam hose streams.

The Report of the Committee on Foam is presented for adoption in 2 parts.

Part I of this Report was prepared by the Technical Committee on Foam and proposes for adoption a complete revision to NFPA 11-1988, Standard for Low Expansion Foam and Combined Agent Systems. NFPA 11-1988 is published in Volume 1 of the 1992 National Fire Codes and in separate pamphlet form.

The title of the standard has been changed to Standard for Low Expansion Foam.

Part I of this Report has been submitted to letter ballot of the Technical Committee on Foam which consists of 27 voting members; of whom 19 voted affirmatively, 3 negatively (Messrs. Meldrum, Purvis, Ramsden), and 5 ballots were not returned (Ms. Leedy, Messrs. Marini, Mendes, Olson, and Watrous).

Mr. Meldrum voted negative and stated:

The proposed revised NFPA 11 is, in my opinion, a marked improvement to the current standard. However, I believe that there are several corrections that should be made before it is issued. These are given below by paragraph:

1. In the definition of Expansion the phrase “before adding air” is redundant.

2. The definition of Fixed Foam Discharge Outlet is somewhat restrictive, e.g., they may also be attached to dike walls (See par 5-7-1.2). Recommend the definition be expanded or changed to read: “A device permanently attached to a tank or a dike by means of which foam is introduced to the fuel to be protected.”

3. The definition of AFFF concentrates should be qualified so as not to be misleading. It has been established that the aqueous film drained from AFFF does not necessarily form a vapor suppressing medium on hot volatile hydrocarbons or on certain aromatics, e.g. toluene. At the least, the word “some” should be inserted so that the definition would read: “... an aqueous film on some hydrocarbon fuel surfaces...”

4. Why include a definition of chemical foam when there is no reference to it in the body of the standard? Recommend deletion of the definition.

5. In paragraph 2-3.2.3 delete “or be lined with”. I was aware that at the September Meeting the Committee voted against this recommendation. However, I’m still opposed to lining of tanks for foam concentrate storage as poor practice.

Mr. Purvis voted negative and stated:

1. Paragraph A-3-3.1 Full Surface Protection. It is inappropriate for this committee to make the statement that open top floating roof tanks “do not justify a fixed system” to protect for risk of a full surface fire. Paragraph 1-1 Scope states that “it is not the intent of this standard to specify where foam protection is required” and it refers the reader to other publications. Justification of the need for this type of system must be left to the authority having jurisdiction since it involves many local factors. This standard should give advice and design guidance and avoid stating when certain types of protection are justified or not justified.

2. Paragraph (A-1-4(d)) Primary-Secondary Eduction Method. This paragraph should be deleted since the system has not been manufactured or used for many years. Figure A-1-4(d) should also be deleted.

3. Paragraph A-1-4 Type I Discharge Outlets. There have been discussions at recent meetings relative to deletion of Type I discharge outlets. I believe the consensus of the committee was to include a statement explaining that these devices are no longer manufactured and seldom used. This is because the current alcohol resistant foams do not require this type of gentle application.

I suggest adding an opening statement to this paragraph which explains the above.
4. Paragraph (A-3-2.10) Semisubsurface Injection Methods. This paragraph should be deleted since paragraph A-3-2.5 is a new rewrite of this material. Also figures A-3-2.5(b) and A-3-2.5(c) should be deleted because they denote obsolete designs which are no longer manufactured. Figure A-3-2.5(a) illustrates the current design.

5. Paragraph A-3-2.4.1 General. Figure A-3-2.4.1(a) is not a correct illustration for this paragraph since it does not illustrate a semi-fixed subsurface system. It should be deleted and replaced by Figure A-1-4(m)-(A-3-2.2(d)) of current publication of 1988.

Mr. Ramsden voted negative and stated:

Although I agree wholeheartedly with the new layout and style of the standard which represents a major improvement to it, I disagree strongly with some basic points as follows:

1. Chapter 6 and Appendix G-2 (A6-1.1.3). Regarding concentration of foam solution actually achieved by a system, I believe that some guidance on acceptable results should be given. It is of no value whatsoever to explain a test method and then not given any assistance to the user as to what results would be acceptable. It would be extremely useful to provide this. For example, if using a 3% grade, then 3-3.6% actual value would be acceptable.

The same comment applies to some extent for expansion and drainage time results. However, these properties vary greatly according to the system, foam liquid and equipment used, so it would be much more difficult to give such precise values. Guidance on typical values to be expected according to system type may be possible though. Alternatively, guidance could be given on the procedure by which system designers or equipment manufacturers should be made to provide the anticipated value of such parameters prior to any commissioning test so that they can be compared with actual values.

Our company gives lectures on testing of foam systems around the world and, in our experience, there is a great deal of confusion on this subject. I believe that the above would help take some of the confusion away.

2. Section 3-3.1 and Appendix A-3-3.1. These refer to full surface protection of floating roof tanks. A-3-3.1 states that "These fires...do not justify a fixed system to protect for this risk." This is an opinion and cannot be applied universally. Whether or not a system is justified depends on the criticality of a hazard to life safety, the environment, asset value and continued company operations. If a particular tank is of extremely high criticality then systems for full surface protection could very well be justified.

Again, from worldwide experience, I know of at least 2 installations (one in Oman, one in Abu Dhabi) where Quantitative Risk Analysis techniques have been used to assess whether or not such a system has been justified and a decision has been taken to install a complete system. The analysis naturally took due account of local site conditions including incident probability, manning levels for mobile equipment attack, tank size, tank condition etc. etc. as well as the "cost" of an incident.

I do not therefore believe it is the place of NFPA to express opinions such as that stated here unless the wording was changed to state "not normally justified". Essentially it is up to the Authority having Jurisdiction and the tank owner to decide whether or not fixed protection is justified.


Part II of this Report has been submitted to letter ballot of the Technical Committee on Foam which consists of 27 voting members; of whom 22 voted affirmatively, and 5 ballot(s) were not returned (Ms. Leedy, Messrs. Marini, Mendes, Olson, and Watrous).
NFPA 11 — F93 TCR

11-1 - (29.3.3, 25.3.3): Accept in Principle
SUBMITTER: Christopher L. Vollman, Rolf Jensen & Associates, Inc.
RECOMMENDATION: Reference to NFPA 72A should be NFPA 72, Standard for the Installation, Maintenance and Use of Protective Signaling Systems.
SUBSTANTIATION: Editorial.
COMMITTEE ACTION: Accept in Principle.
COMMITTEE STATEMENT: See Proposal 11-4 (Log #CP1).

11-2 - (A-6.1.1.1): Accept in Principle
SUBMITTER: Hal Cohen, Lebanon, PA
RECOMMENDATION: In 8th paragraph (foam chamber), Line 19, delete the word "definitely."
SUBSTANTIATION: The term "may definitely" is a dichotomy. The word "may" is more appropriate.
COMMITTEE ACTION: Accept in Principle.
COMMITTEE STATEMENT: See Proposal 11-4 (Log #CP1).

11-3 - (A-6.1.1.2): Reject
SUBMITTER: Aleksandar Regent, Fiorello la Guardia 13
RECOMMENDATION: Revised text: "Stainless steel 800 MESH should be specified by the other characteristics (such as 165 x 800) or by MESH 800 and particle retention size."
SUBSTANTIATION: MESH 800 doesn't specify the screen clear enough.
Note: Supporting material is available for review at NFPA Headquarters.
COMMITTEE ACTION: Reject.
COMMITTEE STATEMENT: The test is not practical in the field. It is a test for listing the foam. Therefore the text was deleted from the rewrite text. (See Proposal 11-4 (Log #CP1).

11-4 - (Entire Document): Accept
SUBMITTER: Technical Committee on Foam,
RECOMMENDATION: Revise NFPA 11 to more clearly state the requirements and to separate the mandatory from the nonmandatory requirements to assist in making the document more reasonable, enforceable and adoptable.
Revise the body of the standard and Appendix A as shown in the draft shown on the following pages.
SUBSTANTIATION: 1. Explanatory material, or wording which did not state a requirement or was not essential to understanding a requirement was deleted or relocated to the appendix, as appropriate.
2. Revised language to stipulate specific enforceable criteria.
3. Specific attention was given to revising existing mandatory text that uses the word "may" and replacing it with phrases such as "shall," shall be permitted to," or similar wording.
4. Text that was informational or explanatory implying a requirement or permissive use was revised using "shall," "shall be permitted to," or similar wording to properly stipulate the intended requirements.
5. Terms such as adequate or suitable were (whenever possible) replaced with actual requirements or the terms were deleted.
6. Advisory information with alternatives were placed in the Appendix.
7. Requirements that required a decision relative to a range of choices of levels of safety were revised to a specific minimum criteria.
8. The standard was divided into seven separate chapters:
   Chapter 1 General
   Chapter 2 System Components and System Types
   Chapter 3 System Design
   Chapter 4 Specifications and Plans
   Chapter 5 Installation Requirements
   Chapter 6 Testing and Acceptance
   Chapter 7 Maintenance
9. Definitions essential to understanding the text were moved to Section 1-4 (definitions).

5. A thorough review of the document was conducted to ensure conformity with the NFPA Manual of Style.
7. To assist the reader, paragraph designations from the 1988 edition of NFPA 11 appear in parenthesis next to the proposed new paragraph designations.
8. The material on floating roof tanks, which appeared in the appendix in previous editions, was relocated to the body of the standard to make the text enforceable.
9. The scope was revised to clearly state that the document is not intended to mandate when systems are to be installed, but when required the document provides installation requirements.
10. Foam spray systems are deferred to NFPA 16 and 16A.
COMMITTEE ACTION: Accept.
COMMITTEE STATEMENT: See Proposal 11-4 (Log #CP1).
Foam may be applied to protect the surface of a flammable liquid that is not burning. The foam concentrate manufacturer shall be consulted to determine the optimum method of application, rate of discharge, application density, and frequency of reaplication required to establish and maintain the integrity of the foam blanket.

This standard is not applicable for the following types of systems:

(a) Chemical foams and systems
(b) Foam-water deluge sprinkler or spray systems
(c) Foam-water closed head sprinkler systems
(d) Combined agent systems
(e) Mobile foam apparatus
(f) Medium- and high-expansion foam systems.

1-2 Purpose. 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 foam fire extinguishing systems for interior or exterior hazards. 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.

1-3 Units. 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, recognized by SI, is commonly used in international fire protection. Conversion factors for this unit are found in Table 1-3.

### Table 1-3

<table>
<thead>
<tr>
<th>Name of Unit</th>
<th>Unit Symbol</th>
<th>Conversion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>liter</td>
<td>L</td>
<td>1 gal = 3.785 L</td>
</tr>
<tr>
<td>liter per minute per square meter</td>
<td>(L/min) m²</td>
<td>1 gpm/ft² = 40.746 (L/min)/m²</td>
</tr>
<tr>
<td>cubic decimeter</td>
<td>dm³</td>
<td>1 gal = 3.785 dm³</td>
</tr>
<tr>
<td>pascal</td>
<td>Pa</td>
<td>1 psi = 6894.757 Pa</td>
</tr>
<tr>
<td>bar</td>
<td>bar</td>
<td>1 psi = 0.0689 bar</td>
</tr>
<tr>
<td>bar</td>
<td>bar</td>
<td>1 bar = 10² Pa</td>
</tr>
<tr>
<td>kilopascal</td>
<td>kPa</td>
<td>1 psi = 6.895 kPa</td>
</tr>
</tbody>
</table>

For additional conversions and information, see ASTM E 380, Standard for Metric Practice. (See Appendix E.)

1-4* Definitions.

Air-Aspirating Discharge Devices. These devices are specially designed to aspirate and mix air into the foam solution to generate foam. The foam is then discharged in a specific design pattern.

Approved. Acceptable to the "authority having jurisdiction."

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

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

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

Concentration. The percent of foam concentrate contained in a foam solution. The type of foam concentrate being used determines the percentage of concentration required. A 3 percent foam concentrate is mixed in the ratio of 97 parts water to 3 parts foam concentrate to make foam solution. A 5 percent concentrate is mixed with 94 parts water to 6 parts foam concentrate.

Discharge Device. A fixed, semifixed, or portable device that directs the flow of foam to the fire or flammable liquid surface.

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.

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

Fixed Foam Discharge Outlet. A device permanently attached to a tank that introduces foam into the tank.

Fixed Monitor (Cannon). A device that delivers a large foam stream and is mounted on a stationary support that is either elevated or at grade. The monitor may be fed solution by permanent piping or hose.

Flammable and Combustible Liquids. Flammable liquids shall "be" or "include" any liquids having a flash point below 100°F (57.8°C) and having a vapor pressure not exceeding 40 psi (276 kPa) (absolute) at 100°F (37.8°C). Flammable liquids shall be subdivided as follows:

(a) Class I liquids shall include those having flash points below 100°F (37.8°C) and may be subdivided as follows:

1. Class IA liquids shall include those having flash points below 75°F (23.9°C) and having a boiling point below 100°F (37.8°C).
2. Class IB liquids shall include those having flash points below 75°F (23.9°C) and having a boiling point above 100°F (37.8°C).
3. Class IC liquids shall include those having flash points at or above 75°F (23.9°C) and below 100°F (37.8°C).

Combustible liquids shall "be" or "include" any liquids having a flash point at or above 100°F (37.8°C). They may be subdivided as follows:

(a) Class II liquids shall include those having flash points at or above 100°F (37.8°C) and below 140°F (60°C).
(b) Class II A liquids shall include those having flash points at or above 140°F (60°C) and below 200°F (93.3°C).
(c) Class II B liquids shall include those having flash points at or above 200°F (93.8°C).

Foam. Fire fighting foam, within the scope of this standard, is a stable aggregation of small bubbles of lower density than oil or water that exhibits a tenacity for covering horizontal surfaces. Air foam is made by mixing air into a water solution containing a foam concentrate by means of suitably designed equipment. It flows freely over a burning liquid surface and forms a tough, air-excluding, continuous blanket that seals volatile combustible vapors from access to air. It resists disruption from wind and draft, or heat and flame attack, and is capable of rescaling in case of mechanical rupture. Fire fighting foams retain these properties for relatively long periods of time. Foams are also defined by expansion and are arbitrarily subdivided into three ranges of expansion. These ranges correspond broadly to certain types of usage described below. The three ranges are: low-expansion foam — expansion up to 20; medium-expansion foam — expansion 20-200; and high-expansion foam — expansion 200-1000.

Foam Chamber. See Fixed Foam Discharge Outlet.
Foam Concentrate. Foam concentrate is a concentrated liquid foaming agent as received from the manufacturer.

(a) Protein-Foam Concentrates — Consist 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 assure readiness for use under emergency conditions. They are diluted with water to form 3 percent to 6 percent solutions depending on the type. These concentrates are compatible with certain dry chemicals.

(b) Fluoroprotein-Foam Concentrates — Very similar to protein-foam concentrates as described above, but with a synthetic fluorinated surfactant additive. In addition to an air-excluding foam blanket, they may also deposit a vaporization-preventing film on the surface of a liquid fuel. They are diluted with water to form 3 percent to 6 percent solutions depending on the type. These concentrates are compatible with certain dry chemicals.

(c) Synthetic Foam Concentrates — Based on foaming agents other than hydrolyzed proteins.

They include:

1. Aqueous Film-Forming Foam (AFFF) Concentrates — Based on fluorinated surfactants plus foam stabilizers and usually diluted with water to a 3 percent or 6 percent solution. The foam formed acts as a barrier both to exclude air or oxygen and to develop an aqueous film on the fuel surface capable of suppressing the evolution of fuel vapor. The foam produced with AFFF concentrate is dry chemical compatible and thus is suitable for combined use with dry chemicals.

2. Medium- and High-Expansion Foam Concentrates (usually derived from hydrocarbon surfactant) — Are used in specially designed equipment to produce foams of foam-to-solution volume ratios of 20:1 to approximately 1000:1. This equipment may be air-aspirating or blow-exhaust type. Guidance for the use of these materials is given in NFPA 11A, Standard for Medium- and High-Expansion Foam Systems.

3. Other Synthetic Concentrates — Also based on hydrocarbon surfactant active agents and are listed as wetting agents, or as foaming agents, or both. In general, their use is limited to portable nozzle foam application to spill fires within the scope of their listings. The appropriate listings shall be consulted to determine proper application rates and methods. (See NFPA 18, Standard on Wetting Agents.)

(d) Film-Forming Fluoroprotein (FFFP) Foam Concentrates — Uses fluorinated surfactants to produce a fluid aqueous film for suppressing hydrocarbon fuel vapors. This type of foam utilizes a protein base plus stabilizing additives and inhibitors to protect against freezing, corrosion, and bacterial decomposition, and it also resists fuel pickup. The foam is usually diluted with water to a 3 or 6 percent solution and is dry chemical compatible.

(e) Alcohol-Resistant Foam Concentrates — Used for fighting fires on water-soluble materials and other fuels destructive to regular, AFFF, or FFFP foams, as well as fires involving hydrocarbons. There are three general types. One is based on water-soluble natural polymers, such as protein or fluoroprotein concentrates, and also contains alcohol insoluble materials that precipitate as an insoluble barrier in the bubble structure.

Another is based on synthetic concentrates and contains a gelling agent that surrounds the foam bubbles and forms a protective raft on the surface of water-soluble fuels: these foams may also have film-forming characteristics on hydrocarbon fuels. The third is based on both water-soluble natural polymers, such as fluoroprotein, and contain a gelling agent that protects the foam from water-soluble fuels. This foam may also have film-forming and fluoroprotein characteristics on hydrocarbon fuels. Alcohol-resistant foam concentrates are increasingly used in concentrations of 3 to 10 percent solutions, depending on the nature of the hazard to be protected and the type of concentrate.

(f) Compatibility of Concentrates and Their Foams — Different types and brands of concentrates may be incompatible and shall not be mixed in storage. Foams generated separately from protein, fluoroprotein, FFFP, and AFFF concentrates may be applied to a fire in sequence or simultaneously.

(g) Chemical Foam — Made by the reaction of an alkaline salt solution (usually bicarbonate of soda) and an acid salt solution (usually aluminium sulfate) to form a gas (carbon dioxide) in the presence of a foaming agent that causes the gas to be trapped in bubbles to form a tough, fire-resistant foam.

NOTE: This type of foam is considered obsolete and has generally been replaced by air foam.

Foam Generating Methods.* The methods of generation of air foam recognized in this standard include:

Foam Hose Stream. A foam stream from a hose-line nozzle.

Foam Nozzles or Fixed Foam Makers. A specially designed hose line nozzle or fixed foam maker designed to aspirate air is connected to a supply of foam solution. They are so constructed that one or several streams of foam solution issue into a space with free access to air. Part of the energy of the liquid is used to aspirate air into the stream, and turbulence downstream of this point creates a stable foam capable of being directed to the hazard being protected. Various types of devices may be installed at the end of the nozzle to cause the foam to issue in a wide pattern or a compacted stream.

Pressure Foam Maker (High Back-Pressure or Foaming Type). A foam maker utilizing the Venturi principle for aspirating air into a stream of foam solution forms foam under pressure. Sufficient velocity energy is conserved in this device so that the resulting foam may be conducted through piping or hoses to the hazard being protected.

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

Foam Solution. A homogeneous mixture of water and foam concentrate in the proper proportions.

Handline. A hose and nozzle that may be held and directed by hand. The nozzle reaction usually limits the solution flow to about 300 gpm (1135 l/min).

Labeled. Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization acceptable to the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Listed. Equipment or materials included in a list published by an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials and whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Non-Air-Aspirating Discharge Devices. These devices are designed to provide a specific water discharge pattern. When discharging AFF or FFFP solution, they generate an effective AFF or FFFP with a discharge pattern similar to the water discharge pattern.

Portable Monitor (Cannon). A device that delivers a foam discharge and is in a movable support or wheels so it may be transported to the fire scene.

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

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

Proportioning Methods for Air Foam Systems. The methods of proportioning to give the proper solution of water and foam liquid concentrate recognized in this standard include:

Coupled Water-Motor Pump. A suitably designed positive displacement pump in the water supply line is coupled to a second, smaller, positive displacement foam concentrate pump to provide proportioning.
2-2.1.4 Temperature. Optimum foam production is obtained using water at temperatures between 40°F (4°C) and 100°F (37.8°C). Higher or lower water temperatures may reduce foam efficiency.

2-2.1.5 Design. The water system shall be designed and installed in accordance with NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances. Where solids of sufficient size to obstruct openings or damage the foam equipment may be present, strainers shall be provided. Hydrants furnishing the water supply for foam equipment shall be provided in sufficient number and shall be located as required by the authority having jurisdiction.

2-2.1.6 Storage. Water supply or premixed solution shall be protected against freezing in climates where freezing temperatures can be expected.

2-2.2 Water Pumps. When water pumps are required for foam system operation they shall be designed and installed in accordance with NFPA 20, Standard for the Installation of Centrifugal Fire Pumps.

2-3 (New) Foam Concentrates.

2-3.1 (New) Types of Foam Concentrate. Foam concentrate shall be listed or approved. The concentrate used in a foam system shall be acceptable for use on the specific flammable or combustible liquid to be protected. Some concentrates are suitable for use both on hydrocarbon fuels and on water miscible or polar fuels and solvents. The limitations of the listing and the manufacturer’s specifications shall be followed.

2-3.1.1 (New) Foam concentrates for protection of hydrocarbon fuels shall be one of the following types:

(a) Protein,
(b) Fluoroprotein,
(c) Aqueous film-forming foam (AFFF),
(d) Film-forming fluoroprotein (FFFP),
(e) Alcohol-resistant type, or
(f) Others listed for this purpose.

2-3.1.2 (New) Water miscible and polar flammable or combustible liquids shall be protected by alcohol-resistant concentrates listed for this purpose.

2-3.2 (2-3.1) Concentrate Storage.

2-3.2.1 (2-3.1.1) Storage Facilities. Foam concentrates and equipment shall be stored in an accessible location not exposed to the hazard they protect. If housed, they shall be in a noncombustible structure. For outdoor nonautomatic systems, the authority having jurisdiction may permit the storage of foam concentrate off the premises where these supplies are available at all times. Adequate loading and transportation facilities shall be assured. Off-premises supplies shall be of the proper type for use in the systems of the given installation. At the time of a fire, these off-premises supplies shall be accumulated in sufficient quantities, before placing the equipment in operation, to ensure uninterrupted foam production at the design rate for the required period of time.

2-3.2.2* (2-3.1.2) Quantity. The amount of concentrate shall be at least sufficient for the largest single hazard protected or group of hazards that are to be protected simultaneously.

2-3.2.3 (2-3.1.3) Foam Concentrate Storage Tanks. Bulk liquid storage tanks shall be fabricated from or be lined with materials compatible with the concentrate.

2-3.2.4 (2-3.1.4) Storage Conditions. 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. Since such systems may or may not be operated for long periods after installation, the choice of proper storage conditions and maintenance methods will determine to a large extent the reliability and the degree of excellence of operation of the system when it is called upon to operate.

2-3.2.4.1* (2-3.1.4) Foam concentrates are subject to freezing and to deterioration from prolonged storage at high temperatures and shall be stored within the listed temperature limitations. They may be stored in the containers in which they are transported or may be transferred into large bulk storage tanks, depending on the requirements of the system. The location of stored containers requires special consideration to protect against exterior deterioration due to rusting or other causes. Bulk storage containers also require special design consideration to minimize the liquid surface.
in contact with air. Clear markings shall be provided on storage vessels to identify the type of concentrate and its intended concentration in solution.

2-3.2.5 (3-1.7) Foam Concentrate Supply.

2-3.2.5.1 (3-1.7.1) Foam Concentrate Consumption Rates. The consumption rates shall be based on the percentage concentrate used in the system design (e.g., 3 or 6 percent or other if so listed or approved by the authority having jurisdiction).

2-3.2.5.2 (4-4.3) Reserve Supply of Foam Concentrate. There shall be a readily available reserve supply of foam concentrate sufficient to meet design requirements in order to put the system back into service after operation. This supply may be in separate tanks or compartments, in drums or cans on the premises, or available from an approved outside source within 24 hours.

2-3.2.6 (2-3.2.2) Auxiliary Supplies. Other equipment that may be necessary to recommission the system, such as bottles of nitrogen or carbon dioxide for premix systems, shall also be readily available.

2-4 (New) Concentrate Compatibility.

2-4.1 (1.4 Foam f. rev) Compatibility of Foam Concentrates. Different types and brands of concentrates and solutions may be incompatible and shall not be mixed in storage. Foams generated separately from protein, fluoroprotein, FFPF, and AFFF concentrates may be applied to a fire in sequence or simultaneously.

2-4.2 (4-1.3 revised) Foam Compatibility with Dry Chemical Agents. Some expanded foam may not be compatible with all dry chemical agents. The manufacturers of the dry chemical and foam concentrate to be used in the system shall confirm that their products are mutually compatible. When used, limitations imposed on either of the agents alone shall be applied.

2-5 (New) Foam Proportioning. The method of proportioning shall conform to one of the following recognized by this standard:

(a) Foam nozzle eductor
(b) Inline eductor
(c) Pressure proportioners
(d) Around-the-pump proportioners
(e) Direct pumping proportioners
(f) Metered proportioning
(g) Balanced pressure proportioners.

2-6 (24 revised) Piping.

2-6.1 (2-4.2) Pipe Materials. Pipe within the hazard area shall be steel or other alloy suitable for the pressure and temperature involved, but not less than standard weight, in accordance with current American standards. Pipe specifications normal for water use shall be permitted outside the hazard area. Where exposed to corrosive influences, the piping materials shall be corrosion resistant or protected against corrosion.

2-6.1.1 (3-3.8 rev) Foam System Piping. Galvanized pipe shall be used for normally noncorrosive atmospheres. Corrosive atmospheres may require other coatings. Pipe carrying foam concentrate shall not be galvanized. Piping in constant contact with foam concentrate shall be constructed of material compatible with and not affected by the concentrate.

2-6.1.2 (2-4.2.1) Lightweight Pipe. Lightweight pipe [schedule 10 in nominal sizes through 5 in.; 0.134 in. (3.40 mm) wall thickness for 6 in.; and 0.185 in. (4.76 mm) wall thickness for 8 and 10 in.] may be used in areas where fire exposure is improbable. Selection of pipe wall thickness shall anticipate internal pressure, internal and external pipe wall corrosion, and mechanical bending requirements.

2-6.2 (2-4.4) Fittings. All pipe fittings shall be American standard for the pressure class involved but not less than standard weight. Fittings shall be steel or malleable iron in dry sections of the piping exposed to possible fire. All fittings subject to stress in self-supporting systems shall be of steel or other alloy or of malleable iron.

2-6.2.1 (2-4.4) Rubber or elastomeric gasketed fittings shall not be used in fire-exposed areas unless the foam system is automatically actuated.

2-6.2.2 (3-3.8) Galvanized fittings shall be used for normally noncorrosive atmospheres. Corrosive atmospheres may require other coatings. Fittings carrying foam concentrate shall not be galvanized.

2-6.3 (2-4.4) Joining of Pipes and Fittings. Pipe threading shall be in conformance with ANSI B1.1, Pipe Threads. Dimensions of cut-and-roll-grooves and outside diameters of piping materials shall conform to the manufacturers’ recommendations and the approval laboratories’ certifications.

2-6.3.1* (2-4.4 rev) Welding practices shall conform to the requirements of AWS D10.9, Standard for the Qualification of Welding Procedures and Welders for Piping and Tubing. Special care shall be taken to ensure that the openings are fully cut out and that no obstructions remain in the waterway.

2-6.3.2 Care shall be taken to assure that no galvanic corrosion can occur between piping and fittings.

2-6.4 (2-4.5) Strainers. Where solids of sufficient size may be present to obstruct openings in foam equipment, approved strainers shall be used. The strainer shall have a ratio of open basket area to inlet pipe area of at least 10 to 1.

2-6.5* (2-4.3) Valves. All valves for water and foam solution lines shall be of the indicator type such as OS & Y or post indicator. Valve specifications normal for water use shall be permitted outside the hazard or diked area. Inside the hazard or diked area, automatic control valves and shutoff valves shall be stainless steel or other alloy capable of withstandind exposure to expected fire temperatures.

2-6.5.1 All valves required for automatic foam systems shall be supervised in their normal operating position by one of the following methods:

(a) Electrically, per NFPA 72
(b) Locked
(c) Sealed.

2-7 (2-1.4) System Types. There are four basic types of systems:

(a) Fixed
(b) Semi-fixed
(c) Mobile
(d) Portable.

2-7.1 (2-1.4.1) Fixed Systems. These are complete installations piped from a central foam station, discharging through fixed delivery outlets to the hazard to be protected. Any required pumps are permanently installed.

2-7.2 (2-1.4.2) Semi-fixed Systems. The type in which the hazard is equipped with fixed discharge outlets connected to piping that terminates at a safe distance. The fixed piping installation may or may not include a foam maker. Necessary foam-producing materials are transported to the scene after the fire starts and are connected to the piping.

2-7.3 (2-1.4.3) Mobile Systems. This includes any foam-producing unit that is mounted on wheels, and that may be self-propelled or towed by a vehicle. These units may be connected to a suitable water supply or may utilize a premixed foam solution. For mobile systems, refer to NFPA 11C, Standard for Mobile Foam Apparatus.

2-7.4 (2-1.4.4) Portable Systems. The type in which the foam-producing equipment and materials, hose, etc., are transported by hand.

2-8 (2-5) Operation and Control of Systems.

2-8.1 (2-5.1) Methods of Actuation. Systems may be automatically or manually actuated. All systems shall have provisions for manual actuation.

2-8.2 (2-5.3) Automatically Actuated Systems.

2-8.2.1 An automatic system is one that is activated by automatic detection equipment.

2-8.2.2 Operation shall be controlled by listed or approved mechanical, electrical, hydraulic, or pneumatic means. When operation is automatic, an adequate and reliable source of energy shall be used. The need for an alternate power supply shall be determined by the authority having jurisdiction.
2.8.2.3 (2-5.3.3) Automatic detection equipment, whether pneumatic, hydraulic, or electric, shall be provided with supervision so arranged that failure of equipment or loss of supervising air pressure or loss of electric energy will result in positive notification of the abnormal condition. See applicable sections of NFPA 72, Standard for the Installation, Maintenance, and Use of Protective Signaling Systems. Exception: Small systems for localized hazards may be unsupervised subject to approval of the authority having jurisdiction.

2.8.2.4 (2-5.3.4) Electric automatic detection equipment and any auxiliary electric equipment, if in hazardous areas, shall be expressly designed for use in such areas. See NFPA 70, National Electrical Code, Article 500 and other articles in Chapter 5.

2.8.2.5 (2-5.3.5) In some cases it may be desirable to arrange the system to shut off automatically after a predetermined operating time. This feature shall be subject to approval of the authority having jurisdiction.

2.8.2.6 (2-5.3.6) The detection system shall activate a local alarm as well as an alarm at a constantly attended location. These alarms shall also be actuated when the system is operated manually.

2.8.3 (2-5.2) Manually Actuated Systems. Controls for manually actuated systems shall be located in an accessible place sufficiently removed from the hazard zone to permit them to be safely operated in an emergency, yet close enough to ensure operator knowledge of fire conditions. The location and purposes of the controls shall be plainly indicated, and shall be related to the operating instructions.

2.8.4 (2-5.3.1) Equipment. All operating devices shall be suitable for the service conditions they will encounter. They shall neither be readily rendered inoperative, nor be susceptible to inadvertent operation, by environmental factors such as high or low temperature, atmospheric humidity or pollution, or marine conditions. Such systems shall have means for manual actuation.

Chapter 3 System Design

3.1 (new) Types of Hazards. This chapter covers design information for the use of foam to protect outdoor storage tanks, interior flammable liquid hazards, loading racks, diked areas, and non-diked spill areas.

3.2 (new) Outdoor Fixed (Cone) Roof Tanks. Within the scope of this standard, fixed (cone) roof tanks are defined as vertical cylindrical tanks with a fixed roof designed as a conical section and that comply with the requirements set forth in NFPA 30, Flammable and Combustible Liquids Code (paragraph 2.2.3.1). Typically these tanks have a weak seam at the junction of the vertical side and roof. In the event of an internal explosion, the seam usually permits roof blows off leaving the shell intact to retain the tank contents. The resulting fire will involve the entire exposed surface of the product.

3.2.1 (new) Methods of Protection. The following methods for protecting exterior fixed roof tanks are included within this section:

(a) Foam monitors and handlines
(b) Surface application with fixed foam discharge outlets
(c) Subsurface application
(d) Semi-subsurface injection methods

The list of methods above shall not be considered as in any order of preference.

3.2.1.1 (new) Supplementary Protection. In addition to the primary means of protection there shall be provisions for supplementary protection in accordance with the requirements found in Section 3.0.

3.2.1.2 (3.2.1 part of) Basis of Design. System design shall be based on protecting the tank requiring the largest foam solution flow, including supplementary hose streams.

3.2.1.3* (3.2.3) Limitations. The limitations given in this section are based on extrapolations of test experience and appropriate listings and reflect the limitations known to date.

Foam may fail to seal against the tank shell as a result of prolonged free burning prior to agent discharge. If adequate water supplies are available, cooling of the tank shell is recommended.

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

3.2.2 (3.1.3) Foam Monitors and Handlines Design Criteria.

3.2.2.1 (A-3.1.2) Limitations. Monitor nozzles shall not be considered as the primary means of protection for fixed-roof tanks over 60 ft (18 m) in diameter. Foam handlines shall not be considered as the primary means of protection for fixed-roof tanks over 30 ft (9 m) in diameter or those over 20 ft (6 m) high.

3.2.2.2 (3-1.4 revised) Foam Application Rates. The stated minimum delivery rate for primary protection is based on the assumption that all the foam reaches the area being protected. In determining actual solution flow requirements, consideration shall be given to potential foam losses from wind and other factors.

3.2.2.3* (new) The design parameters for the use of monitors and handline nozzles to protect tanks containing hydrocarbons shall be in accordance with Table 3.2.2.3.

<table>
<thead>
<tr>
<th>Hydrocarbons Type</th>
<th>Minimum Application Rate</th>
<th>Minimum Discharge Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>gpm/r2</td>
<td>(lpm/m2)</td>
</tr>
<tr>
<td>Flash Pt. between 100°F and 140°F</td>
<td>.16 (6.5)</td>
<td>50</td>
</tr>
<tr>
<td>(37.8°C and 93.3°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flash Pt. below 100°F(37.8°C)</td>
<td>.16 (6.5)</td>
<td>65</td>
</tr>
<tr>
<td>liquids heated above their flash points</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crude petroleum</td>
<td>.16 (6.5)</td>
<td>65</td>
</tr>
</tbody>
</table>

NOTE 1: (3-1.4.1 Note 1 revised) Included in this section are gasohols and unleaded gasolines containing no more than 10 percent oxygenated additives by volume. When oxygenated additives content exceeds 10 percent by volume, protection is normally in accordance with 3.2.2.4. Certain non-alcohol-resistant foams may be suitable for use with fuel containing more than 10% by volume oxygenated additives. The manufacturer should be consulted as to specific listing or approvals.

NOTE 2: (3-1.4.1 Note 2) Flammable liquids having a boiling point of less than 100°F (37.8°C) may require higher rates of application. Suitable rates of application may be determined by test. Flammable liquids with a wide range of boiling points may develop a heat layer after prolonged burning and then may require application rates of 0.2 gpm/ft2 [8.1 (L/min)/m2] or more.

NOTE 3: (3-1.4.1 Note 3) Care should be taken in applying portable foam streams to high-velocity materials heated above 300°F (93.3°C). Judgment should be used in applying foam to tanks containing hot oils, burning asphalts, or burning liquids that are above the boiling point of water. Although the comparatively low water content of foams may beneficially cool such fuels at a slow rate, it may also cause violent frothing and "stop over" of the contents of the tank.

3.2.2.4* (5-1.4.2 revised) Tanks Containing Flammable and Combustible Liquids Requiring Alcohol-Resistant Foams. Water-soluble and certain flammable and combustible liquids and polar solvents that are destructive to regular (non-alcohol-resistant) foams require the use of alcohol-resistant foams. In general, alcohol-resistant foams may be effectively applied through foam monitor or foam hose streams to spill fires of these liquids when the liquid depth does not exceed 1 in. (25 mm). For liquids in greater depths, monitor and foam hose streams shall be limited for use with special alcohol-resistant foams listed and/or approved for the purpose. If application results in foam submergence, the performance of alcohol-resistant foams usually deteriorates significantly, particularly where there is a substantial depth of fuel. The degree of deterioration of performance will depend on the degree of water solubility of the fuel, i.e., the more soluble, the greater the deterioration.
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.

3-2.2.5 (new) [Excerpted from 3-1.4.2 & 5-1.4.3.1(b)] Design Parameters. When 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 manufacturer has established, by fire tests, that a shorter time may be permitted.

3-2.3 (3-2.5 revised) Surface Application with Fixed Foam Discharge Outlets — Design Criteria.

3-2.3.1 (3-2.5.2 revised) Fixed Foam Discharge Outlets. For this application discharge outlets are commonly called foam chambers. Most foam chambers are of a Type II discharge outlet design, since they are normally suitable for use with modern foams. For the protection of a flammable liquid contained in a vertical fixed (cone) roof atmospheric storage tank, discharge outlets shall be attached to the tank. Where two or more discharge outlets are required, the outlets shall be equally spaced around the tank periphery and each outlet shall be sized to deliver foam at approximately the same rate. Fixed foam discharge outlets shall be securely attached at the top of the shell and so located or connected as to preclude the possibility of the tank contents overflowing into the foam lines. They shall be securely attached so that displacement of the roof is not likely to subject them to serious damage. Fixed foam discharge outlets shall be provided with an effective and durable seal, frangible under low pressure, to prevent entrance of vapors into foam outlets and pipelines. Fixed foam discharge outlets shall be provided with suitable inspection means to permit proper maintenance and for inspection and replacement of vapor seals.

3-2.3.2 (3-2.5.2(a) revised) Design Criteria for Tanks Containing Hydrocarbons.

3-2.3.2.1 (3-2.5.2(a)) Number of Fixed Foam Discharge Outlets for Fixed Roof Tanks Containing Hydrocarbons or Flammable and Combustible Liquids Requiring Alcohol Resistant Foams.

<table>
<thead>
<tr>
<th>Tank Diameter (or equivalent area)</th>
<th>Minimum Number Discharge Outlets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feet (Meters)</td>
<td></td>
</tr>
<tr>
<td>Up to 80 (2.45)</td>
<td>1</td>
</tr>
<tr>
<td>Over 80 to 120 (2.45 to 3.66)</td>
<td>2</td>
</tr>
<tr>
<td>Over 120 to 140 (3.96 to 4.27)</td>
<td>3</td>
</tr>
<tr>
<td>Over 140 to 160 (4.27 to 4.88)</td>
<td>4</td>
</tr>
<tr>
<td>Over 160 to 180 (4.88 to 5.49)</td>
<td>5</td>
</tr>
<tr>
<td>Over 180 to 200 (5.49 to 6.04)</td>
<td>6</td>
</tr>
</tbody>
</table>

3-2.3.2.2 Minimum Discharge Times and Application Rates. When fixed foam discharge outlets are used for fixed (cone) roof tanks containing hydrocarbons, the minimum discharge times and application rates shall be in accordance with Table 3-2.3.2.2 below.

<table>
<thead>
<tr>
<th>Hydrocarbon Type</th>
<th>Minimum Application Rate (gpm/ft² (lpm/m²))</th>
<th>Minimum Discharge Time (Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flash point below 100°F (57°C) or liquids heated above the flash point</td>
<td>0.10 (4.1)</td>
<td>Type I Foam Discharge Outlet 20</td>
</tr>
<tr>
<td>Crude petroleum</td>
<td>0.10 (4.1)</td>
<td>Type II Foam Discharge Outlet 30</td>
</tr>
</tbody>
</table>

NOTE 1: (3.2.5.1 revised) Included in this section are gasohols and unleaded gasolines containing no more than 10 percent oxygenated additives by volume. When oxygenated additives content exceeds 10 percent by volume, protection is normally in accordance with 3-2.3.5. Certain non-alcohol-resistant type foams may be suitable for use with fuels containing more than 10% by volume oxygenated additives. The manufacturer shall be consulted as to specific listings and/or approvals.

NOTE 2: (3-2.5.1 Note 2) Flammable liquids having a boiling point of less than 100°F (37.8°C) may require higher rates of application. Suitable rates of application should be determined by test.

NOTE 3: (3-2.5.1 Note 3) For high-viscosity liquids heated above 200°F (93.3°C), lower initial rates of application may be desirable to minimize frothing and expulsion of the stored liquid. Judgment should be used in applying foams to tanks containing hot oils, burning asphalts, or burning liquids that are above the boiling point of water. Although the comparatively low water content of foams may beneficially cool such liquids at a slow rate, it may also cause violent frothing and "slop over" of the contents of the tanks.

3-2.3.3.2 Minimum Discharge Times and Application Rates. When monitors and handline nozzles are used to protect tanks containing hot oils, etc., the outlet shall be sized to deliver foam at approximately the same rate. Fixed foam discharge outlets shall be provided with approved fixed foam discharge outlets as indicated in Table 3-2.3.2.1 below.

<table>
<thead>
<tr>
<th>Tank Diameter (or equivalent area)</th>
<th>Minimum Number Discharge Outlets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feet (Meters)</td>
<td></td>
</tr>
<tr>
<td>Up to 80 (2.45)</td>
<td>1</td>
</tr>
<tr>
<td>Over 80 to 120 (2.45 to 3.66)</td>
<td>2</td>
</tr>
<tr>
<td>Over 120 to 140 (3.96 to 4.27)</td>
<td>3</td>
</tr>
<tr>
<td>Over 140 to 160 (4.27 to 4.88)</td>
<td>4</td>
</tr>
<tr>
<td>Over 160 to 180 (4.88 to 5.49)</td>
<td>5</td>
</tr>
<tr>
<td>Over 180 to 200 (5.49 to 6.04)</td>
<td>6</td>
</tr>
</tbody>
</table>

3-2.3.3.3 Application Rate for Specific Product Stored Type I Foam Type II Foam

<table>
<thead>
<tr>
<th>Product Stored</th>
<th>Minimum Discharge Time (Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I Foam Discharge Outlet</td>
<td>50</td>
</tr>
<tr>
<td>Type II Foam Discharge Outlet</td>
<td>55</td>
</tr>
</tbody>
</table>

Consult manufacturer for specific products.

NOTE 1: (New with excerpts from 3-2.7 last para.). 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. Consult manufacturers for listings on specific products.

3-2.4 (3-2.6 revised) Subsurface Application Design Criteria.

3-2.4.1* (3-2.6.1 & 3-2.6.2 revised) Subsurface foam injection systems are suitable for protection of liquid hydrocarbons in vertical fixed-roof atmospheric storage tanks. Subsurface injection systems shall not be used for protection of Class IA hydrocarbon liquids or for the protection of alcohols, gasohols, esters, ketones, aldehydes, anhydrides, or other products requiring the use of alcohol-resistant foams. Foam concentrates and equipment for subsurface injection shall be listed for this purpose. Fluoroprotein foam, AFFF, and FFFP for subsurface injection shall have expansion ratios between 2 and 4.

3-2.4.2* (3-2.6.3 & 3-2.6.3(a) revised) Foam Discharge Outlets. The discharge outlet into the tank may be the open end of a foam delivery line or product line. Outlets shall be sized so that the generator discharge pressure and foam velocity limitations are not exceeded. The foam velocity at the point of discharge into the tank...
shall be sized to deliver foam at approximately the same rate. For actual tests prove higher velocities are satisfactory. Where two or more outlets are required, they shall be located so that the foam travel on the surface does not exceed 100 ft (30 m). Each outlet shall be sized to deliver foam at approximately the same rate. For even foam distribution, outlets may be shell connections or may be fed through a pipe manifold within the tank from a single shell connection. Rather than installing additional tank nozzles, shell connections may be made in manway covers. Tanks shall be provided with subsurface foam discharge outlets as shown in Table 3-2.4.2.

### Table 3-2.4.2 (3-2.6.3 revised) Minimum Number of Subsurface Foam Discharge Outlets for Fixed Roof Tanks Containing Hydrocarbons

<table>
<thead>
<tr>
<th>Tank Diameter</th>
<th>Minimum Number of Discharge Outlets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feet</td>
<td>Meters</td>
</tr>
<tr>
<td>Up to 80</td>
<td>24</td>
</tr>
<tr>
<td>Over 80 to 120</td>
<td>24 to 36</td>
</tr>
<tr>
<td>Over 120 to 140</td>
<td>36 to 42</td>
</tr>
<tr>
<td>Over 140 to 150</td>
<td>42 to 48</td>
</tr>
<tr>
<td>Over 160 to 180</td>
<td>48 to 54</td>
</tr>
<tr>
<td>Over 180 to 200</td>
<td>54 to 60</td>
</tr>
<tr>
<td>Over 200 ft. (60m)</td>
<td>plus 1 outlet for</td>
</tr>
<tr>
<td></td>
<td>6000 ft² (465 m²)</td>
</tr>
</tbody>
</table>

**NOTE 1:** (3-2.6.3(a)) Liquids with flash points below 73°F (23.3°C), combined with boiling points below 100°F (37.8°C), require special consideration.

**NOTE 2:** The above table is based on extrapolation of fire test data on 25-, 93-, and 115-ft (7.5-, 27.9-, and 34.5-m) diameter tanks containing gasoline, crude oil, and hexane, respectively.

**NOTE 3:** The most viscous fuel that has been extinguished by subsurface injection when stored at ambient conditions [60°F (15.6°C)] had a viscosity of 2000 ssu (440 centistokes) and a pour point of 15°F (-9.4°C). Subsurface injection of foam is generally not recommended for fuels that will have a viscosity greater than 2000 ssu (440 centistokes) at their minimum anticipated storage temperature.

**NOTE 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 may be further enhanced by the rolling of cool water to the surface.

### 3-2.4.2.1* (3-2.6.4) Foam Discharge Outlet Elevation

Foam discharge outlets shall be so located as not to discharge into a water bottom. This shall be accomplished by having the outlets located at least 1 foot above the highest water level to prevent destruction of the foam.

### 3-2.4.2.2* (2.4.1)(c) 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.

### 3-2.4.3 Minimum Discharge Times and Application Rates

The minimum discharge times and application rates for subsurface application on fixed roof storage tanks shall be in accordance with Table 3-2.4.3 below.

<table>
<thead>
<tr>
<th>Hydrocarbon Type</th>
<th>Minimum Discharge Time (minutes)</th>
<th>Minimum Application Rate gpm/ft² (Lpm/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flash Point Below 100°F and 140°F (37.8°C and 93.3°C)</td>
<td>30</td>
<td>0.1</td>
</tr>
<tr>
<td>Flash Point Below 100°F (37.8°C) or Liquids Heated Above Their Flash Points</td>
<td>55</td>
<td>0.1</td>
</tr>
</tbody>
</table>

**NOTE 1:** The maximum application rate shall be 0.20 gpm/ft² (8.1 Lpm/m²).

**NOTE 2:** For high-viscosity liquids heated above 200°F (93.3°C), lower initial rates of application may be desirable to minimize frothing and expulsion of the stored liquid. Judgment should be used in applying foams to tanks containing hot oils, burning asphalts, or burning liquids that are above the boiling point of water. Although the comparatively low water content of foams may beneficially cool such liquids at a slow rate, it may also cause violent frothing and "slop over" of the contents of the tanks.

### 3-2.4.3.1* (from 3-2.6.2(a)(Revised)) Liquid hydrocarbons that contain foam-destructive products may require higher application rates. Some foams fail to extinguish fires in gasolines containing oxygenates when using subsurface discharge at the usually required rate. In such cases, the manufacturer of the foam concentrate shall be consulted for recommendations based on listings and/or approvals.

### 3-2.5* (3-2.2) Semi-Subsurface Systems

All equipment used in such systems shall be listed or approved for this purpose.

### 3-3 (A-3.2.1.1 revised) Outdoor Open-Top Floating Roof Tanks

Within the scope of this standard, open-top floating roof tanks are defined as vertical cylindrical tanks without fixed roofs, that have double-deck or pontoon-type floating roofs and are constructed in accordance with the requirements set forth in NFPA 30, Flammable and Combustible Liquids Code (3-2.11.1). The seal may be a mechanical shoe seal or tube seal. The tube seal may be equipped with a metal weather shield. Secondary seals of combustible or noncombustible materials may also be installed. (See Figures 3-3(a) through (d).)

Tanks that are equipped with the following floating roof types are not covered in this section:

(a) roofs made from floating diaphragms
(b) roofs made from plastic blankets
(c) roofs made from plastic or other flotation material even if encapsulated in metal or fiberglass
(d) roofs that rely on flotation device closures that can be easily submerged if damaged
(e) pan roofs

Tanks so equipped shall be treated as fixed (cone) roof tanks.
Figure 3-3(a) Pantograph-type seal open-top floating roof tank.

Figure 3-3(b) Tube seal open-top floating roof tank.

Figure 3-3(c) Double seal system for floating roofs.

Figure 3-3(d) Double seal system for floating roofs using a plastic-foam log (secondary seal).
3.3.1* (new) Types of Fires Anticipated. Open-top floating roof tanks can experience two distinct types of fires: a seal fire or a full surface area fire (as a result of the floating roof sinking). Experience indicates that the most frequent type of fire involves only the seal of the floating roof tank. Prior to selecting the method of protection, the type of fire that will serve as the basis for design shall be defined (refer to NFPA 30 for fire protection requirements).

3.3.1.1 (3-2.6.2(b) Revised) Sub-surface and semi-sub-surface 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.

3.3.1.2 (new) Seal Area Protection. The foam protection facilities for an open-top floating roof tank seal area shall be based on 3-3.2 through 3-3.6.

3.3.2 (new) Methods of Seal Fire Protection. The following methods for fire protection of seals in open-top floating roof tanks are described:

(a) Fixed discharge outlets
(b) Foam handlines
(c) Foam monitors.

3.3.2.1 (new) Supplementary Protection. In addition to the primary means of protection there shall be provisions for supplementary protection in accordance with requirements found in Section 3-9.

3.3.2.2 (3.2.3 revised) Basis of Design. System design shall be based on protecting the tank requiring the largest foam solution flow, including supplementary hose streams.

3.3.2.3 (3.2.3 revised) Limitations. The requirements given in this section are based on extrapolations of test experience and appropriate listings, and reflect the limitations known to date.

Foam may fail to seal against the tank shell as a result of prolonged free burning prior to agent discharge. If adequate water supplies are available, cooling of the tank shell is recommended.

3.3.3 Fixed Discharge Outlets Design Criteria for Seal Area Protection. Application of foam from fixed discharge outlets can be in either of two ways:

(a) The first method discharges foam above the mechanical shoe seal, a metal weather shield, or a secondary seal.

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

3.3.3.1* (A-3-2.11.1(a) revised) Top-of- Seal Method with Foam Dam. 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. Refer to 3.5.3.1 for foam dam design criteria. There are two acceptable arrangements when utilizing fixed foam discharge outlets. They are as follows:

(a) Fixed foam discharge outlets (normally Type II) mounted above the top of the tank shell

(b) Fixed foam discharge outlets mounted on the periphery of the floating roof.

See Appendix Figures A-3-3.3.1(a) and Figure A-3-3.3.1(b).

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

3.3.3.1.2 Top of Seal System Design. 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 3-3.3.1.2 below. The requirements given in the table apply to tanks containing hydrocarbons or flammable and combustible materials requiring alcohol resistant foams. The required minimum application rates given in Table 3-3.3.1.2 apply unless listings for specific products require higher application rates when Type II fixed foam discharge outlets are used. (See Figure 3-3.3.1.2 on following page.)

3.3.3.1.3 If the application rate is higher than the minimum rate specified above, the discharge time may be reduced proportionately, but not less than 70 percent of the minimum discharge times indicated.

<table>
<thead>
<tr>
<th>Seal Type</th>
<th>Applicable Illustration Detail</th>
<th>Minimum Application Rate gpm/ft2 (1 pm/m2)</th>
<th>Minimum Discharge Time (minutes)</th>
<th>Maximum Spacing Between Discharge Outlets with 12&quot; (305mm) Foam Dam ft (m)</th>
<th>24&quot; (610mm) Foam Dam ft (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical Shoe Seal</td>
<td>A</td>
<td>0.3 (12.2)</td>
<td>20</td>
<td>40 (12.2)</td>
<td>80 (24.4)</td>
</tr>
<tr>
<td>Tube Seal w/ Metal Weather Shield</td>
<td>B</td>
<td>0.3 (12.2)</td>
<td>20</td>
<td>40 (12.2)</td>
<td>80 (24.4)</td>
</tr>
<tr>
<td>Fully or Partially Combustible Secondary Seal</td>
<td>C</td>
<td>0.3 (12.2)</td>
<td>20</td>
<td>40 (12.2)</td>
<td>80 (24.4)</td>
</tr>
<tr>
<td>All Metal Secondary Seal</td>
<td>D</td>
<td>0.3 (12.2)</td>
<td>20</td>
<td>40 (12.2)</td>
<td>80 (24.4)</td>
</tr>
</tbody>
</table>

NOTE: When the fixed discharge outlets are mounted above the top of the tank shell a foam splash board is required due to the effect of winds.
3.3.2.1 (A-3.2.11.1(b)) 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. Refer to 3.3.3.3 for the foam dam design.

3.3.2.2 (A-3.2.11.1(b)) Below-the-Seal of Weather Shield System. 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 3-3.3.2.2 below. The requirements given in the table apply to tanks containing hydrocarbons or flammable and combustible materials requiring alcohol resistant foams. The required minimum application rates given in Table 3-3.3.2.2 apply unless listings for specific products require higher application rates when Type II fixed foam discharge outlets are used. (See Table 3-3.3.2.2 on following page.)

NOTE: Both fixed foam (wall mounted) and roof mounted discharge outlets are shown for illustrative purposes. Although both methods are shown, only one is necessary.

3.3.2.2 (A-3.2.11.1 revised) Below Primary Seal or Weather Shield Method. Fixed foam discharge outlets located below either a mechanical shoe seal, a metal weather shield, or a metal secondary seal, shall use the following design:

Figure 3.3.1.2 Typical foam system illustrations for top-of-seal fire protection.

Figure 3.3.2.2 Typical foam system arrangement illustrations for below-the-seal (or shield) application.
3-3.3.3.3 (A-3-2.11.1(c)) Foam Dam Design.

3-3.3.3.1 (A-3-2.11.1(c)) The foam dam shall be circular and constructed of at least No. 10 U.S. Standard Gage Thickness [0.134 in. (3.4 mm)] steel plate.

3-3.3.3.2 (A-3-2.11.1(c)) The foam dam shall be welded or otherwise securely fastened to the floating roof.

3-3.3.3.3 (A-3-2.11.1(c)) The foam dam shall be designed to retain foam at the seal area, at a sufficient depth to cover the seal area while causing the foam to flow laterally to the point of seal rupture. Dam height shall be at least 12 in. (305 mm). The dam shall extend at least 2 in. (51 mm) above a metal secondary seal or a combustible secondary seal using a plastic foam log. Dam height shall be at least 2 in. (51 mm) higher than any burnout panels in metal secondary seals.

3-3.3.3.4 (A-3-2.11.1(c)) The foam dam shall be at least 1 ft (0.3 m), but no more than 2 ft (0.6 m), from the edge of the roof.

3-3.3.3.5 (A-3-2.11.1(c)) To allow drainage of rain water, the foam dam bottom shall be sloped on the basis of 0.04 sq in. of slot area per sq ft (278 mm²/m²) of dammed area, restricting slots to 3/8 in. (9.5 mm) in height. Excessive dam openings for drainage should be avoided to prevent loss of foam through the drainage slots. (See Figure 3-3.3.3.5)

Tanks that are equipped with the following floating roof types are not covered in this section:

(a) Roofs made from floating diaphragms
(b) Roofs made from plastic blankets
(c) Roofs made with plastic or other flotation material even if encapsulated in metal or fiberglass
(d) Roofs that rely on flotation device closures which can be easily submerged if damaged
(e) Pan roofs.

3-4.1* (new) Types of Fires Anticipated. Covered (internal) floating roof tanks can experience two distinct types of fires: a full surface area fire (a result of the floating roof sinking) or a seal fire. There have been few fires in double-deck or pontoon type floating roof tanks when fixed roofs and venting were designed in accordance with NFPA 30. Prior to selecting the method of protection, the type of fire that will serve as the basis for design shall be defined.

3-4.1.1* (A-3-2.11.2 Revised) Design for Full Surface Fire. When the basis for design is a full surface fire, the covered (internal) floating roof tank shall be considered as equivalent to a fixed (cone) roof tank of the same diameter for the purpose of foam system design. For a full surface fire, the foam facilities shall be designed in accordance with 3-2.3 and Section 3-9 except that separately valved fixed foam discharge outlets shall not be fitted with a tangible vapor seal device.

3-4.1.1.1 (A-3-2.11.2(a)) Sub-surface and semi-subsurface injection shall not be used because of the possibility of improper distribution of foam.

3-4.1.2 (A-3-2.11.2(b)) Design for Seal Area Fire. When the basis for design is a seal fire, the covered (internal) floating roof tank shall be considered as equivalent to a fixed (cone) roof tank of the same diameter for the purpose of foam system design. For a seal fire, the foam discharge system shall be designed in accordance with the requirements defined in Table 3-3.3.1.2 utilizing fixed foam discharge outlets.

3-4.1.2.1 (new) Supplementary Protection. In addition to the primary means of protection there shall be provisions for supplementary protection in accordance with the requirements found in Section 3-9.

3-4.1.2.2 (3-2.1 part of) Basis of Design. System design shall be based on protecting the tank requiring the largest solution flow, including supplementary hose streams.

If the application rate is higher than the minimum rate specified above, the discharge time may be reduced proportionately, but not less than 70 percent of the minimum discharge times indicated.

3-4.1.2.3 (3-2.3 Limitations. The requirements given in this section are based on extrapolations of test experience and appropriate listings and reflect the limitations known to date.

Foam may fail to seal against the tank shell as a result of prolonged free burning prior to agent discharge. If adequate water supplies are available, cooling of the tank shell is recommended.

3-5 (5-3.1 revised) Indoor Hazards. This section relates to foam fire extinguishing systems, which are intended to protect indoor storage tanks that have liquid surface areas of 400 ft² (37.2 m²) or more. For other types of indoor hazards refer to design criteria within NFPA 16, Standard for the Installation of Closed-Head Foam-Water Sprinkler and Foam-Water Spray Systems, and NFPA 16A, Standard for the Installation of Closed-Head Foam-Water Sprinkler Systems.

3-5.1 Discharge Outlets. Tanks for storing liquid hydrocarbons shall be fitted with Type II tank mounted fixed foam discharge outlets as defined in Table 3-2.3.2.1.

3-5.2 Minimum Discharge Time and Application Rate. The minimum application rate for indoe hydrocarbon storage tanks shall be 0.16 gpm/ft² (6.5 Lpm/m²) of liquid surface area. Minimum discharge time shall be in accordance with Table 3-2.3.2.2 for Type II fixed foam discharge outlets.

3-5.2.1 If the application rate is higher than the minimum rate specified above, the discharge time may be reduced proportionately, but not less than 70 percent of the minimum discharge times indicated.
3-5.3 (3-3.5.2 revised) Design Criteria for Indoor Storage Tanks Containing Flammable or Combustible Liquids Requiring Alcohol Resistant Foams. Water soluble and certain flammable and combustible liquids and polar solvents that are destructive to non-alcohol-resistant foams require the use of alcohol-resistant foams. Systems using these foams require special engineering consideration. 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.

3-6* (new) Loading Racks. Within the scope of this standard loading racks are defined as being either truck or rail car types for the purpose of loading or unloading product. Total rack size, flammable or combustible products involved, proximity of other hazards and exposures, drainage facilities, wind conditions, ambient temperatures, and available manpower must all be considered when designing a loading rack foam system. Speed of system operation is always critical in minimizing life and property loss.

3-6.1 (new) Methods of Protection. There are two acceptable methods of protecting loading racks, described as follows:

(a) Foam-water sprinkler application utilizing air-aspirating foam water nozzles or non-air-aspirating standard sprinklers

(b) Foam monitors.

3-6.2 (new) Design Criteria for Foam-Water Sprinkler Systems. For design criteria related to sprinkler systems refer to the following standards:

(a) NFPA 16, Standard on Deluge Foam-Water Sprinkler and Foam-Water Spray Systems

(b) NFPA 16A, Standard for the Installation of Closed-Head Foam-Water Sprinkler Systems.

3-6.3 (new) Design Criteria for Foam Monitor Protection Systems.

3-6.3.1* (3-3.1 revised) Areas to Be Protected by Monitor Nozzles. Monitor nozzle system design shall be based on the total ground area. The design is intended to protect the canopy, pumps, meters, vehicles, and miscellaneous equipment associated with the loading and unloading operation in the event of a spill fire. Although most systems are designed to protect the canopy area only, it is often desirable to protect the total curbed area around the loading rack or the entire length of the truck or rail car.

3-6.3.2 (new) Minimum Application Rates and Discharge Times. Minimum foam application rates and discharge times for loading racks protected by monitor nozzles shall be in accordance with Table 3-6.3.2.
Table 3-6.3.2 Minimum Application Rates and Discharge Times for Loading Racks Protected by Foam Monitor Nozzle Systems

<table>
<thead>
<tr>
<th>Foam Type</th>
<th>Minimum Application Rate</th>
<th>Minimum Discharge Time</th>
<th>Product Being Loaded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein, Fluoroprotein</td>
<td>0.16 (6.5) gpm/ft² (1 lpm/m²)</td>
<td>15 minutes</td>
<td>Hydrocarbons</td>
</tr>
<tr>
<td>AFF, FFFF &amp; Alcohol Resistant AFF or FFFF</td>
<td>0.10 (4.1) gpm/ft² (1 lpm/m²)</td>
<td>15 minutes</td>
<td>Hydrocarbons</td>
</tr>
<tr>
<td>Alcohol Resistant Foams</td>
<td>Consult manufacturer for Listings on Specific products</td>
<td>15 minutes</td>
<td>Flammable and Combustible Liquids Requiring Alcohol Resistant Foam</td>
</tr>
</tbody>
</table>

3-7.1 (new) Methods of Application. Where fixed foam protection is considered for a diked area, it can be accomplished by any of the following methods:

(a) Fixed low-level foam discharge outlets.
(b) Foam monitors.
(c) Fixed foam spray systems.

The list of methods above shall not be considered as being in the order of preference.

3-7.1.1 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 in accordance with Table 3-7.1.1.

3-7.1.2 Fixed Foam Discharge Outlets. Fixed foam discharge outlets vary considerably in capacity and range area of coverage. Fixed foam discharge outlets shall be so sized and located as to apply foam uniformly over the dike area at the application rate specified in Table 3-7.1.1. Large dike areas shall be permitted to be subdivided to keep the total design solution within practical limits to be subdivided to keep the total application rate within practical limits.

3-7.1.2.1 (3-3.4.1 revised) Fixed Foam Spray or Sprinkler Outlets. When fixed foam spray or sprinkler outlets are used they shall be in accordance with NFPA 16.

3-7.1.2.1.1 (3-3.3.1 revised) Limitations. When foam spray or sprinkler outlets are used as the primary protection consideration shall be given to the possibility that some of the foam discharge may be carried by the wind beyond the area of the fuel spill.

Overhead application by foam spray or sprinkler outlets may need supplementary low-level foam application to provide coverage below large obstructions.

Overhead pipework may be susceptible to damage by explosion.

3-7.1.2.2 (new) Fixed Low-Level Foam Discharge Outlets. These outlets may take the form of open pipe fittings or directional flow nozzles designed to discharge a compact low-velocity foam stream onto the inner wall of the dike, or directly onto the dike floor as necessary. They shall be located around the dike wall, and inside the dike area where necessary, to apply foam uniformly over the dike area.

3-7.1.2.2.1 Limitations. When fixed discharge outlets installed at low level are used as the primary protection, they shall be so located that no point in the dike area is more than 30 ft (9 m) from a discharge outlet when the discharge per outlet is 60 gpm (225 lpm) or less.

For outlets having discharge rates above 60 gpm (225 lpm) the maximum distance between discharge outlets shall be 60 ft (18 m).

Low-level foam discharge outlets may need supplementary overhead foam spray application to provide coverage or cooling for overhead structures or for tank surfaces.

Table 3-7.1.1 Minimum Application Rates and Discharge Times for Fixed Foam Application on Diked Areas Involving Hydrocarbon Liquids

<table>
<thead>
<tr>
<th>Type of Foam Discharge Outlets</th>
<th>Minimum Application Rate</th>
<th>Minimum Discharge Time-Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>gpm/ft² (1 lpm/m²)</td>
<td>Class I Hydrocarbon</td>
</tr>
<tr>
<td>Fixed low-level foam discharge outlets</td>
<td>0.10 (4.1)</td>
<td>30</td>
</tr>
<tr>
<td>Foam monitors</td>
<td>0.16 (6.5)</td>
<td>30</td>
</tr>
</tbody>
</table>

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3-7.2 Diked Areas Involving Flammable or Combustible Liquids Requiring Alcohol Resistant Foams. Water soluble and certain flammable and combustible liquids and polar solvents that are destructive to non-alcohol-resistant foams require the use of alcohol-resistant foams. Systems using these foams require special engineering consideration.

3-7.2.1 Design Criteria for Diked Areas Involving Flammable or Combustible Liquids Requiring Alcohol Resistant Foams. Design criteria shall be as follows:

(a) Methods of fixed protection shall be the same as those described in 3-7.1.2 for hydrocarbon hazards.
(b) Application rates shall be in accordance with manufacturers recommendations based on listings or approvals for specific products and corresponding foam making devices.
(c) Minimum discharge time shall be 30 minutes.

3-8 Non-Diked Spill Areas. This section relates to areas where a flammable or combustible liquid spill might occur, uncontainted by curbing, dike walls or walls of a room or building. In such cases it is assumed that any fire would be classified as a spill fire, i.e., one in which the flammable liquid spill has an average depth not exceeding 1 in. (25 mm) and is bounded only by the contour of the surface on which it is lying. For these reasons the only practical means of protection is by portable foam handlines and monitors.

3-8.1 Design Criteria for Protection of Spill Fires Involving Hydrocarbons or Flammable and Combustible Liquids Requiring Alcohol Resistant Foams. The minimum application rates and discharge times shall be in accordance with Table 3-8.1.

3-9* Supplementary Protection. In addition to the primary means of protection some types of hazards are required to have provisions for supplemental means of protection. The supplemental protection requirements are described herein.

3-9.1 Supplemental Foam Hose Stream Requirements. Approved foam hose stream equipment shall be provided in addition to tank foam installations as supplementary protection for small spill fires. The minimum number of fixed or portable hose streams required shall be specified in the following table and shall be available to provide protection of the area. For the purpose of this requirement, the equipment for producing each foam stream shall have a solution rate of at least 50 gpm (189 L/min) with the minimum number of hose streams shown as follows:

<table>
<thead>
<tr>
<th>Diameter of Largest Tank</th>
<th>Minimum number of hose streams required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 65 ft (19.5 m)</td>
<td>1</td>
</tr>
<tr>
<td>65 to 120 ft (19.5 to 36 m)</td>
<td>2</td>
</tr>
<tr>
<td>Over 120 ft (36 m)</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 3-8.1 Minimum Application Rate and Discharge Times for Spill Fire Protection Using Portable Foam Nozzles or Monitors.

<table>
<thead>
<tr>
<th>Foam Type</th>
<th>Minimum Application Rate (gpm/ft²)</th>
<th>Minimum Discharge Time (minutes)</th>
<th>Anticipated Product Spill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>0.16 (6.5)</td>
<td>15</td>
<td>Hydrocarbon</td>
</tr>
<tr>
<td>Fluoroprotein</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AFFF, FFFP &amp; Alcohol Resistant</td>
<td>0.10 (4.1)</td>
<td>15</td>
<td>Flammable and Combustible Liquids Requiring Alcohol Resistant Foam</td>
</tr>
<tr>
<td>AFFF or FFFP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcohol Resistant Foams</td>
<td>Consult Manufacturer for Listings on Specific Products</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

* Based on simultaneous operation of the minimum number of 50 gpm (189 L/min) hose streams required. Adjustments may be made where streams of greater capacity are provided.

Chapter 4 (2-6) Specifications and Plans

4-1 Preliminary Approval. It is good practice for the owner or his or her designated representative (architect, contractor, or other authorized person) to review the basic hazard with the authority having jurisdiction to obtain guidance and preliminary approval of the proposed protection concept.

4-2 Approval of Plans. Plans shall be submitted to the authority having jurisdiction for approval before installation.

4-3 Specifications. Specifications for foam systems shall be drawn up with care. To ensure a satisfactory system, the following items shall be in the specifications:

(a) The specifications shall designate the authority having jurisdiction and indicate whether submission of plans is required.
(b) The specifications shall state that the installation shall conform to this standard and meet the approval of the authority having jurisdiction.
(c) The specifications shall include the specific tests that may be required to meet the approval of the authority having jurisdiction, and indicate how cost of testing is to be borne.

4-4 Plans. Preparation of plans shall be entrusted only to fully experienced and responsible persons. They shall be submitted for approval to the authority having jurisdiction before foam systems are installed or existing systems modified. These plans shall be drawn to an indicated scale or be suitably dimensioned.

4-4.1 Plans shall contain or be accompanied by the following information, when applicable:

(a) Physical details of the hazard, including the location, arrangement, and hazardous materials involved.
(b) Type and percentage of foam concentrate.
(c) Required solution application rate.
(d) Water requirements.
(e) Calculations showing required amount of concentrate.
(f) Hydraulic calculations. (See Chapter 6 of NFPA 13, Standard for the Installation of Sprinkler Systems, for hydraulic calculation procedures.)
(g) Identification and capacity of all equipment and devices.
(h) Location of piping, detection devices, operating devices, generators, discharge outlets, and auxiliary equipment.

(i) Schematic wiring diagram.

(j) Explanation of any special features.

4-4.2 (2-6.4.2) Only listed or approved concentrates, equipment, and devices shall be used in these systems.

4-4.3 (2-6.4.3) Complete plans and detailed data describing pumps, drivers, controllers, power supply, fittings, suction and discharge connections, and suction conditions shall be submitted by the engineer or contractor to the authority having jurisdiction for approval before installation.

4-4.3.1 (2-6.4.5) Where field conditions necessitate any significant change from the approved plan, correctness of "as installed" plans shall be supplied for approval to the authority having jurisdiction.

4-4.4 (2-6.4.4) Charts showing head, delivery, efficiency, and brake horsepower curves of pumps shall be furnished by the contractor.

Chapter 5 Installation Requirements

5-1* (2-3.3) Foam Concentrate Pumps.

5-1.1 (2-3.3.1 Revised) The design and materials of construction for foam concentrate pumps shall be suitable for use with the type of foam concentrate used in the system to minimize corrosion, foaming, or sticking. Special attention shall be paid to the type of seal or packing used.

5-1.2 (2-3.3.2 Revised) Pumps shall have adequate capacities to meet the maximum system design requirements. The discharge pressure rating throughout the designed operating range shall be sufficiently in excess of the maximum water pressure likely under any condition at the point of injection of the concentrate, to ensure positive injection.

5-1.3 (2-3.3.3 Revised) Pressure shall not exceed the working pressure of the concentrate piping system. Positive displacement pumps and centrifugal pumps capable of overpressuring the system shall be provided with adequate means of pressure relief from the discharge to the supply side of the circuit to prevent excessive pressure and temperature.

5-1.4 (2-3.3.4 Revised) Pumps shall have adequate means for flushing with water. They shall be provided with a drain cock or valve.

5-1.5 (New) Power Supply.

5-1.5.1 Power supply for the drivers of foam concentrate pumps shall be installed in accordance with NFPA 20, Standard for the Installation of Centrifugal Fire Pumps, and NFPA 70, National Electrical Code.

5-1.5.2 Power supplies shall be arranged such that disconnecting power from the protected facility during a fire, shall not disconnect the power supply to the foam concentrate pump feeder circuit.

5-1.5.3 (2-3.3.5 Revised) Controllers governing the starting of concentrate pumps with electric drivers of 30 horsepower or less shall be listed as "Limited Service Controller." Controllers governing the starting of foam concentrate pumps with electric drivers of greater than 30 horsepower shall be listed as "Fire Pump Controller." Controllers governing the starting of foam concentrate pumps with diesel engine drivers shall be listed as "Diesel Engine Fire Pump Controller."

5-1.5.4* A service disconnecting means in the feeder circuits to Limited Service Controllers is acceptable, where allowed by the authority having jurisdiction, providing the disconnecting means is supervised for the proper position. Supervision for proper position shall be by one of the following:

(a) Central station, proprietary, or remote station signaling electrical supervision service.

(b) Local electrical supervision through use of a signaling service that will cause the sounding of an audible signal at a constantly attended point.

(c) Locking the disconnect in the correct position with monthly recorded inspections.

5-2 (2-4) Piping.

5-2.1 (2-4.1) General Requirements.

5-2.1.1 (2-4.1(a) Revised) All piping inside of dikes or within 50 ft (15 m) of tanks not diked shall either be buried under at least 1 ft (0.3 m) of earth or, if aboveground, shall be properly supported and protected against mechanical injury.

5-2.1.2 (2-4.1(b) Revised) Piping that is subject to freezing shall be either installed for proper drainage with a pitch of 1/2-inch per each 10 ft (4 mm per m) or protected from freezing temperatures.

5-2.1.3 (2-4.1(c) Revised) For systems applying 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 due to a tank roof rupture. One of the following designs shall be used:

(a) Piping less than 4 in. (100 mm) in diameter:

1. When piping is buried, a swing joint or other suitable means shall be provided at each tank riser to absorb the upward force. The swing joint may consist of approved standard weight steel, ductile, or malleable iron fittings.

2. When piping is supported above ground, it shall not be held down for a distance of 50 ft (15 m) from the tank shell to provide flexibility in an upward direction so that a swing joint is not needed. If there are threaded connections within this distance, they shall be back welded for strength.

(b)* The vertical piping on the protected tank 4 in. (101 mm) in diameter and greater shall be provided with one brace at each shell course. This design may be used in lieu of swing joints or other approved aboveground flexibility, as described in 5-2.1.3(a) and 5-2.1.3(a)2.

(c) One flange or union joint shall be provided in each riser at a convenient location, preferably immediately below the foam maker, to permit hydrostatic testing of the piping system up to this joint. With all welded construction, this may be the only joint that can be opened.

(d) In systems with semi-fixed equipment on fixed roof tanks, the foam or solution laterals to each foam maker shall terminate in connections that are at a safe distance from the tanks. These connections shall be outside the dikes of diked tanks or at least 50 ft from tanks 50 ft (15 m) in diameter or less. These connections shall be a distance from the tank shell equal to the diameter of the tank for all tanks over 50 ft (15 m) in diameter. 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.

5-3 Valves in Systems.

5-3.1 (2-4.1(f) Revised) The laterals to each foam discharge outlet on fixed roof tanks shall be separately valved outside the dike in fixed installations. Shutoff valves to divert the foam or solutions to the proper tank shall be either in the central foam station or at points where laterals to the protected tanks branch from the main feed line. These valves shall be located outside dikes of diked tanks or 50 ft (15 m) from tanks 50 ft (15 m) in diameter or less. These valves shall be a distance from the tank equal to the diameter of the tank for all tanks over 50 ft (15 m) in diameter.

Exceptions: Shutoff valves may be permitted at less than the above distances where adequately protected or remotely operated, subject to the approval of the authority having jurisdiction.

5-3.2 (2-4.1(f)) Where two or more foam proportioners are installed in parallel discharging into the same outlet header, valves shall be provided between the outlet of each device and the header. The water line to each proportioner inlet shall be separately valved.

5-3.3 (2-4.1(f)) For subsurface applications, each foam delivery line shall be provided with a valve and 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. When product lines are used for foam, product valving shall be arranged to ensure foam enters only the tank to be protected.

5-3.4 (Part of 24.3) Drain valves that are readily accessible shall be provided for low points in underground and aboveground piping.
54-2 [24.6(d)] All hangers shall be of approved types. Tapping or drifting of load-bearing structural members shall not be permitted when unacceptable weakening of the structure would occur. Attachments may be made to existing steel or concrete structures and equipment supports. Where systems are of such a nature 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.

5-5 (3-1.8) Hose Requirements. Unlined fabric hose shall not be used with foam equipment.

Chapter 6 Testing and Acceptance

6-1 (5-2.1) Inspection and Visual Examination. Foam systems shall be examined visually to determine that they have been properly installed. They shall be inspected for the same items as conforming with installation plans: continuity of piping; removal of temporary blanks; accessibility of valves, controls, and gages; and proper installation of vapor seals, where applicable. Devices shall be checked for proper identification and operating instructions.

6-2 (5-1) Flushing after Installation. In order to remove foreign materials that may have entered during installation, water supply mains, both underground and aboveground, shall be flushed thoroughly at the maximum practicable rate of flow before connection is made to system piping. The minimum rate of flow for flushing shall not be less than the water demand rate of the system, as determined by the system design. The flow shall be continued for a sufficient time to ensure thorough cleaning. Disposal of flushing water must be suitably arranged. All foam system piping shall be flushed after installation, using its normal water supply with foam-forming materials shut off, unless the hazard cannot be subjected to water flow. Where flushing cannot be accomplished, pipe interiors shall be carefully visually examined for cleanliness during installation.

6-3* (5-2*) Acceptance Tests. The completed system shall be tested by qualified personnel to meet the approval of the authority having jurisdiction. These tests shall be adequate to determine that the system has been properly installed, and will function as intended.

6-3.1 (5-2.2) Pressure Tests. All piping, except that handling expanded foam for other than subsurface application, shall be subjected to a two-hour hydrostatic pressure test at 200 psig (1379 kPa gage) or 50 psi (345 kPa) in excess of the maximum pressure anticipated, whichever is greater, in conformity with NFPA 15, Standard for the Installation of Sprinkler Systems. All normally dry horizontal piping shall be inspected for drainage pitch.

6-3.2 (5-2.3) Operating Tests. Before acceptance, all operating devices and equipment shall be tested for proper function.

6-3.3* (5-2.4*) Discharge Tests. Where conditions permit, flow tests shall be conducted to ensure that the hazard is fully protected in conformance with the design specification. The following data are considered essential: static water pressure, residual water pressure at the control valve and at a remote reference point in the system, actual discharge rate, consumption rate of foam-producing material, and the concentration of the foam solution. The foam discharged shall be visually inspected to ensure that it is satisfactory for the purpose intended.

NOTE: Solution concentration may be measured by either refractometric or conductivity means (see Appendix G2 (A.6.1.3b)) or it may be calculated from solution and concentrate flow rates. Solution flow rates may be calculated by utilizing recorded inlet or end-of-system operating pressures or both.

The rate of concentrate flow may be measured by timing a given displacement from the storage tank.

6-4 (5-2.5) System Restoration. After completion of acceptance tests, the system shall be flushed and restored to operational condition.

Chapter 7 Maintenance

7-1 (5-3) Periodic Inspection. At least annually, all foam systems shall be thoroughly inspected and checked for proper operation. This shall include performance evaluation of the foam concentrate or premix solution quality or both. Deviation of results exceeding 10 percent from those recorded in acceptance testing shall be discussed immediately with the manufacturer. Regular service contracts are recommended. The goal of this inspection and testing shall be to ensure that the system is in full operating condition and that it will remain in that condition until the next inspection. The inspection report, with recommendations, shall be filed with the owner. Between the regular service contract inspections or tests, the system shall be inspected by competent personnel following an approved schedule.

7-1.1* (5-3.1) Foam-Producing Equipment. Proprietary devices, their accessory equipment, and foam makers shall be inspected.

7-1.1.1 (5-2.5.2(b)) Fixed discharge outlets provided with flangeable seals shall be provided with suitable inspection means to permit proper maintenance and for inspection and replacement of vapor seals.

7-1.2 (5-3.2) Piping. Aboveground piping shall be examined to determine its condition and that proper drainage pitch is maintained. Pressure tests of normally dry piping shall be made when visual inspection indicates questionable strength due to corrosion or mechanical damage. Underground piping shall be spot checked for deterioration at least every 5 years.

7-1.3 (5-3.3) Strainers. Strainers shall be inspected periodically and cleaned at each use and flow test.

7-1.4 (5-3.4) Detection and Actuation Equipment. Control valves, including all automatic and manual-actuating devices, shall be tested at regular intervals.

7-2 (5-3.5) Foam Concentrate Inspection. At least annual inspection shall be made of foam concentrates and their tanks or storage containers for evidence of excessive sludging or deterioration. Samples of concentrates shall be referred to the manufacturer or qualified laboratory for quality condition testing. Quantity of concentrate in storage shall meet design requirements, and tanks or containers shall normally be kept full, with adequate space allowed for expansion.

7-3 (5-4) Operating Instructions and Training. Operating and maintenance instructions and layouts shall be posted at control equipment with a second copy on file. All persons who may be expected to inspect, test, maintain, or operate foam-generating apparatus shall be thoroughly trained and kept trained in the functions they are expected to perform.

Chapter 8 (7) Referenced Publications

8-1 (7.1) The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

8-1.1 (7-1.1) NFPA Publications. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.


NFPA 18, Standard on Wetting Agents, 1990 edition


Appendix A Explanatory Notes

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

A-1-4 Eductor.

(A-1-4(a)) Air Foam Hose Nozzle with Built-in Eductor. Figure A-1-4(a) shows this type of proportioner where the jet in the foam maker is utilized to draft the concentrate.

Limitations. The bottom of the concentrate container should not be more than 6 ft (1.8 m) below the level of the foam maker.

The length and size of hose or pipe between the concentrate container and the foam maker should conform to the recommendations of the manufacturer.

Hydrocarbon Surfactant-type Foam Concentrates. These are synthetic foaming agents generally based on hydrocarbon surface active agent. They produce foams of widely different character (expansion and drainage times) dependent on the type of foam-producing devices employed. In general, such foams do not provide the stability and burn-back resistance of protein-type foams or the rapid control and extinguishment of AFFF but can be useful for petroleum-product spill fire fighting in accordance with their listings and approvals.

There are hydrocarbon-base foaming agents that have been listed as foaming agents, wetting agents, or as combination foaming/wetting agents. The appropriate listings should be consulted to determine proper application rates and methods.

(A-1-4(b),(c)) In-Line Eductor. This eductor is for installation in a hose line, usually at some distance from the foam maker or playpipe, as a means of drafting air foam concentrate from a container. [See Figures A-1-4(b) and A-1-4(c).]

Limitations.

1. The in-line eductor must be designed for the flow rate of the particular foam maker or playpipe with which it is to be used. The device is very sensitive to down-stream pressures and is accordingly designed for use with specified lengths of hose or pipe between it and the foam maker.

2. The pressure drop across the eductor is approximately one-third of the inlet pressure.

3. The elevation of the bottom of the concentrate container should not be more than 6 ft (1.8 m) below the eductor.

Figure A-1-4(a) Air foam nozzle with built-in eductor.

Figure A-1-4(b) In-line eductor.
Primary-Secondary Eduction Method. This method of introducing air foam concentrate into the water stream en route to a fixed foam maker is illustrated in Figure A-1-4(d).

The unit consists of two eductors designated as the primary eductor and the secondary eductor. The primary eductor is located outside the firewall enclosure and is installed in a bypass line connected to and in parallel with the main water supply line to the foam maker. A portion of the water flows through the primary eductor and draws the concentrate from a container by means of a pickup tube.

The main water line discharges through the jet of a secondary eductor located at the foam maker proper, the mixture of water and concentrate from the primary eductor being delivered to the suction side of the secondary eductor.

Limitations.

1. The primary eductor may be installed as much as 500 ft (150 m) from the secondary eductor. The size of piping used, both in the water and the solution lines, should be as specified by the manufacturer.

2. The elevation of the bottom of the concentrate container should not be more than 6 ft (1.8 m) below the primary eductor.

(A-1-4(e) Around-the-Pump Proportioner. This device consists of an eductor installed in a bypass line between the discharge and suction of a water pump. A small portion of the discharge of the pump flows through this eductor and draws the required quantity of air foam concentrate from a container, delivering the mixture to the pump suction. Variable capacity may be secured by the use of a manually controlled multiported metering valve. [See Figure A-1-4(e).]

Limitations.

1. The pressure on the water suction line at the pump must be essentially zero gage pressure or on the vacuum side. A small positive pressure at the pump suction can cause a reduction in the quantity of concentrate educted or cause the flow of water back through the eductor into the concentrate container.

2. The elevation of the bottom of the concentrate container should not be more than 6 ft (1.8 m) below the proportioner.

3. The bypass stream to the proportioner uses from 10 to 40 gpm (38 to 151 L/min) of water depending on the size of the device and the pump discharge pressure. This factor must be recognized in determining the net delivery of the water pump.
Balanced Pressure Proportioning (Metered Proportioning). By means of an auxiliary pump, foam compound is injected into the water stream passing through an inductor. The resulting foam solution is then delivered to a foam maker or playpipe. The proportioner may be inserted in the line at any point between the water source and foam maker or playpipe. [See Figures A-l-4(f) and A-l-4(g).]

To operate, the main water valve is opened and a reading of the pressure indicated on the duplex gage is taken. When both gage hands are set at the same point, the proper amount of foam concentrate is being injected into the water stream. This is done automatically by the use of a differential pressure diaphragm valve.

Limitations.

1. The capacity of the proportioner may be varied from approximately 50 to 200 percent of the rated capacity of the device.

2. The pressure drop across the proportioner ranges from 5 to 30 psi (34 to 207 kPa) depending on the volume of water flowing through the proportioner within the capacity limits given above.

3. A separate pump is required to deliver concentrate to the proportioner.

Figure A-l-4(f) Balanced pressure proportioning with single injection point (metered proportioning).
Figure A-1-4(g) Balanced pressure proportioning with multiple injection points (metered proportioning).

(A-1-4(h)) Pressure Proportioning Tank. This method employs water pressure as the source of power. With this device, the water supply pressurizes the foam concentrate storage tank. At the same time, water flowing through an adjacent Venturi or orifice creates a pressure differential. The low-pressure area of the Venturi is connected to the foam concentrate tank, so that the difference between the water supply pressure and this low-pressure area forces the foam concentrate through a metering orifice and into the Venturi. Also, the differential across the Venturi varies in proportion to the flow, so one Venturi will proportion properly over a wide flow range. The pressure drop through this unit is relatively low. [See Figure A-1-4(h).]

A special test procedure is available to permit the use of a minimum amount of concentrate when testing the pressure proportioner system.

Limitations.

1. Foam concentrate with specific gravities similar to water may create a problem by mixing.

2. The capacity of these proportioners may be varied from approximately 50 to 200 percent of the rated capacity of the device.

3. The pressure drop across the proportioner ranges from 5 to 30 psi (34 to 207 kPa) depending on the volume of water flowing within the capacity limits given above.

4. When the concentrate is exhausted, the system must be turned off, and the tank drained of water and refilled with foam concentrate.

5. Since water enters the tank as the foam concentrate is discharged, the concentrate supply cannot be replenished during operation, as with other methods.

6. This system will proportion at a significantly reduced percentage at low flow rates and should not be used below minimum design flow.

Figure A-1-4(h) Typical arrangement of pressure proportioning tank.
(A-1-4(i)) Diaphragm (Bladder) Pressure Proportioning Tank. This method also uses water pressure as a source of power. This device incorporates all the advantages of the pressure proportioning tank with the added advantage of a collapsible diaphragm that physically separates the foam concentrate from the water supply. Diaphragm pressure proportioning tanks operate through a similar range of water flows and according to the same principles as pressure proportioning tanks. The added design feature is a reinforced elastomeric diaphragm (bladder) that can be used with all concentrates listed for use with that particular diaphragm (bladder) material. [See Figure A-1-4(i).]

The proportioner is a modified Venturi device with a foam concentrate feed line from the diaphragm tank connected to the low-pressure area of the Venturi. Water under pressure passes through the controller and part of this flow is diverted into the water feed line to the diaphragm tank. This water pressurizes the tank, forcing the diaphragm filled with foam concentrate to slowly collapse. This forces the foam concentrate out through the foam concentrate feed line and into the low-pressure area of the proportioner controller. The concentrate is metered by use of an orifice or metering valve and joins in the proper proportion with the main water supply, sending the correct foam solution to the foam makers downstream.

Limitations. Limitations are the same as those listed under A-1-4(h), Pressure Proportioning Tank, except the system can be used for all types of concentrates.

A-1-4 (A-3-2.2) Type I Discharge Outlet. Among the approved Type I discharge outlets are:

(a) Porous tube [see Figure A-1-4(j) (A-3-2.2(a))].

(b) Foam trough along the inside of tank wall [see Figure A-1-4(k) (A-3-2.2(b))].

These are designed to extinguish fire with a minimum of foam-producing materials. It should be noted, however, that Type I devices become Type II devices if they suffer mechanical damage.

Porous Tube. The coarsely woven tube is rolled up in the foam chamber, one end being securely fastened to the foam supply line, the free end being so stitched as to close the opening at this point. When foam is admitted to the tube, the diaphragm closing the mouth of the chamber is broken out by the pressure of the tube against it. The tube then unrolls, dropping into the tank. The buoyancy of the foam causes the tube to rise to the surface and foam to flow forth through the interstices of the fabric directly onto the liquid surface.

Foam Trough. The trough shown schematically in Figure A-1-4(k) (A-5-2.2(b)) consists of sections of steel sheet formed into a chute that is securely attached to the inside of the tank wall so that it forms a descending spiral from the top of the tank to within 4 ft (1.2 m) of the bottom.
Figure A-1.4(j) (A-3.2.2(a)) Crosssection of a moeller tube chamber. Tube is designed to unroll and fall to oil level. Foam flows through interstices in tube.

Figure A-1.4(k) (A-3.2.2(b)) Foam trough.

Figure A-1.4(l) (A-3.2.2(c)) Air foam chamber with Type II outlet.

Figure A-1.4(m) (A-3.2.2(d)) Semifixed subsurface foam installation.

Figure A-1.4(n) (A-3.2.2(e)) Typical air foam piping for intermediate back-pressure foam system.

For S1 Units: 1 in. = 25.4 mm; 1 ft = 0.305 m.

NOTE: One brace (1/2 in. plate, 12 in. long) is to be provided at each shell course. This will help keep the shell in place during the early stages of the fire and prevent buckling before cooling water is applied.

A-1.4 (A.3-1.2) Foam Generating Methods. Foam nozzle and monitor streams may also be employed for the primary protection of process units and buildings, subject to the approval of the authority having jurisdiction. It is important that the discharge characteristics of the equipment selected to produce foam nozzle and monitor streams for outdoor storage tank protection be verified by actual tests to make certain that the streams will be effective on the hazards involved.

Figure A-1.4(o) (A-3.1.2(a)) Handline Foam Nozzle.
Figure A-1-4(p) (A-3-1.2(b)) Adjustable Straight-Stream-to-Fan Pattern Foam-Water Monitor.

Figure A-1-4(q) (A-3-1.2(c)) Adjustable Straight Stream-to-Spray Foam-Water Monitor.

Figure A-1-4(r) (A-3-1.2(d)) Wheeled Portable Foam-Water Monitor.

Figure A-1-4(s) (A-3-1.2(e)) Portable Foam-Water Monitor.

A-2.2.1.2 Additional water supplies are recommended for cooling the hot tank shell to assist the foam in sealing against the shell. Some foams are susceptible to breakdown and failure to seal as a result of heating the tank shell due to prolonged burning prior to agent discharge.

A-2.3.2.2 The level of concentrate in the storage tank should be monitored to ensure an adequate supply is available at all times.

A-2.3.2.4.1 The storage temperature should be monitored to ensure that listed temperature limitations are not exceeded.

A-2.6.3.1 Welding is preferable when it can be done without introducing fire hazards.

A-2.6.5 Hazard area generally includes all areas within dikes and within 50 feet of tanks without dikes. Other areas may be considered hazard areas such as: locations more than 50 feet from tanks without dikes, if the ground slope would permit an exposure from accidentally released flammable and combustible liquids; extensive manifold areas where flammable and combustible liquids may be accidentally released; or other similar areas. The presence of flammable and combustible liquids within pipe lines, which do not have a potential for releasing liquids, should not be considered a hazard area.

Ball valves may be used for foam concentrate proportioning systems.

A-3.2.1.3 When the entire liquid surface was involved, fires in tanks up to 150 ft (39 m) in diameter have been extinguished with large-capacity foam monitors. Depending on the fixed-roof tank outage and fire intensity, the updraft due to chimney effect may prevent sufficient foam from reaching the burning liquid surface for formation of a blanket. Foam should be applied continuously and evenly. Preferably, it should be directed against the inner tank shell so that it flows gently onto the burning liquid surface without undue submergence. This can be difficult to accomplish as adverse winds, depending on velocity and direction, will reduce the effectiveness of the foam stream. Fires in fixed-roof tanks having ruptured roofs with only limited access for foam are not easily extinguished by monitor application from ground level. Fixed foam monitors may be installed for protection of drum storage areas or diked areas.

A-3.2.2.3 (A-3.1.4.3.1) Where protection is desired for hydrocarbons having a flash point above 200°F (93.3°C), a minimum discharge time of 35 minutes should be used.

A-3.2.2.4 (A-3.1.4.2 Partial-Revised) When using some older types of alcohol-resistant foam concentrates, consideration should be given to solution transit time. Solution transit time (the elapsed time between injection of the foam concentrate into the water and the induction of air) may be limited, depending on the characteristics of the foam concentrate, the water temperature, and the nature of the
The maximum solution transit time of each specific installation should be within the limits established by the manufacturer.

A-3-2.3.2.1 (3-2.5.2(a) revised) It is suggested that, for tanks above 200 ft (60 m) in diameter, at least one additional discharge outlet be added for each additional 5000 sq ft (465 m²) of liquid surface or fractional part thereof. Since there has been limited experience with foam application to fires in fixed-roof tanks over 140 ft (42 m) in diameter, requirements for foam protection on tanks above this size are based on extrapolation of data from successful extinguishments in smaller tanks. Tests have shown that foam may travel effectively across at least 100 ft (30 m) of burning liquid surface. On fixed-roof tanks of over 200 ft (60 m) diameter, subsurface injection may be used to reduce foam travel distances for tanks containing hydrocarbons only.

(A-3-2.5.2) Unless subsurface foam injection is utilized, it may be deemed advisable to install a properly sized flanged connection on all atmospheric pressure storage tanks, regardless of present intended service, to facilitate the future installation of an approved discharge outlet if a change in service should require such installation. Figures A-3-2.3.2.1(a) (A-3-2.5.2(a)) and A-3-2.3.2.1(b) (A-3-2.5.2(b)) are typical fixed foam discharge outlets or foam chambers.

Figure A-3-2.3.2.1(a) (A-3-2.5.2(a)) Air Foam Maker in Horizontal Position at Top of Storage Tank.

A-3-2.3.2.2 (A-3-2.4) Where protection is desired for hydrocarbons having a flash point above 200°F (93.3°C), a minimum time of 15 minutes for Type I and 25 minutes for Type II outlets should be used.

A-3-2.3.3 (A-3-2.7 revised) Rate of Application - Products Requiring Alcohol Resistant Foams. The system should be designed on the basis of fighting a fire in one tank at a time. The rate of application for which the system is designed should be the rate computed for the protected tank considering both the liquid surface area and the type of flammable liquid stored.

Example: The property contains a 40-ft (12.2-m) diameter tank storing ethyl alcohol and a 35-ft (10.7-m) diameter tank storing isopropyl ether.

Liquid surface area, 40 ft (12.2 m) diameter tank = 1257 sq ft (116.8 m²)

Assuming the solution rate for ethyl alcohol, 0.1 gpm/ft² (4.1 (L/min)/m²) or 1257 x 0.1 = 126 gpm

For SI Units
Solution Rate = (116.8) (4.1) = 477 L/min

Liquid surface area, 35 ft (10.7 m) diameter tank = 962 ft² (89.4 m²)

Assuming the solution rate for isopropyl ether, 0.15 gpm/ft² (6.1 (L/min)/m²) or 962 x 0.15 = 144 gpm

For SI Units
Solution Rate = (89.4) (6.1) = 545 L/min

In this case, the smaller tanks storing the more volatile product require the higher foam-generator capacity. Applying this requirement, due consideration must be given to the future possibility of change to a more hazardous service requiring greater rates of application.

Unfinished solvents or those of technical grade may contain quantities of impurities or diluents. The proper rate of application for such stock, as well as for mixed solvents, should be selected with due regard to the foam breaking properties of the mixture.

A-3-2.4.1 (A-3-2.6.1 Revised) General. Experience with fuel storage tank fire fighting has shown that the main problems are operational, i.e., difficulty in delivering the foam relatively gently to the fuel surface at an application rate sufficient to effect extinguishment. A properly engineered and installed subsurface foam system offers the potential advantages of less chance for foam-generation equipment disruption as a result of an initial tank explosion or the presence of fire surrounding the tank, and the conduct of operations a safe distance from the tank. Thus, opportunity for establishing and maintaining an adequate foam application rate is enhanced. The following guides regarding fire attack are suggested.

After necessary suction connections are made to the water supply and foam maker connections are made to foam lines, foam pumping operations should be initiated simultaneously with opening of block valves permitting start of foam flow to the tank. Solution pressure should be brought up to and maintained at design pressure.

When foam first reaches the burning liquid surface, there may be a momentary increase in intensity caused by mechanical action of steam formation when the first foam contacts the heat of the fire.
Initial flame reduction and reduction of heat is then usually quite rapid, and gradual reduction in flame height and intensity will occur as the foam closes in against the tank shell and over the turbulent areas over foam injection points. If sufficient water supplies are available, cooling of the tank shell at and above the liquid level will enhance extinguishment and should be used. Care should be taken that water streams are not directed into the tank to disrupt the established foam blanket.

After the fire has been substantially knocked down by the foam, some fire may remain over the point of injection. With flash point below 100°F (37.8°C) (Class IB and IC liquids), the fire over the turbulent area will continue until it is adequately covered by foam. With gasoline or equivalent liquids, when fire remains only over the area of injection, intermittent injection should be used so that foam will retrogress over the area during the time foam injection is stopped. Depending on local circumstances, it may be possible to extinguish any residual flickers over the turbulent area with portable equipment rather than continue the relatively high rate of application to the whole tank.

If the tank contains a burning liquid capable of forming a heat wave, a slop-over may occur from either topside or subsurface injection of foam, especially if the tank has been burning for 10 minutes or longer. Slop-over can be controlled by intermittent foam injection or reduction in foam-maker inlet pressure until slop-over ceases. Once slop-over has subsided, and in the case of liquids that do not form a heat wave, pump rate should be continuous.

Figures A-3-2.4.1 (a) and (b) illustrate typical arrangements of semi-fixed subsurface systems.
Figures A-3-2.4.2 (a) through A-3-2.4.2 (d) should be used to determine foam velocity.

Figure A-3-2.4.2 (e) illustrates optional arrangements for multiple subsurface discharge outlets.

Figure A-3-2.4.2(a) Foam Velocity vs. Pipe Size (2 1/2", 3", 4", 6", 8", 10", 12" and 14" Pipe) – Standard Sched. 40 Pipe

Figure A-3-2.4.2(b) Foam Velocity vs. Pipe Size (14", 16", 18" Pipe) – Standard Sched. 40 Pipe
Figure A-3-2.4.2(c) Foam Velocity vs. Pipe Size (20" and 24" Pipe) - Standard Sched. 40 Pipe

NOTE: Expanded foam velocity may also be calculated by using the following formulae

\[
\text{EXPANDED FOAM VELOCITY} = \frac{GPM}{A \times K} \quad \text{OR} \quad \frac{LPM}{A \times K}
\]

\(A = \text{AREA of FOAM NOZZLE in SQ FT} \)
\(K = \text{CONSTANT (449)}\)
\(GPM = \text{GALLONS PER MINUTE} \)
\(LPM = \text{LITERS PER MINUTE} \)

\( \text{WHERE } d = \text{PIPE DIAMETER IN INCHES} \)

Figure A-3-2.4.2(e) Typical Arrangement of Semi-Fixed Subsurface System

A-3.2.4.2.1 (new) Subsurface Foam Outlet Elevation. Figure A-3-2.4.2.1 illustrates a typical foam inlet tank connection.

A-3.2.4.2.2 (A-2.4.7.1 Revised) Air Foam Friction Loss Through Piping. The back-pressure consists of the static head plus pipe friction losses between the foam maker and the foam inlet to the tank. The friction loss curves [Figures A-3.2.4.2.2(a) and A-3.2.4.2.2(b)] are based on a maximum foam expansion of 4, which is the value to be used for friction loss and inlet velocity calculations.
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Figure A-3-2.4.2.2(a) Foam Friction Losses – 4 Expansion (2 1/2", 3", 4", 6" 8" and 10" Pipe) – Standard Sched. 40 Pipe

Figure A-3-2.4.2.2(b) Foam Friction Losses – 4 Expansion (12", 14", 16", 18", 20" and 24" Pipe) – Standard Sched. 40 Pipe

All dimensions in inches (millimeters) unless otherwise noted.

NOTE: Curves are approximate and may differ somewhat from actual calculated values.
A-3.2.4.3.1 (A-3.2.6.5) Foam-Producing Materials and Equipment.
Optimum fluoroprotein foam, AFFF, and FFFP characteristics for subsurface injection purposes are expansion ratios between 2 and 4. [See Figures A-3-2.4.3.1(a) and (b).]

Figure A-3-2.4.3.1(a) (A-3-2.6.5(a)) Portable high back-pressure foam maker for semifixed systems.

Figure A-3-2.4.3.1(b) (A-3-2.6.5(b)) Fixed high back-pressure foam maker for fixed systems.

A-3-2.5 (A-3-2.10 Revised) Semi-Subsurface Systems. This section describes the design criteria which is applicable to systems used to apply foam to the surface of fixed (cone) roof storage tanks via a flexible hose rising from the base of the tank. Manufacturers recommendations should be followed for the design and installation of such systems.

These systems are not considered appropriate for floating roof tanks with or without a fixed roof because the floating roof prevents foam distribution. The flexible foam delivery hose is initially contained in a sealed housing and is connected to an external foam generator capable of working against the maximum product head. When operated the hose is released from its housing and the hose floats to the surface as a result of the buoyancy of the foam. Foam then discharges through the open end of the hose directly onto the liquid surface.

Consideration should be given to the following when considering the selection of this type of system.

(a) The total foam output reaches the surface of the burning liquid.
(b) With large tanks, the semi-subsurface units can be arranged to produce an even distribution over the fuel surface.
(c) Any type of concentrate suitable for gentle surface application to the particular fuel may be used.
(d) Foam generating equipment and operating personnel may be located at a distance from the fire.
(e) The system may be used for the protection of foam destructive liquids provided the flexible hose is not affected by them.
(f) Certain high viscosity fuels may not be suitable for protection by this system.
(g) There is no circulation of the cold fuel and therefore, no assistance in extinguishment.
(h) The system may be difficult to check, test and maintain.
(i) The high back pressure foam generator has to produce foam at a pressure sufficient to overcome the of the head of fuel as well as all friction losses in the foam pipework. Friction losses with foam differ from those with foam solution.

Design application rates and discharge times for hydrocarbons are typically the same as for Type II topside application systems, i.e., 0.1 gpm/ft² (4.1 Lpm/m²). Manufacturers should be consulted for appropriate application rates and design recommendations to be followed for protection of products requiring the use of alcohol resistant foams.
Duration of discharge should be in accordance with the following table:

<table>
<thead>
<tr>
<th>Product Stored Foam</th>
<th>Type Minimum</th>
<th>Discharge Time (Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrocarbons with:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flash Point Below</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100°F (37.8°C)</td>
<td>Protein, AFFF</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Fluoroprotein, FFFP and alcohol resistant AFFF or FFFP</td>
<td>55</td>
</tr>
<tr>
<td>Flash Point at or above 100°F (37.8°C)</td>
<td>All Foams</td>
<td>30</td>
</tr>
<tr>
<td>Liquids Requiring Alcohol-Resistant Foams</td>
<td>Alcohol Resistant Foam</td>
<td>55</td>
</tr>
</tbody>
</table>

Semi-subsurface foam units should be equally spaced and the number of units should be in accordance with the following table:

<table>
<thead>
<tr>
<th>Tank Diameter</th>
<th>Minimum Number of Semi-Subsurface Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 80</td>
<td>24</td>
</tr>
<tr>
<td>Over 80 to 120</td>
<td>24 to 36</td>
</tr>
<tr>
<td>Over 120 to 140</td>
<td>36 to 42</td>
</tr>
<tr>
<td>Over 140 to 160</td>
<td>42 to 48</td>
</tr>
<tr>
<td>Over 160 to 180</td>
<td>48 to 54</td>
</tr>
<tr>
<td>Over 180 to 200</td>
<td>54 to 60</td>
</tr>
<tr>
<td>Over 200 ft (60m)</td>
<td>54 to 60 plus 1 outlet for each additional 5000 ft² (465m²)</td>
</tr>
</tbody>
</table>

Each semi-subsurface unit should be secured by pipe supports suitable for the intended application and mounting through the tank wall. To prevent leakage of product it is recommended that a check valve be fitted at the foam entry point adjacent to the tank wall for each unit.

Semisubsurface Injection Methods. The arrangement of these devices may take a variety of forms. Figures A-3-2.10(a) and A-3-2.10(b) show a device that has been developed and used primarily in Sweden.

This equipment consists of an immersed container with a base hose having a length equal to the length of the container and with a main hose having a length equal to the height of the tank. The nonporous foam hose is made of a synthetic-coated nylon fabric, and is lightweight, flexible, and oil resistant. It is packed into the container in a special way to facilitate ejection. The container is provided with a cap having a seal to exclude oil from the hose container and foam supply piping. Between the inlet part and the upper part of the hose container is a bypass "shock pipe."

When the foam is forced through the inlet pipe, the air contained in the piping is compressed, the foam flows through the shock pipe, and eventually opens the cap. Then the foam will reach the container and fill the base hose and push out the main hose, which will then fill with foam. The buoyancy of the foam causes the hose to rise to the surface and foam flows forth through the open end directly onto the liquid surface.

Discharge outlets should be provided in such sizes, numbers, and locations to meet the requirements for discharge and to distribute the foam as required by the hazard protected.

The sizing of individual discharge outlet assemblies should be in accordance with the manufacturer's ratings and recommendations and subject to the approval of the authority having jurisdiction.

The use of high back-pressure foam generators is required for semisubsurface injection. When using a water pressure of 150 psi to the foam generators, the typical system will function in tanks with heights of up to 60 ft (18 m). Water supply pressure should be determined for each individual installation or tank grouping, and will depend on the requirements of the foam generators, injection devices, and tank heights.

Figure A-3-2.5(a) Semi-Subsurface System Arrangement

Figure A-3-2.5(b) (A-3-2.10(a))
A-3.3.1 Full Surface Protection. Most fires in open top floating roof tanks have occurred in the seal areas and these fires can be extinguished with the foam systems described in Section 3. However, some fires have involved the full surface area when the roof sank. These fires are very infrequent and do not justify a fixed system to protect for this risk. At the same time, plans should be available to fight a full surface fire in a floating roof tank with portable or mobile equipment. Large capacity foam monitor nozzles with capacities up to 6000 gpm are currently available. If foam proportioning devices are not provided with the foam monitors, additional foam proportioning trucks may be required through mutual aid. Generally, the number of foam proportioning trucks available at any location would not be sufficient to fight a sunken floating roof fire and outside assistance would be required.

Generally the fire water systems available in floating roof tank areas will not be designed to fight a full surface fire so additional water will be required. Therefore, relay pumping with municipal or mutual aid water pumpers may be required to obtain enough water for foam generation.

Another aspect to consider is the amount of foam concentrate available. The foam application rate of 0.16 GPM per sq. ft. of surface area listed in section 3 may have to be increased for very large tanks. Therefore, the amount of foam concentrate available through mutual aid should be established prior to the fire. In some cases it may be necessary to increase the onsite foam storage if mutual aid supplies are limited.

If it is decided to fight a fire in a tank with a sunken roof instead of protecting the adjacent facilities and allowing a controlled burnout, the most important aspect is to plan ahead of time and hold simulated drills. Coordinating the efforts of many different organizations and various pumping operations required for fighting potential catastrophic type fires requires well laid out plans and plenty of practice.

A-3.3.2.2 (A-3.2.1) General. These systems are for the protection of outdoor process and storage tanks. They include the protection of such hazards in manufacturing plants as well as in large tank farms, oil refineries, and chemical plants. The systems are usually designed for manual operation but, in whole or in part, may be automatic in operation. Foam systems are the preferred protection for large outdoor tanks of flammable liquids.

A-3.3.3.1 Since all the discharge outlets are supplied from a common (ring) foam solution main some vapor seal devices may not rupture due to pressure variations encountered as the system is activated. (See Figure A-3.3.3.1(a) and (b) following)
Sheet steel shield can be rectangular or cut as shown mounted on top of shell reinforce with suitable supports. Minimum dimensions will depend on minimum clearance needed between foam chamber deflector and top position of roof. See table below. 

```
<table>
<thead>
<tr>
<th>泡沫制造商</th>
<th>泡沫室</th>
<th>泡沫室开口尺寸</th>
</tr>
</thead>
<tbody>
<tr>
<td>泡沫制造</td>
<td>泡沫室</td>
<td>泡沫室开口尺寸</td>
</tr>
<tr>
<td>泡沫制造</td>
<td>泡沫室</td>
<td>泡沫室开口尺寸</td>
</tr>
<tr>
<td>泡沫制造</td>
<td>泡沫室</td>
<td>泡沫室开口尺寸</td>
</tr>
</tbody>
</table>
```

Notes:
1. 40' max. foam maker spacing using 12' high min. foam dam
2. 80' max. foam maker spacing using 24' high min. foam dam

"A" Dimension is the height of the chamber opening above the top edge of tank shell. The minimum height must clear the top position of the floating roof.

"A" Dimension  "L" Dimension
2'     10'
3'     12'
4'     14'

Figure A-3-3.1(a) Typical Foam Splash Foard for Discharge Devices Mounted Above the Top of the Shell.
A-3-3.4 Foam Handline Design Criteria for Seal Area Protection.
Use of foam handlines for the extinguishment of seal fires should be limited to open-top floating roof tanks less than 250 ft (76.2 m) diameter. The following design information applies to foam handline protection method.

(a) A foam dam should be installed per 3-3.3.3.

(b) To establish a safe base for operation at the top of the tank, a single fixed foam discharge outlet should be installed at the top of the stairs. This fixed foam discharge outlet is meant to provide coverage of the seal area for approximately 40 ft (12.2 m) on both sides of the top of the stairs.

(c) The fixed foam discharge outlet should be designed to discharge at least 50 gpm (379 Lpm)

(d) To permit use of foam handlines from the wind-girder, two 1.5 in. (40 mm) diameter valved hose connections should be provided at the top of the stairs in accordance with figure.

The wind-girder should be provided with a railing for the safety of the fire fighters. (See Figure A-3-3.4 following)

A-3-4.1 There have been reported cases where the application of foam through solid streams that were plunged into the flammable liquid, have been thought to be the source of ignition of the ensuing fire. The ignition has been attributed to static discharges resulting from the splashing and turbulence. Therefore, any application of foam to an unignited flammable liquid should be as gentle as possible. Proper application methods with portable equipment could be to use a spray pattern or to bank the foam stream off a backboard so that the foam flows gently onto the liquid surface. Also, properly designed fixed foam chambers on tanks could be expected to deliver the foam fairly gently and not cause a problem.

A-3-4.1.1 Since all the discharge outlets are supplied from a common (ring) foam solution main some vapor seal devices may not rupture due to pressure variations encountered as the system is activated.

A-3-6 (new) Speed of System Operation. To minimize life and property loss automation of foam systems protecting a truck loading rack needs to be taken into account. NFPA 16-1991 states that “Automatic operation shall be provided and supplemented by auxiliary manual tripping means. Exception: Manual operation only may be provided when acceptable to the authority having jurisdiction.” There are two methods of automating foam monitor systems for this application, as follows:

(a) Completely automatic detection and actuation. Refer to applicable sections of NFPA 72 and 72E for design criteria.

(b) Actuation by push-button stations or other means of manual release.

A-3-6.3.1 (new) Design Factors for Foam Monitor Nozzle Application. A very important factor in designing a foam monitor system is the proper choice of extinguishing agent. The effective use of foam requires the proper choice of extinguishing agent for the fires being covered. The type of agent selected should be based on the fire involved and the properties of the fuel. The extinguishing agent should be selected to provide the most effective protection for the specific application.

Consult the manufacturer of the monitor nozzle for specific performance criteria related to stream range and pattern, discharge capacity, and pressure requirements. Manufacturers should also be consulted to confirm applicable listings and/or approvals.

A-3-7 A-3-1.6 Fixed foam protection may sometimes be desirable for common diked areas surrounding multiple vertical fixed roof tanks with less than the spacing specified in NFPA 30, Flammable and Combustible Liquids Code. Fixed foam protection may also be desirable for diked areas surrounding horizontal storage tanks, drum storage areas, or other areas where a substantial depth of flammable or combustible liquid spill might be possible.

A-3-9 (A-3-2.8.2) Auxiliary foam hose streams may be supplied directly from the main system protecting the tanks (e.g., in the case of centralized fixed pipe systems) or may be provided by additional equipment. The supplementary hose streams requirements as given herein are not intended to protect against fires involving major fuel spills; rather, they are considered only as second-tier type protection for extinguishing or covering small spills involving areas in square feet equal to that covered by about six times the rated capacity (in gpm) of the nozzle.

Permanently installed foam hydrants, where used, should be located in the proximity of the hazard protected and in safe and accessible locations. Location should be such that excessive lengths of hose are not required. Limitations as to length of hose that may be used depend on the pressure requirements of the foam nozzle.

A-4-1 (A-2-6.1) Limitations. The possibility and extent of damage by the agent must be evaluated in the choice of any extinguishing system. In certain cases, such as tanks or containers of edible oils, cooking oils, or other food processing agents, or in other cases where contamination through the use of foam could increase the loss potential substantially, the authority having jurisdiction should be consulted as to the type of extinguishing agent preferred.

A-5-1 Provisions should be made for automatic shutoff of the foam concentrate pump after the concentrate supply is exhausted.

A-5-1.5.4 Limited Services Controllers generally do not have a service disconnect means. In order to safely perform routine inspection and maintenance, it may be desirable to provide an external service disconnect. Special care must be taken to insure the disconnect is not left in a position rendering the foam concrete pump inoperable.

A-5-2.1.3(b) (New) This riser can be welded to the tank by means of steel brace plates positioned perpendicular to the tank and centered on the riser pipe.
Figure A-3-3.4 Typical Installation of Foam Handlines for Seal Area Fire Protection.

A-6.3 (A-5.2) Acceptance Tests.

(a) A foam system will extinguish a flammable liquid fire if operated within the proper ranges of solution pressure and concentration and at sufficient discharge density per sq ft of protected surface. The acceptance test of a foam system should ascertain:

1. All foam-producing devices are operating at "system design" pressure and at "system design" foam solution concentration.

2. The laboratory-type tests have been conducted, where necessary, to determine that water quality and foam liquid are compatible.

(b) The following data are considered essential to the evaluation of foam system performance:

1. Static water pressure.

2. Stabilized flowing water pressure at both the control valve and a remote reference point in the system.

3. Rate of consumption of foam concentrate.

The concentration of foam solution should be determined. The rate of solution discharge may be computed from hydraulic calculations utilizing recorded inlet or end-of-system operating pressure or both. The foam liquid concentrate consumption rate may be calculated by timing a given displacement from the storage.
tank or by refractometric or conductivity means. The calculated concentration and the foam solution pressure should be within the operating limit recommended by the manufacturer.

A-6-3.3 (A-5-2.4) Introduction. With the greatly expanding uses of foam in aircraft fire fighting and in foam-water sprinkler systems, in addition to those applications previously covered in this standard, there has arisen the need for a standardized laboratory procedure for analyzing and expressing the significant physical properties of mechanical foam as related to fire fighting capability. The equipment and techniques used have been selected to assist in the development of system components, nozzles, and foaming agents.

The numerical values obtained by these tests generally enable a characterization of the foam. Only by describing results obtained on a standardized basis will it be possible to describe the optimum foam for the various operating conditions such as petroleum storage tanks, foam-water sprinklers, dip tanks, etc. Attempts have been made to select these foam types; however, because of the limited amount of data taken under a limited number of conditions, the conclusion must be accepted with understandable reservations.

A-7-1.1 Flushing of the concentrate pump may be necessary at periodic intervals or following complete discharge of concentrate.

**Appendix B Storage Tank Protection Summary**

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

<table>
<thead>
<tr>
<th>Top Side Foam Application</th>
<th>Fixed (Cone) Roof Tanks and Pan-type Floating Roof Tanks</th>
<th>Pontoon or Double-Deck Floating Roof Tanks (Open Top or Covered)</th>
<th>Annular Seal Area</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No. of Foam Outlets Required</strong></td>
<td>Up to 80 ft (24.4 m) dia.</td>
<td>1 Foam Chamber</td>
<td>For each 40 ft (12.2 m) of circumference with a 12 in. (30.5 cm) high foam dam.</td>
</tr>
<tr>
<td></td>
<td>81 to 120 ft (24.7-36.6 m) dia.</td>
<td>2 Foam Chamber</td>
<td>For each 80 ft (24.4 m) of circumference with a 24 in. (61 cm) high foam dam.</td>
</tr>
<tr>
<td></td>
<td>121 to 140 ft (36.9-42.7 m) dia.</td>
<td>3 Foam Chamber</td>
<td>See A-3-2.11.1(a). A-3-2.11.2.</td>
</tr>
<tr>
<td></td>
<td>141 to 160 ft (43-48.8 m) dia.</td>
<td>4 Foam Chamber</td>
<td></td>
</tr>
<tr>
<td></td>
<td>161 to 180 ft (49.5-54.9 m) dia.</td>
<td>5 Foam Chamber</td>
<td></td>
</tr>
<tr>
<td></td>
<td>181 to 200 ft (55.2-61 m) dia.</td>
<td>6 Foam Chamber</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Over 201 ft (61.2 m) dia.</td>
<td>1 additional for each</td>
<td></td>
</tr>
<tr>
<td></td>
<td>See 3-2.5.2</td>
<td>5000 sq ft.</td>
<td></td>
</tr>
</tbody>
</table>

- **Hydrocarbon Application Rates**
  - 0.10 gpm (.38 L/m) per sq ft of liquid surface.
  - See 3-2.5.1.

- **Polar Solvent Rates**
  - See Manufacturer's Approval Report.

- **Hydrocarbon Discharge Times**
  - Type I
    - Flash Pt. 100°F (37.8°C) - 140°F (194.4°C)
      - 20 min 30 min
  - Type II
    - Flash Pt. below 100°F (37.8°C)
      - 30 min 55 min

- **Polar Solvents**
  - Type I
    - 30 min
  - Type II
    - 55 min

- **Mechanical Shoe Seal**
  - 1 For each 130 ft (39.6 m) of tank circumference (no foam dam required)
  - Tube Seal - Over 6 in. (15.2 cm) from top of seal to top of pontoon with foam outlets under metal weather shield or secondary seal.
  - 1 For each 60 ft (18.3 m) of tank circumference (no foam dam required)
  - Tube seal - Less than 6 in. (15.2 cm) from top of seal to top of pontoon with foam outlets under metal weather shield or secondary seal.
  - 1 For each 60 ft (18.3 m) of tank circumference (at least 12 in. (30.5 cm) high required).
  - See A-3-2.11.1(c).

- **Forest Fire Seal**
  - Not Applicable.

- **Foam Outlets Under Floating Roof Tank Seals or Metal Secondary Seal**
  - Hydrocarbon Application Rates
    - Not Applicable.
  - Discharge Times
    - Not Applicable.
  - Polar Solvents
    - Not Applicable.

- **Storage Tank Protection Summary**

  - **No. of Foam Chambers Required**
    - Not Applicable.

  - **Foam Chamber**
    - 0.30 gpm (1.14 L/m) per sq ft of annular ring area with foam dam or with foam application under metal weather seal or secondary seal.
    - 0.50 gpm (1.9 L/m) per sq ft for all other applications.

  - **Discharge Times**
    - Not Applicable.

  - **Polar Solvents**
    - Not Applicable.

  - **Not covered by NFPA 11.**
### Storage Tank Protection Summary (cont.)

<table>
<thead>
<tr>
<th>Size of Tank</th>
<th>Fixed (Cone) Roof Tanks</th>
<th>Pontoon or Double-Deck Floating Roof Tanks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrocarbon Application Rates</td>
<td>Monitors for tanks up to 60 ft (18.3 m) in diameter. Hand hoseslines for tanks less than 30 ft (9.2 m) in diameter and less than 20 ft (6.1 m) high. See 3-1.3.1.</td>
<td>Monitors not recommended. Handlinees are suitable for extinguishment of rim fires in open-top floating roof tanks. See 3-1.1.</td>
</tr>
<tr>
<td>Hydrocarbon Application Rates</td>
<td>0.16 gpm/ft² (6.5 L/min/m²)</td>
<td>0.16 gpm/ft² (6.5 L/min/m²)</td>
</tr>
<tr>
<td>Discharge Times</td>
<td>Flash point below 100°F (37.8°C) 65 min</td>
<td>Use same times as for open-top floating roof tank rim fires.</td>
</tr>
<tr>
<td>Discharge Times</td>
<td>Flash point between 100°F and 140°F (37.8 and 194.4°C) 50 min</td>
<td>65 min</td>
</tr>
<tr>
<td>No. Required</td>
<td>Same as table for Foam Chambers. See above. See 3-2.6.1, 3-2.6.2, 3-2.6.3, 3-2.6.4, 3-2.6.5.</td>
<td>Not Recommended.</td>
</tr>
<tr>
<td>Subsurface Application Outlets</td>
<td>Minimum 0.1 gpm/ft² (4.1 L/min/m²) of liquid surface</td>
<td>Not Recommended.</td>
</tr>
<tr>
<td>Hydrocarbon Application Rates</td>
<td>Foam velocity from outlet shall not exceed 10 ft per sec (3.05 m per sec) for Class 1B liquids or 20 ft per sec (6.1 m per sec) for all other liquids. See 3-2.6.3, 3-2.6.6.</td>
<td>Not Recommended.</td>
</tr>
<tr>
<td>Discharge Times</td>
<td>Flash point 100°F (37.8°C) to 140°F (194.4°C) 30 min</td>
<td>Not Recommended.</td>
</tr>
<tr>
<td>Discharge Times</td>
<td>Flash point below 100°F (37.8°C) 55 min</td>
<td>Not Recommended.</td>
</tr>
<tr>
<td>Polar Solvents</td>
<td>Crude Petroleum 55 min</td>
<td>55 min</td>
</tr>
<tr>
<td>Polar Solvents</td>
<td>Not Recommended.</td>
<td>Not Recommended.</td>
</tr>
</tbody>
</table>

For SI Units: 1 gpm/ft² = 0.017286 L/min/m²; 1 ft = 0.305 m; 1 ft² = 0.0929 m²; 1 in. = 0.0254 m; °C = °F - 32/1.8

#### Appendix C Tests for the Physical Properties of Foam

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

**C-1 (A-6-1.1.1) Procedures for Measuring Expansion and Drainage Rates of Foams.**

Foam Sampling. The object of foam sampling is to obtain a sample of foam typical of that to be applied to the burning surface under anticipated fire conditions. Inasmuch as foam properties are readily susceptible to modification through the use of improper techniques, it is extremely important that the prescribed procedures be followed.

A collector has been designed chiefly to facilitate the rapid collection of foam from low-density patterns; in the interest of standardization it is also used for all sampling except where pressure-produced foam samples are being drawn from a line tap. A backboard is inclined at a 45 degree angle suitable for use with vertical streams falling from overhead applicators as well as horizontally directed streams. [See Figures C-1 (a) (A-6-1.1.1 (a)) and C-1 (b) (A-6-1.1.1 (b)) following.]

The standard container is 7.9 in. (20 cm) deep and 3.9 in. (10 cm) inside diameter (1600 ml) preferably made of 1/16-in. (1.6 mm) thick aluminum or brass. The bottom is sloped to the center where a 1/4-in. (6.4-mm) drain fitted with a 1/4-in. valve is provided to draw off the foam solution. [See Figure C-1 (b) (A-6-1.1.1 (b)) following.]

**Turrets or Handline Nozzles.** (Here it is presumed that the turret or nozzle is capable of movement during operation to facilitate obtaining the sample.) It is important that the foam samples taken for analysis represent as nearly as possible the foam reaching the burning surface in a normal fire fighting procedure. With adjustable stream devices, it is usually desirable to sample both from the straight stream position, and the fully dispersed position, and possibly other intermediate positions.

Initially, the collector should be placed at the proper distance from the nozzle so as to be the center of the ground pattern. The nozzle or turret should be placed in operation while it is directed off to one side of the collector. After the pressure and operation have become stabilized, the stream is swung over to center on the collector. When a sufficient foam volume has accumulated to fill the sample containers, usually in a matter of only a few seconds, a stopwatch is started for each of the two samples in order to provide the "zero" time for the drainage test described later. Immediately, the nozzle is turned away from the collector, the sample containers are removed, and the top struck off with a straight edge. After all foam has been wiped off from the outside of the container, the sample is ready for analysis.
Overhead Devices. (Here it is presumed that the devices are fixed and not capable of movement.) Prior to starting up the stream, the collector is situated within the discharge area where it is anticipated a representative foam pattern will occur. The two sample containers are removed prior to positioning the collector. The foam system is activated and permitted to achieve equilibrium after which time the technician, wearing appropriate clothing, enters the area without delay. The sample containers are placed and left on the collector board until adequately filled. Stopwatches are started for each of the samples to provide the "zero" time for the drainage rate test described later. During the entry and retreat of the operator through the falling foam area, the containers shall be suitably shielded from extraneous foam. Immediately after removing the samples from under the falling foam, the top should be struck off with a straight edge and all foam wiped off from the outside of the container. The sample is then ready for analysis.

Pressure Foam. (Here it is presumed that foam is flowing under pressure from a foam pump or high-pressure aspirator toward an inaccessible tank outlet.) A 1-in. size pipe tap fitted with a globe valve should be located as close to the point of foam application as practicable. The connection should terminate in an approximate 18-in. (457-mm) section of flexible rubber tubing to facilitate filling the sample container. In drawing the sample, the valve should be opened as wide as possible without causing excessive splashing and air entrainment in the container. Care must be exercised to eliminate air pockets in the sample. As each container is filled, a stopwatch is started to provide the "zero" time for the drainage test described later. Any excess foam is struck off the top with a straight edge and all foam clinging to the outside of the container is wiped off. The sample is then ready for analysis.

Foam Chambers. In some instances where the foam makers are integral with the foam chambers on the top ring of a tank, none of the above methods of sampling may be workable. In this case it will be necessary to improvise as well as possible, making sure any unusual procedures or conditions are pointed out in reporting the results. Where access can be gained to a flowing foam stream, the container can be inserted into the edge of the stream to split off a portion for the sample. The other alternative is to scoop foam from a layer or blanket already on the surface. Here an attempt must be made to obtain a full cross section of foam from the entire depth but without getting any fuel below the foam layer. The greatest difficulty inherent in sampling from a foam blanket is the undesirable lag-in-time factor involved in building up a layer deep enough to scoop a sample. At the normal rates of application, it may take a few minutes to build up the several inches in depth required and this time may definitely affect the test results. The degree of error thus incurred will in turn depend on the type of foam involved, but it can vary from zero percent to several hundred percent.

In a Moeller tube installation, it would be advisable to sample right alongside the tube as foam oozes out in good volume.

Immediately after filling the container, a stopwatch is started to provide the "zero" time for the drainage test described later. Any excess foam is struck off the top with a straight edge and all foam wiped off from the outside of the container. The sample is then ready for analysis.

Foam Testing. The foam samples, as obtained in the above described procedures, are analyzed for expansion, 25 percent drainage time, and foam solution concentration. It is recommended that duplicate samples be obtained whenever possible and the results averaged for the final value. However, when a shortage of personnel or equipment or both creates a hardship, the taking of one sample will be acceptable.

Apparatus Required.
- 2 1 1600 ml sample containers
- 1 -- foam collector board
- 1 -- balance (triple beam balance, 2610 g capacity)

Procedure. Prior to the testing, the empty containers fitted with a drain hose and clamp should be weighed to obtain the tare weight. (All containers should be adjusted to the same tare weight to eliminate confusion in handling.) Each foam sample is weighed to the nearest gram and the expansion calculated from the following equation:

$$\frac{1600}{(\text{full weight minus empty weight})} = \text{expansion}$$

(All weights to be expressed in grams.)
Foam 25 Percent Drainage Time Determination. The rate at which the foam solution drops out from the foam mass is called the drainage rate and is a specific indication of degree of water retention ability and the fluidity of the foam. A single value is used to express the relative drainage rates of different foams in the "25 percent drainage time." It is the time in minutes that it takes for 25 percent of the total solution contained in the foam in the sample containers to drain.

Apparatus Required

2 — Stopwatches
1 — Sample stand
4 — 100-ml capacity plastic graduates

Procedure. This test is performed on the same sample as used in the expansion determination. Dividing the net weight of the foam sample by 4 will give the 25 percent volume, in ml., of solution contained in the foam. To find the time required for this volume to drain out, the sample container should be placed on a stand, as indicated, and at regular suitable intervals the accumulated solution in the bottom of the container should be drawn off into a graduate. The time intervals at which the accumulated solution is drawn off are dependent on the foam expansion. For foams of expansion 4 to 10, 30-second intervals should be used, and for foams of expansion 10 and above, 4-minute intervals should be used because of the slower drainage rate of foams of this type. In this way, a time-drainage volume relationship is obtained and after the 25 percent volume has been exceeded, the 25 percent drainage time is interpolated from the data. The following example shows how this is done:

The net weight of the foam sample has been found to be 180 grams. Since 1 gram of foam solution occupies essentially 1 ml., the total volume of foam solution contained in the given sample is 180 ml.

Expansion \[= \frac{1600}{180} = 8.9\]

25% Volume \[= \frac{180}{4} = 45 \text{ mL}\]

Then if the time-solution volume data has been recorded as follows:

<table>
<thead>
<tr>
<th>Time — Min.</th>
<th>Drained Solution Volume — mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.5</td>
<td>10</td>
</tr>
<tr>
<td>1.0</td>
<td>20</td>
</tr>
<tr>
<td>1.5</td>
<td>30</td>
</tr>
<tr>
<td>2.0</td>
<td>40</td>
</tr>
<tr>
<td>2.5</td>
<td>50</td>
</tr>
<tr>
<td>3.0</td>
<td>60</td>
</tr>
</tbody>
</table>

It is seen that the 25 percent volume of 45 ml lies within the 2.0- and 2.5-minute period. The proper increment to add to the lower value of 2.0 minutes is determined by interpolation of the data:

45 mL (The 25% Vol.) — 40 mL (The 2.0 min Vol.)

50 mL (The 2.5 min. Vol.) — 40 mL (The 2.0 min Vol.)

\[= \frac{5}{10} = \frac{1}{2}\]

This means it is halfway between 2.0 and 2.5 minutes, or 2.25 minutes, which is rounded off to 2.3 minutes.

An effort should be made to conduct foam tests with water temperatures between 60 and 80°F (15.6 to 26.7°C). The water, air, and foam temperatures should be noted in the results. Lower water temperature tends to depress the expansion values and increase the drainage time values.

NOTE: When handling fast-draining foams, remember that they lose their solution rapidly and the expansion determination should be carried out with speed and dispatch in order not to miss the 25 percent drainage volume. The stopwatch is started at the time the foam container is filled and continues to run during the time the sample is being weighed. It is recommended that expansion weighing be deferred until after the drainage curve data has been received.

C-2 (A-6.1.1.3) Foam Solution Concentration Determination.

General. This test is used to determine the percent concentration of a foam concentrate in the water being used to generate foam concentrate in the water being used to generate foam. It is typically used as a means of determining the accuracy of a system's proportioning equipment. If the level of foam concentrate injection values vary widely from design, it may abnormally influence the expansion and drainage foam quality values which may influence the foams fire performance.

There are two acceptable methods for measuring foam concentrate percentage in water. Both methods are based on comparing foam test samples to pre-measured solutions which are plotted on a graph or percent concentration versus instrument reading.

Refractive Index Method. A hand held refractometer is used to measure the refractive index of the foam solution samples. This method is not particularly accurate for AFFF or alcohol resistant foams since they typically exhibit very low refractive index readings. For this reason the conductivity method is recommended when these products are used.

1. Equipment Required. A base (calibration) curve is prepared using the following apparatus:

(a) Three 100-milliliter graduates
(b) One measuring pipette (10 milliliter) or hypodermic syringe (10 cc)
(c) One 100 milliliter beaker
(d) One 500 milliliter beaker
(e) One hand-held refractometer.

2. Procedure. Using water and foam concentrate from the system to be tested make up three standard solutions in the 100 milliliter graduates. These samples should include the nominal intended percentage of injection the nominal percentage plus 1 percent and the nominal percentage minus 1 percent. Place the water in the 100 milliliter graduates (leaving adequate space for the foam concentrate) and then carefully measure the foam concentrate samples into the water using the pipette or syringes. Use care not to draw air into the foam concentrate samples.

After thoroughly mixing the foam sample solutions, a refractive index reading is taken of each percentage foam sample solution. This is done by placing a few drops of the solution on the refractometer prism closing the cover plate, and observing the scale reading at the dark field intersection. Since the refractometer is temperature compensated it may take 10 to 20 seconds for the sample to be read properly. It is important to take all refractometer readings at ambient temperatures of 50°F (10°C) or above.

Using standard graph paper plot the refractive index readings on one axis against percent concentration on the other. This plotted curve will serve as the known base line for the test series.

3. Sampling and Analysis. Collect foam solution samples from the proportioning system using care to be sure the sample is taken at an adequate distance downstream from the proportioner being tested. Take refractive index readings of the samples and compare them to the plotted curve to determine the percentage of the samples.
Conductivity Method. This method is based on changes in electrical conductivity as foam concentrate is added to water. A hand held conductivity meter is used to measure the conductivity of foam solutions in microsiemen units. Conductivity is a very accurate method providing there are substantial changes in conductivity as foam concentrate is added to the water in relatively low percentages (i.e., 1 percent, 3 percent, or 6 percent). Since salt or brackish water is very conductive this method may not be suitable due to small conductivity changes. Thus, it may be necessary to make foam and water solutions in advance to determine if adequate changes in conductivity can be detected if the water source is salty or brackish.

1. Equipment Required. Prepare a base (calibration) curve using the following apparatus:
   (a) Four 500 ml plastic bottles with caps.
   (b) One plastic syringe (10 or 20 ml).
   (c) One 500 ml graduated cylinder.
   (d) Three or four plastic coated magnetic stirring bars.
   (e) Portable temperature compensated conductivity meter.
   (f) Standard graph paper.
   (g) Ruler or other straight edge.

2. Procedure. Using the water and foam concentrate from the system to be tested make up three standard solutions using the 500 ml graduate. These samples should include the nominal intended foam concentrate plus 1 percent and the nominal percentage minus 1 percent. Place the water in the 500 ml graduate (leaving adequate space for the foam concentrate) and then carefully measure the foam concentrate samples into the water using the syringe. Use care not to pick up air in the foam concentrate samples. Pour each measured foam solution from the 500 ml graduate into a 500 ml plastic bottle. Each bottle should be marked with the percent solution it contains. Add a plastic stirring bar to the bottle, cap it and shake thoroughly to mix the foam solutions.

After making the three foam solutions in this manner, measure the conductivity of each solution. Refer to the instructions which come with the conductivity meter to determine proper procedures for taking readings. It will be necessary to switch the meter to the correct conductivity range setting in order to obtain a proper reading. Most synthetic based foams used with fresh water will result in foam solution conductivity readings of less than 2000 microsiemens. Protein based foams will generally produce conductivity reading in excess of 2000 in fresh water solutions. Due to the temperature compensation feature of the conductivity meter it may take a minute or two to obtain a consistent reading.

Once the solution samples have been measured and recorded, set the bottles aside for control sample references. The conductivity readings should then be plotted on the graph paper. It is most convenient to place the foam solution percentage on the horizontal axis and conductivity readings on the vertical axis.

Use a rule or straight edge to draw a line which approximates connecting all three points. While it may not be possible to hit all three points with a straight line, they should be very close. If not, repeat the conductivity measurements and if necessary make new control sample solutions until all three points plot in a nearly straight line. This plot will serve as the known base (calibration) curve to be used for the test series.

3. Sampling an Analysis. Collect foam solution samples from the proportioning system using care to be sure the sample is taken at an adequate distance downstream from the proportioning being tested. Using foam solution samples which are allowed to drain from expanded foam may produce misleading.

C3 (A6-1.1.4) Interpretation of Foam Test Results. When the intent of conducting these tests is to check the operating efficiency or standby condition, it is not necessary to compare the results with the manufacturers' standards. The manufacturers should be consulted if any appreciable deviations occur.

After a short period of experience with the test procedure, it will be observed that foams exist in a wide variety of physical properties. Not only may the expansion vary in value from 3 to 20, but at the same time the 25 percent drainage time may also vary from a few seconds to several hours. These variations result in foams that vary in appearance from a watery consistency to the stiffest whipped cream.

It is observed here that the foam solution rapidly drains out of the very watery foams, while with the stiff foams the drop out is very slow. It is possible to have a foam that is fluid and free flowing and, at the same time, able to hold onto its foam solution. From the standpoint of quickly forming a cohesive foam blanket and rapid flow around obstructions, a fluid-type foam is desirable; however, foams of this nature lose their water more rapidly, which may reduce their resistance to flame burnback and shorten the effective time of sealability. On the other hand, foams that retain their water for a long time are stiff and do not spread readily over a burning area. Thus, good fire fighting practice indicates a compromise between these two opposite foam properties in order to obtain an optimum foam. An optimum foam is defined as that foam, with physical properties defined by expansion and drainage time, that will extinguish a fire faster, at a lower application rate, or with less water consumed than any other foam.

Numerous test fires conducted in the course of research and development work have shown that the characteristics of an optimum foam depend on the type of the fire and the manner of foam application. Experience over many years of satisfactory results has supported this viewpoint. For example, in a large fuel storage tank, foam may be gently applied from one chamber and be required to flow 66 ft (19.8 m) across a burning surface to seal off the fuel. In this case, the optimum foam is physically different from that applied in a splashing manner from a turret which can direct the foam application as needed, and the foam has to flow no more than in. (12.7 mm) to form a seal. The formation of a complete specification for the various methods of application has not as yet been accomplished; however, for guidance purposes, the best data available to date is presented.

C4 (A6-1.1.5) Inspection of Foam Concentrate. To determine the condition of the apparatus, the foam concentrate, and for the training of personnel, foam should actually be produced annually with portable foam nozzles. Following this operation, the concentrate container (can) should be cut open and examined for deposits of sludge, scale, etc., which are capable of impairing the operation of the equipment.

Where the concentrate is stored in tanks, a sample should be drawn from the bottom of the tank annually, and actual foam production tested as indicated above, using a portable foam nozzle and the withdrawn sample to verify the quality of foam produced.

In the event that sludging of the concentrate is noted, the manufacturer should be promptly consulted.

Appendix (D) Foam Fire Fighting Data Sheet

This will appear on a separate tearout page in the final document.

(D-1) The following data sheet is used to record and evaluate data on actual fires and fire tests where fire fighting foam is used. This data may be considered in evaluating suggestions for changes to NFPA 11, Standard for Low Expansion Foam and Combined Agent Systems. Persons having knowledge of such fires are requested to complete the form and send it to:

National Fire Protection Association, Inc.
Batterymarch Park
Quincy, MA 02269

In the case of multiple attacks or refills of the same fire, additional data sheets should be prepared for each attack.
## FOAM FIRE FIGHTING DATA SHEET

**DATE OF FIRE**

**TIME OF FIRE**

**LOCATION** [City, State, Country, Facility (if available)]

**SIZE OF FIRE** (Dimensions of tank, pit, spill, and extent involved)

**IGNITION SOURCE** (Specify if test)

**METHOD OF DETECTION**

**FUEL:**
- **GENERAL TYPE** (Indicate percentage polar solvent content or additives)
- **REID VAPOR PRESSURE** (psia)
- **INITIAL TEMPERATURE**
- **BOILING RANGE**
- **FLASH POINT**
- **DEPTH BEFORE FIRE:**
  - **FUEL**
  - **WATER BOTTOM**
- **DEPTH AFTER FIRE:**
  - **FUEL**
  - **WATER BOTTOM**

**AMBIENT CONDITIONS:**
- **TEMPERATURE**
- **HUMIDITY**
- **PRECIPITATION**
- **WIND DIRECTION**
- **WIND SPEED**, INCLUDING GUSTS

**PREBURN TIME PRIOR TO FOAM APPLICATION**

**CONTROL TIME (90%)**

**EXTINGUISHMENT TIME**

**DISCHARGE TIME AFTER EXTINGUISHMENT**

**TIME OF REFRACTION**

**WATER**
- **SALT**
- **FRESH**
- **OTHER** (Explain)
  - **TEMPERATURE**
  - **SOURCE**
  - **ADDITIVES**

**DESCRIPTION OF HAZARD/FACILITY** (Indoors, outdoors, confined or unconfined, material of tank)

**EXTERIOR COOLING RATE**

**FOAM PROPERTIES** (Identify apparatus used):
- **APPARATUS**
- **EXPANSION**
- **25% DRAINAGE**
- **BURNBACK**
- **SEALABILITY**

**BRIEF SCENARIO**

**UNUSUAL CIRCUMSTANCES**

**TEST LABORATORY OR OTHER THIRD PARTY OBSERVER**

**SUBMITTER**

**POINT OF CONTACT**

**TELEPHONE NUMBER**

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**Appendix (E) Referenced Publications**

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

(E-1.1) **Other Publications.**

(E-1.1.1) **ANSI Publication.** American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.


(E-1.1.2) **ASTM Publication.** American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.


(E-1.1.3) **AWS Publication.** American Welding Society, 2501 N.W. 7th Street, Miami, FL 33125.

With reference to the above mentioned NFPA article, we are questioning its application insofar as our Foamex High Expansion System is concerned.

We have taken the liberty to send you our complete technical data along with our F.M. and U.L.C. report, describing our Foamex System from A to Z.

You will find that our system does not fit the descriptions that we have found in the NFPA Book, since it has no moving parts, motors, fans, eductors, proportionners, etc.

Our firm was formed in 1973 and we now have many good fire extinguishing feet to our credit, and feel that our system is a reasonable alternative to other existing fire fighting system, especially in areas that lack large quantities of water or that water is not the extinguishing agent to prescribe.

We must emphasize, that our system should be compared to large self contained, completely automatic fire extinguisher, and is always engineered to meet the need of the hazard it is protecting.

We have come up with certain restrictions of applications at times, when dealing with insurance companies or local fire authorities, insofar as the NFPA Description, Standards etc. are concerned.

NOTE: Supporting material is available for review at NFPA Headquarters.

SUBSTANTIATION: Foamex System.

Not included in various descriptions of foam systems in NFPA 11A.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: No specific wording proposed. The chairman appointed a subcommittee to contact the submitter and make appropriate recommendations.