Report of Committee on Foam

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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.

The Report of the Committee on Foam consists of two parts:

Part I presents for official adoption amendments to NFPA 11, Standard for Foam Extinguishing Systems. Chapters 3, 4, 5 & 6 have been editorially reorganized to make the standard easier to use. The substantive changes are indicated by a vertical line. NFPA 11 is published in the 1975 National Fire Codes, Volume 1, and in separate pamphlet form.

Part II presents for official adoption NFPA 11A, Standard for High Expansion Foam Systems. The standard has been rewritten according to the NFPA Manual of Style and equivalent SI units have been added to the customary units. The substantive changes to the standard are indicated by a vertical line. NFPA 11A is published in the 1975 National Fire Codes, Volume 1, and in separate pamphlet form.

Part II has been submitted to letter ballot of the committee which consists of 26 voting members, of whom 25 have voted affirmatively and Mr. Murphy has not returned his ballot.

Part I

Proposed Revisions to the Standard for Foam Extinguishing Systems

NFPA 11 – 1974

1. 1735. Delete the 4th sentence of paragraph 1735 and rewrite the 4th thru 7th sentences of the paragraph as follows:

Pipe sizes shall be so selected as to produce the proper delivery rate and pressure at the discharge outlet. (See Chapter 7 of NFPA No. 13, Standard for the Installation of Sprinkler Systems, for hydraulic calculation procedures for water and solution flow.) For friction losses in piping carrying foam concentrate see NFPA No. 16, Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems, Section 4064. For friction losses in piping carrying foam, see A-3561. For purpose of computing friction loss in piping, the following “C” factors shall be used for the Hazen and Williams formula:

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

2. 261. In the last sentence delete NFPA No. 16 and add NFPA No. 13, Standard for the Installation of Sprinkler Systems.

3. Revise Chapter 3 to read as follows:
CHAPTER 3.
FIXED SYSTEMS FOR EXTERIOR STORAGE TANKS

*300. General.

301. SCOPE: This chapter contains requirements which apply specifically to the foam systems used for the protection of outdoor vertical atmospheric storage tanks containing flammable and combustible liquids by means of fixed foam discharge outlets. System design shall be based on the maximum solution flow for protecting a single tank and the required supplementary hose streams.

NOTE: Tanks containing Class III liquids are not, as a rule, required to be protected by foam. Foam protection for Class III liquids may be desirable where abnormal situations exist, such as storage of high value stocks or liquids heated above their flash point.

*302. DEFINITIONS:

(a) FIXED FOAM DISCHARGE OUTLET: A device permanently attached to a tank by means of which foam is introduced into the tank.

(b) TYPE I. DISCHARGE OUTLET: An approved discharge outlet which will conduct and deliver foam gently onto the liquid surface without submergence of the foam or agitation of the surface.

(c) TYPE II. DISCHARGE OUTLET: An approved discharge outlet which does not deliver foam gently onto the liquid surface but is designed to lessen submergence of the foam and agitation of the surface.

(d) SUBSURFACE FOAM INJECTION: Discharge of foam into a storage tank from an outlet at the tank bottom or below the liquid surface.

(e) FIXED INSTALLATIONS: These are complete installations piped from a central foam house to the tanks, discharging through fixed delivery outlets on the tanks. Any required pumps are permanently installed.

(f) SEMI-FIXED INSTALLATIONS:

(1) The type in which tanks are equipped with fixed discharge outlets connected to piping which terminates at a safe distance from the tanks. 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) The type in which foam-producing solutions are piped from a central foam house through the area, the solution being delivered through hose lines to portable foam towers which are erected after the fire starts (Chapter 5); or applied by hose streams (Chapter 4).

310. Foam Application Rates.

311. RATES: The minimum delivery rate shall be as follows:

3110: TANKS CONTAINING LIQUID HYDROCARBONS:

(a) For air foam systems, the foam solution delivery rate shall be at least 0.1 gpm/sq. ft. of liquid surface area of the tank to be protected.

NOTE 1: Flammable liquids having a boiling point of less than 100°F may require higher rates of application. Suitable rates of application should be determined by test.

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

3111. TANKS CONTAINING OTHER FLAMMABLE AND COMBUSTIBLE LIQUIDS REQUIRING SPECIAL FOAMS: Water soluble and certain flammable and combustible liquids and polar solvents which are destructive to regular foams require the use of alcohol type foams. Systems using these foams require special engineering consideration. Conditions other than routine may require that higher application rates be used. In all cases, the manufacturer of the foam concentrate and the foam-making equipment should be consulted as to the limitations and for recommendations based on listings or specific fire tests. The following are minimum recommended application rates:

<table>
<thead>
<tr>
<th>TYPE OF LIQUID</th>
<th>SOLUTION RATE gpm/sq.ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methyl and ethyl alcohol</td>
<td>0.1</td>
</tr>
<tr>
<td>Acrylonitrile</td>
<td>0.1</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>0.1</td>
</tr>
<tr>
<td>Methyl ethyl ketone</td>
<td>0.1</td>
</tr>
<tr>
<td>Acetone</td>
<td>0.15</td>
</tr>
<tr>
<td>Butyl alcohol</td>
<td>0.15</td>
</tr>
<tr>
<td>Isopropyl ether</td>
<td>0.15</td>
</tr>
</tbody>
</table>
Products such as isopropyl alcohol, methyl isobutyl ketone, methyl methacrylate monomer, and mixtures of polar solvents in general may require higher application rates. Protection of products such as amines and anhydrides, which are particularly foam destructive, require special consideration.

NOTE 1: The solvent and fire resistance of alcohol type air foam may be adversely affected by such factors as excessive solution transit time, the use of foam-making devices not specifically designed or adequately tested for a particular alcohol foam application, operating pressure, failure to maintain proportioning within the recommended concentration limits, the method of application and the characteristics of the particular solvent to which the foam is to be applied.

Solution transit time, that is 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 hazard protected. The maximum solution transit time of each specific installation shall be within the limits established by the manufacturer.

NOTE 2: For protection of combustible or flammable liquids which are highly toxic, high application rates may be desirable to reduce respiratory hazard to personnel by providing for more rapid coverage of the tank contents.

*3112. Supplementary 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 as 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 hose stream shall have a solution rate of at least 50 gpm, with the minimum number of hose streams shown below:

<table>
<thead>
<tr>
<th>Minimum number of hose streams required</th>
<th>DIAMETER OF LARGEST TANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 65 ft.</td>
<td>1</td>
</tr>
<tr>
<td>Over 65 to 120 ft.</td>
<td>2</td>
</tr>
<tr>
<td>Over 120 ft.</td>
<td>3</td>
</tr>
</tbody>
</table>

320. Duration of Discharge.

321. Minimum Discharge Times: The system shall be capable of operation at the delivery rate specified in 311, for the tank to be protected, for the following minimum periods of time. If the apparatus available has a delivery rate higher than specified in 311, proportionate reduction in the time figures may be made, except that they shall not be less than 70 percent of the minimum discharge times shown.

<table>
<thead>
<tr>
<th>Minimum Operating time*</th>
<th>DIAMETER OF LARGEST TANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 35 ft.</td>
<td>10 min.</td>
</tr>
<tr>
<td>Over 35 to 95 ft.</td>
<td>20 min.</td>
</tr>
<tr>
<td>Over 95 ft.</td>
<td>30 min.</td>
</tr>
</tbody>
</table>

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

NOTE: In the case of alcohol type foam, solution transit time limitations may require the use of separate water and foam concentrate lines and that the introduction of the foam concentrate be accomplished close to the foam nozzle rather than in the central foam house.
REVISIONS TO NFPA 11

334. REQUIREMENTS TO FILL PIPE LINE: A quantity of foam-producing materials sufficient to produce foam or foam solutions to fill the feed lines actually installed between the source and the most remote tank shall also be provided. Where a water supply source will continue after the foam-producing material is depleted and displace the solution or foam from the lines to the tank, no added quantity is required by this paragraph.

335. RESERVE SUPPLY OF FOAM-PRODUCING MATERIALS: There shall be a readily available reserve supply of foam-producing materials as specified in 1742.

*336. TOTAL SUPPLY REQUIREMENTS: Supplies to be maintained shall be the sum of the quantities defined in 332, 333, 334 and 335.

340. Foam Discharge Outlets.

341. SURFACE APPLICATION:

*3411. VERTICAL FIXED ROOF ATMOSPHERIC STORAGE TANKS: For the protection of a flammable liquid contained in a vertical fixed 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 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.

(a) Tanks shall be provided with approved discharge outlets as set forth below:

<table>
<thead>
<tr>
<th>TANK DIAMETER — FEET (or equivalent area)</th>
<th>MINIMUM NUMBER DISCHARGE OUTLETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 80</td>
<td>1</td>
</tr>
<tr>
<td>Over 80 to 120</td>
<td>2</td>
</tr>
<tr>
<td>Over 120 to 140</td>
<td>3</td>
</tr>
<tr>
<td>Over 140 to 160</td>
<td>4</td>
</tr>
<tr>
<td>Over 160 to 180</td>
<td>5</td>
</tr>
<tr>
<td>Over 180 to 200</td>
<td>6</td>
</tr>
</tbody>
</table>

Note: It is suggested that for tanks above 200 feet in diameter, at least one additional discharge outlet be added for each additional 5000 sq. ft. of liquid surfaces. Since there has been no experience with foam application to fires in fixed roof tanks over 140 feet 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 can travel effectively across at least 100 feet of burning liquid surface. On large tanks, subsurface injection may be used to reduce foam travel distances.

(b) Fixed outlets shall be provided with an effective and durable seal, frangible under low pressure, to prevent entrance of vapors into foam outlets and pipe lines. Fixed outlets shall be provided with suitable inspection means to permit proper maintenance and for inspection and replacement of vapor seals.

*3412. OPEN TOP FLOATING ROOF STORAGE TANKS: Fixed outlets are generally not required on open top floating roof tanks. These tanks have an excellent fire record. Their design has been for the purpose of fire prevention as well as for conservation of product. It is usually possible to utilize trained personnel to extinguish fires in the annular ring using portable equipment. There are locations, however, where fixed protection may be desired because of value of products stored, remoteness of installation, or lack of fire fighting personnel. Suggested methods for providing fixed foam systems for open top floating roof tanks will be found in the Appendix.

*3413. COVERED FLOATING ROOF STORAGE TANKS: Fixed outlets are generally not required on covered floating roof tanks. The possibility of fire is greatly reduced in comparison with other types because of the Faraday Cage type construction of this type of tank. In the event of fire, these tanks are difficult to extinguish using portable equipment. Fixed protection may be desired in certain locations because of value of products stored, remoteness of installation, or lack of fire fighting personnel. Suggested methods for providing fixed foam systems for these tanks will be found in the Appendix.

Note: A “Faraday Cage” is a grounded metallic screen completely surrounding a space or piece of equipment in order to shield it from external electrostatic influence.

*3414. Diked Areas: Fixed foam systems are not generally required for tank diked areas. Portable foam monitors or foam streams or both generally provide an acceptable method of protection. See 402 for the recommended method of fighting diked area fires. Where fixed system protection is desirable for diked areas, see Appendix for suggested design criteria.
3415. **Supplementary Protection:** It is desirable that at least one portable tower or portable monitor be provided as supplementary protection in the event that a fixed discharge outlet is damaged by an explosion within the tank (see Chapters 4 and 5).

342. **Subsurface Application to Fixed Roof Storage Tanks Containing Liquid Hydrocarbons:**

*3421. General:* Subsurface foam injection systems are suitable for protection of liquid hydrocarbons in vertical fixed roof atmospheric storage tanks.

**Note:** For pertinent information regarding fire fighting operations, see Appendix A-3421.

3422. **Limitations:** Subsurface injection systems are not suitable for protection of products such as alcohols, esters, ketones, aldehydes, anhydrides, etc. Liquid hydrocarbons that contain such products which are foam destructive may require higher application rates. The manufacturer of the foam system should be consulted for recommendations. Subsurface or semi-subsurface injection systems are not recommended for floating roof tanks because of the possibility of improper distribution of foam to the fuel surface.

*3423. Foam-Producing Materials and Equipment:* Foam-producing materials and equipment for subsurface injection shall be listed for this purpose. Fluoroprotein foam concentrates will provide satisfactory subsurface injection performance.

3424. **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 foam generator discharge pressure and foam velocity limitations are not exceeded. The foam velocity at the point of discharge into the tank contents shall not exceed 10 feet per second for Class IB liquids or 20 feet per second for other type liquids unless actual tests prove higher velocities are satisfactory (see Appendix A-352).

Where two or more outlets are required, they shall be located so that the foam travel on the surface does not exceed 100 feet. Each outlet should 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. Shell connections may be made in manway covers rather than installing additional tank nozzles.

3425. Tanks shall be provided with discharge outlets as set forth below:

<table>
<thead>
<tr>
<th>TANK DIAMETER — FEET</th>
<th>CLASS IB LIQUIDS</th>
<th>CLASSES IC, II &amp; III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 80</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Over 80 to 120</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Over 120 to 140</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Over 140 to 180</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Over 180 to 200</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Over 200, add one inlet for each additional 5000 sq. ft.</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

**Note 1:** Class IA Liquids require special consideration.

**Note 2:** The above table is based on extrapolation of fire test data on 25, 93 and 115 foot diameter tanks containing gasoline, crude and hexane, respectively.

**Note 3:** The most viscous fuel which has been extinguished by subsurface injection when stored at ambient temperatures (80°F) had a viscosity of 25 S.S.U. at 122°F and a pour point of 15°F. This is similar to heavy fuel oil. In addition to the control provided by the smothering effect of the foam and the cooling effect of the water in the foam which reaches the surface, fire control and extinguishment may be further enhanced by the rolling of cool product to the surface. No known tests have been conducted on product having a higher viscosity than this fuel oil.

3426. **Foam Discharge Outlet Elevation:** Foam discharge outlets should be located above an established water bottom, if possible. Otherwise, if it is established that there is a water bottom in the tank above the foam discharge outlets, it should be drained to below the point of foam injection prior to putting the foam system into operation. If this is not accomplished, efficiency will be reduced as a result of dilution of the foam, prolonging or preventing extinguishment.

*343. Semi-Subsurface Injection Method:* Information for the use of this method will be found in the Appendix.

344. **Horizontal Atmospheric and Pressure Tanks:** Fixed outlets are not recommended to discharge into horizontal or pressure tanks.

350. **Foam System Piping.**

351. **General Requirements:**
3511. All piping inside of dikes and within 50 feet of tanks not diked should be buried under at least one foot of earth but may be permitted above ground if properly supported and protected against mechanical injury.

3512. Piping which is normally filled with liquids, such as the suction pipes, shall be protected from freezing when necessary.

3513. Piping from the dike or within 50 feet of tanks not diked to the tank foam discharge outlet shall be designed to absorb the upward force and shock due to a tank roof rupture. Preferably, use steel pipe and all-welded construction. One of the following designs may be used:

(a) When piping is buried, a swing joint or other suitable means shall be provided at the base of each tank riser. The swing joint may consist of a system of approved standard weight steel, ductile or malleable iron fittings.

(b) When piping is supported above ground, it shall have upward and lateral support as needed, but should not be held down a distance of 50 feet from the tank shell to provide flexibility in an upward direction so that a swing joint is not needed. If threaded connections occur within this distance they shall be back welded for strength.

(c) When tank risers are four-inch pipe-size or greater, they can be welded to the tank by means of steel brace plates positioned perpendicular to the tank and centered on the riser pipe. One brace shall be provided at each shell course. This design may be used in lieu of swing joints or above ground flexibility as described above.

3514. One flanged or union joint shall be provided in each riser within five feet of the ground 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.

3515. In systems with semi-fixed equipment on fixed roof tanks, the foam or solution laterals to each foam chamber shall terminate in connections which are at a safe distance from the tanks; outside of dikes and at least 50 feet from tanks of 50 feet in diameter or less, and one tank diameter from the shell of larger tanks. The inlets to the piping shall be fitted with corrosion-resistant metal connections provided with plugs or caps.

*352. PIPE LINES CARRYING FOAM: Pipe lines shall be of such sizes and lengths as to deliver on the surface protected the required quantity of foam of standard quality. The sizes and lengths of discharge pipe or lines used beyond the foam-maker shall be such that the back pressure is within the range of pressures under which the device has been tested and listed by nationally recognized testing laboratories.

353. VALVES IN SYSTEMS: All valves, except hydrant valves, shall be the O.S. and Y. or post indicator type. The laterals to each foam chamber on fixed roof tanks shall be separately valved outside the dike in fixed installations. Control valves to divert the foam or solutions to the proper tank may be in the central foam house or may be at points where laterals to the protected tanks branch from main feed line. Control valves shall be located outside dikes and not less than the following distances from the shell of the tank which they serve: 50 feet for tanks less than 50 feet in diameter; one diameter for tanks 50 feet in diameter or larger, except that control 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. Where two or more air foam proportioners or chemical foam generators 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 air foam proportioner or chemical foam generator inlet shall be separately valved.

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 foam-generator to be connected at time of use. When product lines are used for foam, product line valving shall be arranged to ensure foam enters only the tank to be protected.

354. FOAM HOSE OUTLETS: Centralized fixed piping systems shall be provided with hose outlets for foam hose streams for supplementary use on spill fires, supplying portable towers, etc. In lieu of foam (or solution) outlets, water hydrants and portable proportioners or other devices acceptable to the authority having jurisdiction may be provided. The minimum number of foam outlets or water hydrants shall be located at a distance of 50 to 250 feet from the shells of tanks protected, as set forth below:
4. Revise Chapter 4 to read as follows:

CHAPTER 4. MONITOR AND HOSE NOZZLES FOR EXTERIOR PROTECTION

400. General.

*401. Scope: This chapter relates to systems in which the foam is applied through fixed or portable monitor or hose nozzles. They are recommended as auxiliary protection in conjunction with fixed piping systems or portable towers as specified in Chapters 3 and 5. They are suitable when used alone for extinguishment of spill fires, diked area fires, and fires in vertical fixed roof atmospheric storage tanks. Portable hose nozzles are suitable for extinguishments of rim fires in open top floating roof tanks.

Note 1: Fires in tanks up to 130 feet in diameter have been extinguished when the entire liquid surface was involved by use of large capacity foam monitors. Depending on the fixed roof tank outage and fire intensity, the up-draft due to chimney effect may prevent sufficient foam from reaching the burning liquid surface for formation of a blanket. Foam must 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. Due to their limitations, monitors should not be depended upon as a primary means of extinguishment for fixed roof tanks over 60 feet in diameter. Monitors operated at grade usually are not recommended for floating roof rim fire extinguishment because of the difficulty of directing foam into the annular space. Fixed foam monitors may be installed for protection of drum storage areas or diked areas. Use of portable towers may present a safety hazard to fire fighters inside the diked area if used to apply foam to tanks containing hot oils, burning asphalts, or other liquids which are above the boiling point of water.

Note 2: Foam hose streams are suitable as a primary means of extinguishment of fires in tanks not over 30 feet in diameter nor over 20 feet high. Foam hose streams can be used for open top floating roof rim fires extinguishment when applied from the tank wind girder or roof.

402. Diked Area Protection: Generally, portable monitors, and/or foam hose streams, have been adequate in fighting diked area and other spill fires. In order to obtain maximum flexibility due to the uncertainty of location and the extent of a possible spill in process areas and tank farms, portable or trailer-mounted monitors are more practical than fixed foam systems. The procedure for fighting diked area fires is to extinguish or secure one area and then move on to extinguish the next section within the dike. This technique should be continued until the complete dike area has been extinguished.

*403. Definitions:

(a) Foam Hose Stream: A foam stream from a hose nozzle which can be held and directed by hand. The nozzle reaction usually limits the solution flow to about 300 gpm.

(b) Foam Monitor Stream: A large capacity foam stream from a nozzle which is supported in position and which can be directed by one man. A solution flow of 300 gpm or higher can be used.

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

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

410. Foam Application Rates.

411. Rates: The minimum delivery rate for primary protection based on the assumption that all the foam reaches the area being protected shall be as follows:

4110. Tanks Containing Liquid Hydrocarbons:

(1) The foam solution delivery rate shall be at least 0.16 gpm/sq. ft. of liquid surface area of the tank to be protected.

Note 1: Flammable liquids having a boiling point of less than 100°F. may require higher rates of application. Suitable rates of application may be determined by test. Flammable liquids with a wide range of boiling points can develop a heat layer after prolonged burning and then may require application rates of 0.2 gpm per square foot or more.
I to high viscosity materials heated above 200°F. Judgment must be used in applying foam to tanks containing hot oils, burning asphalts or burning liquids which are above the boiling point of water. Although the comparatively low water content of foams can beneficially cool such fuels at a slow rate, it can also cause violent frothing and "slop over" of the contents of the tank.

4111. Tanks Containing Other Flammable and Combustible Liquids Requiring Special Foams: Water soluble and certain flammable and combustible liquids and polar solvents which are destructive to regular foams require the use of alcohol type foams. In general, alcohol type foams can be effectively applied through foam monitor or foam hose streams to spill fires of these liquids when the liquid depth does not exceed 1 inch. For liquids in greater depth, monitor and foam hose streams shall be limited for use with special alcohol type foams listed for Type II discharge. 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. The following are minimum recommended application rates:

<table>
<thead>
<tr>
<th>TYPE OF LIQUIDS</th>
<th>SOLUTION RATE</th>
<th>gpm/sq. ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methyl and Ethyl Alcohol</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>Acrylonitrile</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>Ethyl Acetate</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>Methyl Ethyl Ketone</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>Acetone</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>Butyl Alcohol</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>Isopropyl Ether</td>
<td>0.24</td>
<td></td>
</tr>
</tbody>
</table>

Products such as isopropyl alcohol, methyl isobutyl ketone, methyl methacrylate monomer, and mixtures of polar solvents in general may require higher application rates. Protection of products such as amines and anhydrides, which are particularly foam destructive, require special consideration.

NOTE 1: The solvent and fire resistance of alcohol type air foam may be adversely affected by such factors as excessive solution transit time, the use of foam-making devices not specifically designed or adequately tested for a particular alcohol foam application, operating pressures, failure to maintain proportioning within the recommended concentration limits, the method of application and the characteristics of the particular solvent to which the foam is to be applied.

Solution transit time, that is, 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 hazard protected. The maximum solution transit time of each specific installation shall be within the limits established by the manufacturer.

NOTE 2: For protection of flammable or combustible liquids which are highly toxic, higher application rates may be desirable to reduce respiratory hazard to personnel by providing for more rapid coverage.

4112. Supplementary Hose Stream Requirements: Additional foam hose streams and required equipment shall be provided as supplemental protection for ground fires at least as specified in 3112.

420. Duration of Discharge.

421. Minimum Discharge Times: The equipment shall be capable of operation to provide primary protection at the delivery rates specified in 411 for the following minimum periods of time.

**Tanks Containing Liquid Hydrocarbons**

<table>
<thead>
<tr>
<th>Type of Liquid</th>
<th>Minimum Discharge Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lubricating Oils; dry viscous residuum (more than 50 seconds Saybolt Furol at 122°F); dry fuel oils, etc. with flash point above 200°F</td>
<td>35 min.</td>
</tr>
<tr>
<td>Kerosene; light furnace oils, diesel fuels, etc. with flash point 100°F. to 200°F.</td>
<td>50 min.</td>
</tr>
<tr>
<td>Gasoline; naphtha, benzol, and similar liquids with flash point below 100°F.</td>
<td>65 min.</td>
</tr>
<tr>
<td>Crude petroleum</td>
<td>65 min.</td>
</tr>
</tbody>
</table>

**Tanks Containing Other Flammable and Combustible Liquids Requiring Special Forms**

Alcohol type foams require special application procedures as discussed in 411. The operation time shall be 65 minutes at specified application rates, unless the manufacturer has established by fire test that a shorter time can be permitted.

**Extinguishment of Spill Fires:** Where the primary purpose of the protection is for extinguishment of spill fires, the minimum discharge time shall be 10 minutes for fixed equipment. For portable equipment, the minimum discharge time shall be 15 minutes. For protection of diked areas designed to contain the contents of a storage tank, see 402.

430. Foam Producing Materials.

431. Foam Concentrate Consumption Rates: The consumption rate 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).
432. **Requirements for Tanks:** The quantity of foam-producing material shall be determined by multiplying the consumption rate in gallons per minute for each tank by the appropriate time in 421. The largest resulting value shall determine the quantity required.

433. **Supplementary Foam Hose Stream Requirements:** Additional foam-producing materials shall be provided to permit operation of hose stream equipment simultaneous with tank foam installations as specified in 333.

434. **Requirements to Fill Pipe Lines:** These shall be the same as specified in 334 when piping is part of the design.

435. **Reserve Supply of Foam-Producing Materials:** There shall be a reserve supply of foam-producing materials the same as specified in 1742.

436. **Total Supply Requirements:** Supplies to be maintained shall be the sum of the quantities defined in 432, 433, 434 and 435.

437. **Requirements for Spill Fires:** Sufficient foam-producing materials shall be available for extinguishment of spill fires as defined in 421 and in addition, as specified in 434 and 435.

440. **Hose Requirements.**

441. **Unlined Fabric Hose:** Unlined fabric hose shall not be used with foam equipment.

5. **Revise Chapter 5 to read as follows:**

**CHAPTER 5. PORTABLE TOWER SYSTEMS FOR EXTERIOR STORAGE TANKS**

500. **General.**

501. **Scope:** This chapter relates to those systems in which the foam is applied through approved portable towers which are placed in operating position after the fire starts.

**Note:** Generally, portable towers are to be regarded as limited in use. Portable tower systems require accessibility to tankage, and an adequate number of men to place and maintain the apparatus in operation; and in some cases, special truck units for the ready transportation of the equipment to the location of the fire. The adequacy of a portable tower system, subject to the approval of the authority having jurisdiction, shall be based upon the number and availability of the men and equipment to extinguish a possible fire. On tanks over 200 feet in diameter, the use of a portable foam towers may not be practical, due to the amount of equipment and number of men needed to meet requirements.

**Note 2:** Tanks containing combustible liquids (at or above 140°F. flash point) are not, as a rule, required to be protected by foam. Foam protection for combustible liquids may be desirable where abnormal situations exist, such as storage of high value stocks or liquids heated above their flash point. Use of portable towers may present a safety hazard to fire fighters inside the diked area if used to apply foam to tanks containing hot oils, burning asphalts, or other liquids which are above the boiling point of water.

*502. Definitions:*

**PORTABLE FOAM TOWER:** A device which is brought to the scene of the fire, erected and placed in operation for delivering foam to the burning surface of a tank after the fire starts. Portable foam towers are equipped with Type I or Type II discharge outlets shaped to apply foam inward toward the tank shell.

**PORTABLE INSTALLATIONS:** The type in which the foam apparatus, foam-producing materials, hose, etc., are transported to the scene after the fire starts, the foam being delivered to the tank by portable towers.

510. **Foam Application Rates.**

511. **Rates:** The minimum delivery rate shall be as specified in 511.

512. **Supplementary Foam Hose Stream and Hose Outlet Requirements:** The minimum requirements for hose streams and hydrants shall be as specified in 5112.

520. **Duration of Discharge.**

521. **Minimum Discharge Time:** The system shall be capable of operation at the delivery rate specified in 511 for the following minimum periods of time. If the apparatus available has a delivery rate higher than that specified in 511, proportionate reduction in the time figures may be made, except that they shall not be less than 70 percent of the minimum discharge times shown.
### TANKS CONTAINING LIQUID HYDROCARBONS

<table>
<thead>
<tr>
<th>Flash Point</th>
<th>Type I</th>
<th>Type II</th>
</tr>
</thead>
<tbody>
<tr>
<td>200°F</td>
<td>25 min</td>
<td>35 min</td>
</tr>
<tr>
<td>200°F-122°F</td>
<td>30 min</td>
<td>50 min</td>
</tr>
<tr>
<td>200°F-100°F</td>
<td>55 min</td>
<td>65 min</td>
</tr>
</tbody>
</table>

### TANKS CONTAINING OTHER FLAMMABLE AND COMBUSTIBLE LIQUIDS

Alcohol type foams require gentle application by Type I outlets unless listed as suitable for application through Type II devices. The operation time shall be 55 minutes at the specified application rate, unless the manufacturer of the foam concentrate has established by fire test that a shorter time can be permitted.

### Foam-Producing Materials

#### FOAM CONCENTRATE CONSUMPTION RATES
The consumption rate 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).

#### REQUIREMENTS FOR TANKS
The quantity of foam-producing material shall be determined by multiplying the consumption rate in gallons per minute for each tank by the appropriate time in 521. The largest resulting value shall determine the quantity required.

#### SUPPLEMENTARY HOSE STREAM REQUIREMENTS
Additional foam-producing materials shall be provided to permit operation of the hose stream equipment simultaneous with tank foam installations as specified in 333.

#### REQUIREMENTS TO FILL PIPE LINES
These shall be the same as specified in 334.

#### RESERVE SUPPLY OF FOAM-PRODUCING MATERIALS
There shall be a reserve supply of foam-producing materials the same as specified in 1742.

#### TOTAL SUPPLY REQUIREMENTS
Supplies to be maintained shall be the sum of the quantities defined in 532, 533, 534, and 535.

### Foam Towers

#### NUMBERS REQUIRED
Towers shall be available in the proper number and size as to deliver foam on the burning liquid surface at a rate to meet the requirements of 511 as set forth below:

#### CENTRALIZED FIXED PIPING SYSTEMS

551. Foam Tower Hose Outlets: Hose outlets used for foam towers shall be as specified in 385.

6. Revise Chapter 6 to read as follows:

### CHAPTER 6. SPRAY FOAM SYSTEMS FOR EXTERIOR PROTECTION

600. General

601. Scope: This chapter relates to systems discharging air foam in a spray pattern that can be effectively used to extinguish spill fires under or around process structures and equipment, horizontal tanks and small vertical tanks. These systems relate to spray discharge of air foam only. Some foam spray systems and devices are not designed to produce effective water patterns for cooling purposes. For system design criteria for discharge of both water and foam, refer to NFPA No. 16, Standard for Installation of Foam-Water Sprinkler and Foam-Water Spray Systems.

NOTE 1: Spray foam applied externally to tanks or vessels has the added advantages of cooling and insulating the tanks or vessels while the spill fire is being extinguished.

Foam is not considered an effective agent for extinguishment of three-dimensional running flammable liquid fires. However, in the event of such a fire, the foam can effectively cover and control the pool fire beneath the running fire thus facilitating approach and extinguishment by other means.

NOTE 2: These systems may also be used to protect small open top tanks having a liquid surface area not exceeding 200 sq. ft.
610. Foam Application Rate.

611. Rate: The minimum rate of foam solution application shall be 0.16 gpm/sq. ft. for the maximum potential fire area.

620. Duration of Discharge.

621. Minimum Discharge Time: There shall be a quantity of foam-producing materials sufficient to supply the system at the design rate for a period of 10 minutes. If the system discharges at a rate above the minimum specified in 611, then the operating time may be reduced proportionately, but shall not be less than 7 minutes.

630. Foam-Producing Materials.

631. Foam Concentrate Consumption Rates: The consumption rate 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).

632. Reserve Supply: There shall be a reserve supply of foam-producing materials in accordance with 1742.

633. Total Supply Requirements: Supplies to be maintained shall be the sum of the quantities defined in 621 and 632.

640. Foam Discharge Outlets.

641. Number and Location: There shall be a minimum of 1 discharge outlet per 100 sq. ft. of protected area unless listing of discharge devices indicates a larger spacing is permitted. These outlets shall be located so as to provide good distribution throughout the protected area. However, an added advantage is gained by locating the outlets so that the foam discharge envelops the equipment within the protected area. Therefore, the discharge outlets may be concentrated over closed tanks or equipment rather than being evenly spaced throughout the protected area. These outlets are then located in plan and elevation to provide the most effective protection of the hazard.

650. Operation.

651. Automatic Operation: This may be accomplished by use of listed fire detectors installed in accordance with their accepted spacing rule for outdoor applications, and connected to a deluge valve and other equipment to make a complete system. The requirements of 212 and 270 shall be complied with where applicable and an auxiliary manual tripping means shall be provided.

652. Manual Operation: Controls shall be located in an accessible place, sufficiently removed from the hazard so that they may be safely operated in an emergency. The location and purpose of the control shall be plainly indicated.

660. Foam System Piping.

661. General Requirements:

(a) Piping which will be normally filled with liquid shall be protected against freezing when necessary.

(b) The requirements of 26 shall be complied with where applicable.

662. Applicable parts of Chapter 3 of the Standard for the Installation of Sprinkler Systems (NFPA No. 13) shall be consulted for requirements applicable to piping, valves, pipe fittings, and hangers, including corrosion-protection coatings (galvanizing or other means). In these open-head systems, galvanized pipe and fittings shall be used for normal occupancies. Corrosive atmospheres may require other coatings.

Since the systems herein covered are required to be hydraulically designed, the pipe-size tables of the Standard for Installation of Sprinkler Systems (NFPA No. 13) are not applicable.

663. Piping carrying foam concentrate shall be black steel or cast iron.

7. Revise Appendix to read as follows:

APPENDIX A

8. A-121(e). Change 3rd paragraph to read as follows:

The device illustrated in A-121(e) shows a pressure proportioning tank with a single operating head.

Delete 4th and 5th paragraphs.

9. A-302 C. Change “C” to lower case with ( ) and “E” to “(f)” to read:
A-302(c) Type II Discharge Outlets and A-302(f) Semi-Fixed Installations.


11. A-3311(2). Change to:

(2) When it is desired to provide fixed foam devices below the pantograph type fabric seal, or the metal weather shield of a tube seal design, the following may be used as a design guide.


14. Renumber A-331 as A-3411 including Figures (a) and (b).

15. Renumber A-3311 as A-3412 including Figures (1), (2) and (3).

16. A-3412(2)(b). New to read as follows:

(b) A circular dam is not required with the tube seal design and the maximum spacing between applicators should be 130 ft. unless the top of the tube seal is less than 6 inches below the top of the pontoon deck. Then a circular dam is required and the maximum spacing between applicators should be no more than 60 ft. measured around the circumference of the tank.

17. Change the first sentence of A-3412(2)(e) to read:

(e) When a foam dam is not required, the rate of application and the supply of foam liquid should be calculated using the area of the annular ring between the tank shell and the floating roof edge.

18. A-3412(2)(f). New to read as follows:

(f) When a foam dam is required, the rate of application and the supply of foam liquid concentrate should be calculated using the area of the annular ring between the tank shell and the dam. The minimum rate should be 0.16 gpm/ft.² of area. The supply should be adequate to operate the system for 20 minutes.

19. Renumber A-3312 as A-3413 including Fig. A-3312.

A-3414. New to read as follows:

Fixed foam protection may be desirable for common diked areas surrounding multiple tanks with less than NFPA No. 30 spacing and/or poor fire fighting access. This can be accomplished by fixed foam outlets discharging onto the inner wall of the dike, or by fixed or oscillating monitors, or by foam spray systems discharging within the diked area. Suggested design criteria are:

For fixed discharge outlets, use a solution application rate of 0.1 gpm/ft.² of area to be protected with sufficient supply of foam-producing materials for 20 minutes application to Class II liquids or 30 minutes application for Class I liquids.

For foam spray systems, see Chapter 6.

For fixed or oscillating monitors, use a solution application rate of 0.16 gpm ft.² with supplies of foam-producing materials as for fixed outlets above. It is not necessary to design to apply foam simultaneously to the total diked area as long as monitor reach will provide adequate coverage.

For protection of diked areas which may contain other flammable and combustible liquids requiring alcohol-type foams, protection may be provided by fixed Type I discharge outlets applying foam from the dike or by application of foams approved for the purpose by Type II devices or fixed or oscillating monitors. For recommended application rates, see table in Chapter 3 under “Tanks Containing Other Flammable and Combustible Liquids Requiring Special Foams.” Supplies of foam-producing materials should be provided for 30 minutes application.


22. Renumber A-3511 as A-3423.


24. Renumber A-342 and A-3561 as A-352 including Figures A-3561 A-D.

25. Renumber A-601 as A-401 including Figures (1) and (2).

26. Renumber A-602 as A-403 including Figures (c)(1)-(c)(5) and (d)(1)-(d)(3).

27. Renumber A-402 as A-502 including Figure A-402.

28. Change Figure A-501A and A-501B to A-601A and A-601B.
Part II
Standard for
High Expansion Foam Systems
(Expansion Ratios from 100:1 to 1000:1)
NFPA 11A – 1976

Chapter 1 General

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

1-1 Scope. This standard includes minimum requirements for the installation of high expansion foam systems.

Only those skilled in this field are competent to design and install this equipment. It may be necessary for many of those charged with the purchasing, inspecting, testing, approving, operating, and maintaining of this equipment to consult with an experienced and competent fire protection engineer in order to effectively discharge their respective duties.

1-2 Purpose. This standard is prepared for use and guidance of those charged with the purchasing, designing, installing, testing, inspecting, approving, listing, operating or maintaining of high expansion foam systems, in order that such equipment will function as intended throughout its life.

1-3 History. High expansion foam is a relatively new agent for control and extinguishment of Class A and Class B fires and is particularly suited as a flooding agent for use in confined spaces. The development of the use of high expansion foams for fire fighting purposes started with the work of the Safety in Mines Research Establishment of Buxton, England, upon the difficult problem of fires in coal mines. It was found that by expanding an aqueous surface active agent solution to a semi-stable foam of about 1000 times the volume of the original solution, it was possible to force the foam down relatively long corridors thus providing a means for transporting water to a fire inaccessible to ordinary hose streams.

This work has led to the development of specialized high expansion foam generating equipment for fighting fires in mines, for application in municipal and industrial fire fighting, and for the protection of special hazard occupancies.
1-4 Description. High expansion foam is an aggregation of bubbles mechanically generated by the passage of air or other gases through a net, screen or other porous medium which is wetted by an aqueous solution of surface active foaming agents. Under proper conditions, fire fighting foams of expansions from 100:1 to 1000:1 can be generated. Such foams provide a unique agent for transporting water to inaccessible places, for total flooding of confined spaces, and for volumetric displacement of vapor, heat and smoke. Tests have shown that under certain circumstances high expansion foam when used in conjunction with water sprinklers will provide more positive control and extinguishment than either extinguishment system by itself. High-piled storage of rolled paper stock is an example. Optimum efficiency in any one type of hazard is dependent to some extent on the rate of application and also the foam expansion and stability.

High expansion foam is particularly suited for indoor fires in confined spaces. Its use outdoors may be limited because of the effects of weather. High expansion foam has several effects on fires:

(a) When generated in sufficient volume, it can prevent air, necessary for continued combustion, from reaching the fire.

(b) When forced into the heat of a fire the water in the foam is converted to steam, reducing the oxygen concentration by dilution of the air. For example, the water in a foam having an expansion ratio of 1000:1 can provide enough steam to reduce the oxygen concentration of the resultant air-steam mix to about 7.5 percent by volume.

(c) The conversion of the water to steam absorbs heat from the burning fuel. Any hot object exposed to the foam will continue the process of breaking the foam, converting the water to steam, and of being cooled.

(d) Because of its relatively low surface tension, solution from the foam, which is not converted to steam, will tend to penetrate Class A materials. However, deep-seated fires may require overhaul.

(e) When accumulated in depth, high expansion foam can provide an insulating barrier for protection of exposed materials or structures not involved in a fire and can thus prevent fire spread.

Class A fires are controlled when the foam completely covers the fire and burning material. If the foam is sufficiently wet and is maintained long enough, the fire may be extinguished.

Class B fires involving high flash point liquids can be extinguished when the surface is cooled below the flash point. Class B fires of low flash point liquids can be extinguished when a foam blanket of sufficient depth is established over the liquid surface.

This standard is based on test data and design experience so far developed for use of high expansion foam. The intent of this standard is to indicate general rules applicable to any system. The limited field experience of approved systems makes it difficult to prepare specific recommendations covering the many potential uses. This standard is issued to outline some of the factors which shall be given consideration in judging the acceptability of specific installations.

1-5 Definitions. For purposes of clarification, the following general terms used with special technical meanings in this standard are defined:

1-5.1 Authority Having Jurisdiction is usually the purchaser or the competent engineer or organization appointed by him to interpret and make decisions as set forth in this standard. Where insurance is involved, the inspection department representing the insurance carrier generally becomes the authority having jurisdiction. In some cases, civil or military authorities may have final jurisdiction.

1-5.2 High Expansion Foam is an aggregation of bubbles resulting from the mechanical expansion of a foam solution by air or other gases with a foam-to-solution volume ratio of 100:1 to approximately 1000:1 (see A-1-9.3).

1-5.3 Foam Concentrate is a concentrated liquid foaming agent as received from the manufacturer.

1-5.4 Foam Solution is water into which foam concentrate has been introduced in the proper proportion.

1-6 General Information and Requirements.

1-6.1 The information and requirements in Chapter 1 are generally common to all high expansion foam systems.

1-6.2 Mechanisms of Extinguishment. High expansion foam extinguishes fire by reducing the concentration of oxygen at the seat of the fire, by cooling, by halting convection, and by excluding additional air from the fire.

1-6.3 Use and Limitations. While high expansion foam is finding application for a broad range of fire fighting problems, this standard is presently limited to considering specific types of hazards.
1-6.3.1 Some important types of hazards that high expansion foam systems may satisfactorily protect include:

(a) Ordinary combustibles
(b) Flammable liquids
(c) Combinations of each

NOTE: Under certain circumstances it may be possible to utilize high expansion foam systems at fires involving flammable liquids or gases issuing under pressure, but no general recommendations can be made in this standard due to the infinite variety of particular situations which can be encountered in actual practice.

1-6.3.2 High expansion foam systems shall not be used on fires in the following hazards unless competent evaluation, which may include tests, indicates acceptability:

(a) Chemicals, such as cellulose nitrate, which release sufficient oxygen or other oxidizing agents to sustain combustion.
(b) Energized unenclosed electrical equipment (see 1-7.1.5).
(c) Water-reactive metals such as sodium, potassium, NaK.
(d) Hazardous water-reactive materials, such as triethylaluminum and phosphorous pentoxide.

1-6.4 Types of Systems. The types of systems recognized in this standard include:

Total Flooding Systems
Local Application Systems
Portable Foam Generating Devices

1-6.5 Systems Protecting One or More Hazards. Systems may be used to protect one or more hazards or groups of hazards using the same supply of foam concentrate and water except as provided in 1-6.5.1.

1-6.5.1 Where, in the opinion of the authority having jurisdiction, two or more hazards may be simultaneously involved in fire by reason of their proximity, each hazard shall be protected with an individual system or the system shall be arranged to discharge on all potentially involved hazards simultaneously.

1-7 Personnel Safety.

1-7.1 Hazards to Personnel. The discharge of large amounts of high expansion foam may inundate personnel, blocking vision, making hearing difficult, and creating some discomfort in breathing. This breathing discomfort will increase with a reduction in expansion ratio of the foam and also under the effect of sprinkler discharge.

1-7.1.1 Personnel working in a hazard area and with no responsibility for fire fighting shall be instructed to immediately vacate the area in the event of fire, if possible. If personnel are unable to vacate and are trapped so that their lives are endangered by smoke or heat, they may enter the foam. Instructions shall be given to move the hand over the nose and mouth to minimize discomfort in breathing within the foam.

1-7.1.2 Where possible the relative location of foam discharge points to building exits shall be arranged to facilitate evacuation of personnel.

1-7.1.3 To re-enter a foam-filled building, a coarse water spray may be used to cut a path in the foam. Personnel shall not enter the foam. The foam is opaque, and it is impossible to see when one is submerged. It is dangerous to enter a building in which there was a fire if one cannot see.

1-7.1.4 Caution. A canister type gas mask shall not be worn in the foam. The chemicals of the canister will react with the water of the foam and cause suffocation. If emergency re-entry is essential, self-contained breathing apparatus shall be used in conjunction with a life line.

1-7.1.5 Unenclosed electrical apparatus shall be de-energized upon system actuation unless by competent evaluation it has been deemed unnecessary.

1-7.2 Electrical Clearances. All system components shall be so located as to maintain minimum clearances from live parts as shown in Table 1-7.2.

As used in this standard, “clearance” is the air distance between high expansion foam equipment, including piping and nozzles, and unenclosed or uninsulated live electrical components at other than ground potential. Since high expansion foam is conductive, these clearances do not prevent flashover through foam. (See 1-7.1.5.)

The clearances given are for altitudes of 3,300 ft (1065m) or less. At altitudes in excess of 3,300 ft (1065m), the clearance shall be increased at the rate of 1 percent for each 330 ft (106.5m) increase in altitude above 3,300 ft (1065m).

The clearances are based upon minimum general practices related to design Basic Insulation Level (BIL) values. To coordinate the required clearance with the electrical design, the design BIL of the equipment being protected shall be used as a basis, although this is not material at nominal line voltages of 161 kv or less.
TABLE 1-7.2
CLEARANCE FROM HIGH EXPANSION FOAM EQUIPMENT TO LIVE UNINSULATED ELECTRICAL COMPONENTS

<table>
<thead>
<tr>
<th>Nominal Line Voltage (kv)</th>
<th>Nominal Design BIL (kv)</th>
<th>Minimum Clearance (inches)</th>
<th>mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>To 15 To 9</td>
<td>110</td>
<td>6</td>
<td>152</td>
</tr>
<tr>
<td>23</td>
<td>150</td>
<td>8</td>
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<td></td>
<td>2300</td>
<td>184</td>
<td>4674</td>
</tr>
</tbody>
</table>

NOTE: Basic Insulation Level (BIL) values are expressed as kilovolts (kv), the number being the crest value of the full wave impulse test that the electrical equipment is designed to withstand.

1-8 Specifications, Plans and Approval.

1-8.1 Purchasing Specifications. Specifications for high expansion foam systems shall be drawn up with care under the supervision of a competent engineer, and with the advice of the authority having jurisdiction. To ensure a satisfactory system, the following items shall be in the specifications.

1-8.1.1 The specifications shall designate the authority having jurisdiction and indicate whether submittal of plans is required.

1-8.1.2 The specifications shall state that the installation shall conform to this standard and meet the approval of the authority having jurisdiction.

1-8.1.3 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.

1-8.2 Plans. Where plans are required, their preparation shall be entrusted only to fully experienced and responsible persons.

1-8.2.1 These plans shall be drawn to an indicated scale or be suitably dimensioned, and shall be made so that they can be easily reproduced.

1-8.2.2 These plans shall contain sufficient detail of the hazard to enable the authority having jurisdiction to evaluate the effectiveness of the system. The details on the hazard shall include the specific materials involved, the location and arrangement and the immediate exposure to the hazard. The detail on the system shall include sufficient information and calculations on the required amount of foam concentrate; water requirements; hydraulic calculations on the size, length and arrangement of connected piping and hose; and the size and location of foam generators so that the adequacy of the quantity, flow rate and distribution of the high expansion foam generated can be determined. (See Chapter 7 of NFPA 13, Standard for the Installation of Sprinkler Systems, for calculation procedures.) Detailed information shall be submitted pertaining to the location and function of detection devices, operating devices, auxiliary equipment including stand-by-power and electrical circuitry, if used. Sufficient information shall be indicated to identify properly the apparatus and devices used. Any special features shall be adequately explained.
1-8.3 Approval of Plans. Where plans are required, they shall be submitted to the authority having jurisdiction for approval before work starts.

1-8.3.1 Where field conditions necessitate any significant change from the approved plan, corrected “as installed” plans shall be supplied for approval to the authority having jurisdiction.

1-8.4 Approval of Installations. 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. Only listed or approved equipment and devices shall be used in these systems.

1-8.4.1 Such tests shall include a discharge of foam if possible. This foam shall be checked visually for desired quality. If actual discharge is not permitted, the supplier or installer shall check air flow and liquid flow in a manner satisfactory to the authority having jurisdiction.

1-8.4.2 All piping up to each foam generator shall be subjected to a 2-hour hydrostatic test pressure at 200 psi (1379 kPa) or 50 psi (345 kPa) in excess of the maximum pressure anticipated, whichever is greater. (See NFPA 13, Standard for the Installation of Sprinkler Systems.)

1-8.4.3 Tests shall include a complete check-out of electrical control circuits and supervisory systems to ensure proper operation and supervision in the event of failure.

1-8.4.4 Tests shall establish that all automatic closing devices for doors, windows and conveyor openings, and automatic equipment interlocks, as well as automatic opening of heat and smoke vents or ventilators, will function upon system operation.

1-8.4.5 Operating instructions provided by the supplier and the proper identification of devices shall be checked.

1-9 Operation and Control of Systems.

1-9.1 Methods of Actuation. Systems shall be classified as manual or automatic in accordance with the method of actuation. An automatic system is one which is actuated by automatic detection equipment. Such systems also shall have means for manual actuation.

1-9.2 Detection of Fires. Fires or conditions likely to produce fire may be detected by human senses or by automatic means.

1-9.2.1 Automatic detection shall be used for fixed systems.

Exception: Automatic detection may be omitted only when approved by the authority having jurisdiction.

1-9.2.2 Automatic detection shall be by listed or approved method or devices capable of detecting and indicating heat, smoke, flame, combustible vapors, or any abnormal condition in the hazard, such as process trouble, likely to produce fire.

1-9.2.3 An adequate and reliable source of energy shall be used in detection systems. The power supply for electrical detection systems shall be independent of the supply for the protected area. Otherwise an emergency, battery-powered supply with automatic switchover shall be provided if the primary supply fails. (See NFPA 72E-1974, Standard on Automatic Detectors.)

1-9.3 Operating Devices. Operating devices include foam generators, valves, proportioners, eductors, discharge controls, and shutdown equipment.

1-9.3.1 Operation shall be controlled by listed or approved mechanical, electrical, hydraulic or pneumatic means. An adequate and reliable source of energy shall be used. The electrical power supply for an electrically operated high expansion foam system shall be as reliable as a fire pump circuit in accordance with NFPA 20-1974, Standard for the Installation of Centrifugal Fire Pumps.

1-9.3.2 All operating devices shall be suitable for the service they will encounter, and shall not be readily rendered inoperative or susceptible to accidental operation. Provision shall be made to protect piping normally filled with liquid from freezing.

1-9.3.3 All devices shall be located, installed, or suitably protected so that they are not subject to mechanical, chemical, climatic or other conditions that will render them inoperative.

1-9.3.4 Manual controls for actuation and shutdown shall be located so as to be conveniently and easily accessible at all times including the time of fire and system operation. Remote control stations for manual actuation may be required where the area is large, egress difficult or when required by the authority having jurisdiction. Manual controls for actuation shall operate the system to the same extent as the automatic control.
1-9.3.5 All automatically operated equipment controlling the generation and distribution of foam shall be provided with approved independent means for emergency manual operation. If the means for manual actuation of the system required in 1-9.1 provides approved positive operation independent of the automatic actuation, it may be used as the emergency means. The emergency means, preferably mechanical, shall be easily accessible and located close to the equipment controlled. If possible, the system shall be designed so that complete emergency actuation can be accomplished from one location.

1-9.3.6 All required door and window closers, vent openers, and electrical equipment shutdown devices shall be considered integral parts of the system and shall function with the system operation.

1-9.3.7 All manual operating devices shall be identified as to the hazards they protect.

1-9.4 Supervision. Supervision of automatic detection and actuation equipment shall be provided and so arranged that there will be an immediate indication of failure, preferably at a constantly attended location.

1-9.5 Alarms. Audible alarms shall be installed to indicate the operation of the system, alert personnel and indicate failure of any supervised device or equipment. Such devices shall be of such a type and shall be provided in such numbers and such locations as are necessary to accomplish satisfactorily their purpose subject to approval of the authority having jurisdiction.

1-9.5.1 An alarm shall be provided to show that the system has operated, personnel response may be needed, and the system shall be reserved.

1-9.5.2 Alarms shall be provided to give ample warning of discharge where hazard to personnel may exist.

1-9.5.3 Alarms indicating failure of supervised devices or equipment shall give prompt and positive indication of any failure and shall be distinctive from alarms indicating operation or hazardous conditions.

1-10 Water, Foam Concentrate and Air Supply.

1-10.1 Water Quantity. Water shall be available in sufficient quantity and pressure to supply the maximum number of high expansion foam generators likely to operate simultaneously in addition to the demands of other fire protection equipment.

1-10.2 Water Quality. Consideration shall be given to the suitability of the water for production of high expansion foam. The presence of corrosion inhibitors, antifreeze agents, marine growths, oil, or other contaminants may result in reduction of foam volume or stability. The manufacturer of the foam concentrate shall be consulted.

1-10.3 Water Storage. Water supply shall be protected against freezing.

1-10.4 Foam Concentrate Quantity. The amount of foam concentrate in the system shall be at least sufficient for the largest single hazard protected or a group of hazards which are to be protected simultaneously (see 2-3.6 and 3-3.2).

1-10.5 Foam Concentrate Quality. The foam concentrate supplied with the system shall be that listed for use with the equipment. The performance of the system is dependent upon the composition of the foam concentrate as well as other factors. The quality of the concentrate for proper performance under the installation requirements of this standard shall be determined by suitable tests. One suitable test, based on fire performance, is described in A-1-10.5.

1-10.6 Foam Concentrate Reserve Supply. Sufficient foam concentrate shall be kept on hand for at least one complete re-charge of the system based on designated requirements. This reserve supply shall be stored in separate tanks, compartments, original shipping containers or by other approved methods. To prevent accidental use and depletion of this reserve supply, it shall be available to the system only by intentional manual operation.

1-10.7 Foam Concentrate Storage. In-service and reserve supplies of foam concentrate shall be stored where the temperature is maintained between 35°F (2°C) and 110°F (43°C), or within such other temperature range for which the concentrate has been listed. The reserve supply containers shall be kept tightly closed in a clean dry area to prevent contamination or deterioration.

1-10.8 Foam Concentrate Storage Tank. The tank shall be of corrosion-resisting materials and construction compatible with the foam concentrate. Consult the foam equipment manufacturer.

1-10.9 Air Supply. Air from outside the hazard area shall be used for foam generation unless the calculated foam genera-
tion rate using inside air is increased to compensate for foam loss because of heat, smoke, and chemical effects during a fire. The degree of loss from such effects shall be determined by test.

1-10.9.1 Vents shall be located to avoid recirculation of combustion products into the air inlets of the foam generators.

1-11 Foam Generating Apparatus Location.

1-11.1 Accessibility for Inspection and Maintenance. Foam generating apparatus shall be so located and arranged that inspection, testing, recharging, and other maintenance is facilitated and interruption to protection is held to a minimum.

*1-11.2 Protection Against Exposure. Foam generating equipment shall be located as near as possible to the hazard or hazards it protects, but not where it will be unduly exposed to a fire or explosion. Foam generators installed inside the hazard area shall be constructed or protected against fire exposure. Such protection may be by insulation, fire retardant paint, water spray, or sprinklers, etc. In certain applications additional generators may be substituted for fire exposure protection with the approval of the authority having jurisdiction.

1-12 Distribution Systems.

1-12.1 Pipe and Fittings. The piping and fittings in continuous contact with foam concentrate shall be of corrosion-resisting materials compatible with the foam concentrate used. The remainder of the piping and fittings should be standard weight (Schedule 40) black or galvanized steel pipe and standard weight black or galvanized steel, ductile, or malleable iron fittings. Consideration shall be given to possible galvanic effects when dissimilar metals are joined, especially in piping which carries foam concentrate.

1-12.2 Arrangement and Installation of Piping and Fittings. Piping shall be installed in accordance with practices outlined in NFPA 13, Standard for the Installation of Sprinkler Systems.

1-12.2.1 All piping systems shall be designed using hydraulic calculations to assure the desired rate of flow at the foam generators. Care shall be taken to avoid possible restrictions due to foreign matter, faulty fabrication, and improper installation.

1-12.2.2 A listed strainer shall be provided in the water line upstream of the water valve suitable for use with the proportioner and foam generator. Supplemental strainers may be used as recommended by the foam equipment manufacturer.

1-12.3 Valves. All valves shall be suitable for the intended use, particularly in regard to flow capacity and operation. Valves shall be of a listed type or deemed suitable for such use as a part of the system.

1-12.3.1 Valves shall not be easily subject to mechanical, chemical, or other damage.

1-12.4 Ducts. Foam distribution and air inlet ducts shall be designed, located, installed and suitably protected so that they are not subject to undue mechanical, chemical or other damage.

1-12.4.1 Duct closures such as selector valves, gates, or doors shall be of the quick-opening type, allowing free passage of the foam. When located where they may be subjected to fire or heat exposure, either inside or outside the area to be protected, special care shall be taken to ensure positive operation.

1-12.4.2 Ducts shall be designed and installed so that undue turbulence is avoided and the foam discharge rate is in accord with the design requirements.

1-13 Maintenance and Instructions.

1-13.1 Inspection and Tests. At least annually, all high expansion foam systems shall be thoroughly inspected and checked for proper operation by a competent engineer or inspector. This shall include determination of any changes in physical properties of the foam concentrate which indicate any deterioration in quality. Regular service contracts with the manufacturer or installing company are recommended.

1-13.1.1 The goal of this inspection and testing shall be to ensure that the system is in full operating condition and to indicate the probable continuance of that condition until the next inspection.

1-13.1.2 Suitable discharge tests shall be made when any inspection indicates their advisability.

1-13.1.3 The inspection report, with recommendations, shall be filed with the owner.

*1-13.1.4 Between the regular service contract inspection or tests, the system shall be inspected by competent personnel, following an approved schedule.

1-13.1.5 Strainers shall be inspected and cleaned after each use and test.
1-13.2 **Maintenance.** These systems shall be maintained in full operating condition at all times. Use, impairment, and restoration of this protection shall be reported promptly to the authority having jurisdiction.

1-13.2.1 Any troubles or impairments shall be corrected at once by competent personnel.

1-13.3 **Instructions.** All persons who may be expected to inspect, test, maintain, or operate foam generating apparatus shall be thoroughly trained and kept thoroughly trained in the functions they are expected to perform.

1-13.3.1 Training programs approved by the authority having jurisdiction shall be established.

1-13.3.2 Operating instructions shall be posted at control stations.

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2-1 **General Information.**

2-1.1 **Description.** A total flooding system consists of fixed foam generating apparatus complete with a piped supply of foam concentrate and water, arranged to discharge into an enclosed space or enclosure about the hazard.

2-1.2 **Uses.** This type of system may be used where there is a permanent enclosure about the hazard that is adequate to enable the required amount of fire extinguishing medium to be built up and to be maintained for the required period of time to ensure the control or extinguishment of the fire in the specific combustible material or materials involved.

2-1.2.1 Examples of hazards that may be successfully protected by total flooding systems include rooms, vaults, storage areas, warehousing facilities and buildings containing Class A and Class B combustibles either singly or in combination. *(See NFPA 231C-1974, Standard for Rack Storage of Materials.)* Three-dimensional fires in flammable liquids (falling or flowing under pressure) having flash points below 100°F (38°C) generally will not be extinguished by total coverage. Although this fire may continue in the foam, heat radiation will be reduced and kept under control with continued foam application.

2-1.2.2 Fires which can be controlled or extinguished by total flooding methods can be divided into two categories: namely, (1) surface fires involving flammable or combustible liquids and solids and (2) deep seated fires involving solids subject to smoldering.

2-1.3 **General Requirements.** Total flooding systems shall be designed, installed, tested and maintained in accordance with the applicable requirements in the previous chapter and with the additional requirements set forth in this chapter. Only listed or approved equipment and devices shall be used in these systems.

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2-2 **Enclosure Specifications.**

2-2.1 **Leakage and Ventilation.** Since the efficiency of the high expansion foam system depends upon the development and maintenance of a suitable quantity of foam within the particular enclosure to be protected, leakage of foam from the enclosure shall be avoided.

2-2.1.1 Openings below design filling depth, such as doorways, windows, etc., shall be arranged to close automatically before, or simultaneously with the start of the foam discharge,
with due consideration for evacuation of personnel. They shall be designed to maintain a closure during a fire and be capable of withstanding pressures of foam and sprinkler water discharge. If any unclosable openings exist, the system shall be designed to compensate for the probable loss of foam and shall be tested to assure proper performance.

2.2.1.2 When outside air is used for foam generation, high level venting shall be provided for air which is displaced by the foam. If possible, venting velocity shall not exceed 1000 feet per minute (305 m/min) in free air. The venting so required shall consist of suitable openings, either normally open, or normally closed and arranged to open automatically when the system operates. When design criteria demand exhaust fans, they shall be approved for high temperature operation and installed with due consideration for protection of switches, wiring, and other electrical devices to assure equal reliability of exhaust fan performance as for the foam generators. Where forced air ventilating systems interfere with the proper build-up of foam, they shall be shut down or closed off automatically.

2.3 Foam Requirements.

2.3.1 General. For adequate protection, sufficient high expansion foam shall be discharged at a rate to fill the enclosure to an effective depth above the hazard before an unacceptable degree of damage occurs.

2.3.2 Foam Depth. The minimum total depth of foam shall be not less than 1.1 times the height of the highest hazard, but in no case less than 2 feet (0.61 m) over this hazard. For flammable or combustible liquids, the required depth over the hazard may be considerably greater and shall be determined by tests.

2.3.3 Submergence Volume. Submergence volume is defined as (1) the depth as specified in 2.3.2 multiplied by the floor area of the space to be protected or (2) in the case of unspinklered rooms or internal combustible construction or finish, the entire volume including concealed spaces. The volume occupied by vessels, machinery or other permanently located equipment may be deducted when determining the submergence volume. The volume occupied by stored material shall not be deducted when determining the submergence volume unless approved by the authority having jurisdiction.

*2.3.4 Submergence Time. Recommended times to achieve submergence volume for various types of hazards and building construction are shown in Table 2-3.4. Shorter submergence times may be required depending on the factors included in 2.3.5.

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Light or Unprotected Steel Construction</th>
<th>Heavy or Protected or Fire-Resistant Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sprinklered Not</td>
<td>Sprinklered Not</td>
</tr>
<tr>
<td>Flammable Liquids (Flash Points below 140°F [60°C])**</td>
<td>3 2</td>
<td>5 3</td>
</tr>
<tr>
<td>Combustible Liquids (Flash Points of 140°F [60°C] and above)**</td>
<td>4 3</td>
<td>6 4</td>
</tr>
<tr>
<td>Low Density Combustibles i.e., Foam Rubber Foam Plastics Rolled Tissue or Crepe Paper</td>
<td>4***</td>
<td>6 4***</td>
</tr>
<tr>
<td>High Density Combustibles i.e., Rolled Paper -Kraft or Coated-Banded</td>
<td>7 5***</td>
<td>8 6***</td>
</tr>
<tr>
<td>High Density Combustibles i.e., Rolled Paper -Kraft or Coated-Unbanded</td>
<td>5 4***</td>
<td>6 5***</td>
</tr>
<tr>
<td>Rubber Tires</td>
<td>7 5***</td>
<td>8 6***</td>
</tr>
<tr>
<td>Combustibles, in cartons, bags, fiber drums</td>
<td>7 5***</td>
<td>8 6***</td>
</tr>
</tbody>
</table>

* This is based on a maximum of 30 sec delay between fire detection and start of foam discharge. Any delays in excess of 30 sec shall be deducted from the submergence times in Table 2-3.4.

** Polar solvents are not included in this table. Flammable liquids having boiling points less than 100°F (38°C) may require higher application rates. Where use of high expansion foam is contemplated on these materials, the foam equipment supplier shall substantiate suitability for the intended use.

*** These submergence times may not be directly applicable to high-piled storage above 15 ft (4.6 m) or where fire spread through combustible contents is very rapid.
2-3.5 Rate of Discharge. The rate of foam discharge necessary for extinguishment or sufficient control to permit overhaul depends upon the strength of sprinkler protection, nature and configuration of the hazard, vulnerability of the structure and contents to fire, and the loss potential to life, property and production. The rate also depends upon foam properties, such as expansion ratio, water retention, effect of water contaminants, temperature effects on water retention, etc. The foam discharge rate shall be sufficient to satisfy the foam depth requirements and submergence times of Table 2-3.4, making compensation for normal foam shrinkage, foam leakage, and breakdown effects of sprinkler discharge.

*2-3.5.1 The minimum rate of discharge or total generator capacity shall be calculated from the following formula:

\[ R = \left( \frac{V}{T} + R_s \right) \times C_N \times C_L \]

where:

- \( R \) = rate of discharge — cfm (m³/min)
- \( V \) = submergence volume — cubic feet (m³)
- \( T \) = submergence time — minutes
- \( R_s \) = rate of foam breakdown by sprinklers — cfm (m³/min)
- \( C_N \) = compensation for normal foam shrinkage
- \( C_L \) = compensation for leakage

*2-3.5.2 The factor \((R_s)\) for compensation for breakdown by sprinkler discharge shall be determined either by test or, in the absence of specific test data, by the following formula:

\[ R_s = S \times Q \]

where:

- \( S \) = Foam breakdown in cfm per gpm of sprinkler discharge. 
  - \( S \) shall be 10 cfm/gpm (0.0748 m³·min/l·min)
- \( Q \) = Estimated total discharge from maximum number of sprinklers expected to operate—gpm (l/min).

2-3.5.3 The factor \((C_N)\) for compensation for normal foam shrinkage shall be 1.15. This is an empirical factor based on average reduction in foam quantity from solution drainage, fire, wetting of surfaces, absorbency of stock, etc.

2-3.6 Quantity. Sufficient foam concentrate and water shall be provided to permit continuous operation of the entire system for at least 25 minutes or to generate four times the submergence volume, whichever is less, but in no case less than enough for 15 minutes of full operation (see 1-10.4).

2-3.6.1 Reserve supplies shall be provided in accordance with 1-10.7.

*2-4 Maintenance of Submergence Volume. To ensure adequate control or extinguishing, the submergence volume shall be maintained for at least 60 minutes for unsprinklered locations and 30 minutes for sprinklered locations. Where only flammable or combustible liquids are involved, this period may be reduced.

2-4.1 Method. The submergence volume may be maintained by continuous or intermittent operation of any or all of the generators provided.

2-4.1.1 Arrangements and procedures shall be provided to maintain the submergence volume without waste of foam concentrate which may be needed in case of re-ignition.

*2-5 Overhaul. As is true with other total flooding extinguishing systems, control established by the system may be lost by improper overhaul procedures.

2-6 Distribution. The discharge arrangements shall be such that a relatively even build-up of high expansion foam will take place during the discharge period.

*2-3.5.4 The factor \((C_L)\) for compensation for loss of foam due to leakage around doors and windows and through unclosable openings shall be determined by the design engineer after proper evaluation of the structure. Obviously this factor cannot be less than 1.0 even for a structure completely tight below the design filling depth. This factor could be as high as 1.2 for a building with all openings normally closed depending upon foam expansion ratio, sprinkler operation, and foam depth.
Chapter 3  Local Application Systems

3-1 General Information.

3-1.1 Description. A local application system consists of fixed foam generating apparatus complete with a piped supply of foam concentrate and water and arranged to discharge foam directly onto the fire.

3-1.2 Uses. Local application systems may be used for the extinguishment of fires in flammable or combustible liquids, and ordinary Class A combustibles where the hazard is not totally enclosed. These systems are best adapted to the protection of essentially flat surfaces such as confined spills, open tanks, drainboards, curbed areas, pits, trenches, etc. For multiple level or three dimensional fire hazards where total building flooding is not practical, the individual hazard shall be provided with suitable containment facilities acceptable to the authority having jurisdiction.

3-1.3 General Requirements. Local application systems shall be designed, installed, tested and maintained in accordance with the applicable requirements in previous chapters and with the additional requirements set forth in this chapter. Only listed or approved equipment and devices shall be used in these systems.

3-2 Hazard Specifications.

3-2.1 Extent of Hazard. The hazard shall include all areas to which or from which fire may spread.

3-2.2 Location of Hazard. The hazard may be indoors, partly sheltered, or completely out-of-doors. Foam shall be protected from strong winds or air currents.

3-3 Foam Requirements.

3-3.1 General. Sufficient foam shall be discharged at a rate to cover the hazard to a depth of at least two feet (0.6 m) within two minutes (see A-2-3.5).

3-3.2 Quantity. Sufficient foam concentrate and water shall be provided to permit continuous operation of the entire system for at least 12 minutes (see I-10.4).

3-3.2.1 Reserve supplies shall be provided in accordance with I-10.7.

3-4 Method. Discharge outlets shall be arranged to ensure that foam is delivered over all areas which constitute the hazard. Where parts of the hazard are elevated or raised up from the ground or floor line, the arrangement of the system shall be such that foam will be delivered to, and retained on, such parts in sufficient depth to ensure prompt and final extinguishment.
Chapter 4 Portable Foam Generating Devices

4-1 General Information.

4-1.1 Description. Portable foam generating devices consist of a high expansion foam generator, manually operable and transportable, connected by means of hose, or piping and hose, to a supply of water and foam concentrate. The proportioning equipment may be integral with or separate from the foam generator. A separate foam concentrate supply may be provided for each unit, or solution may be piped from central proportioning equipment.

4-1.2 General Requirements. Portable foam generating devices and associated equipment shall be used and maintained in accordance with the applicable requirements in the preceding chapters and with the additional requirements set forth in this chapter. Only listed or approved equipment and devices shall be used.

4-2 Hazard Specifications.

4-2.1 Portable foam generating devices may be used to combat fires in all hazards covered under Chapters 2 and 3.

4-3 Location and Spacing.

4-3.1 Location. Portable foam generating devices which are preconnected to a water or solution supply shall be placed where they are easily accessible and with enough hose to reach the most distant hazard which they are expected to protect. Foam concentrate shall be available for immediate use. These devices shall be located such that they are not exposed to the hazard. Those not preconnected to a water or solution supply and their associated equipment shall be located and arranged for immediate transport to all designated hazards.

4-4 Foam Requirements.

4-4.1 Rate and Duration of Discharge. The rate and duration of discharge and consequently the quantity of foam concentrate and water shall be determined by the type and potential size of hazard. To the extent that the specific hazards can be identified, the applicable requirements of Chapters 2 or 3 shall apply.

4-4.2 Simultaneous Use of Portable Foam Generating Devices. Where simultaneous use of two or more devices is possible, sufficient supplies of foam concentrate and water shall be available to supply the maximum number of devices that are likely to be used at any one time.

4-5 Equipment Specifications.

4-5.1 Hose. Hose used to connect the generator to the water or solution supplies shall be listed lined hose. Unlined fabric hose shall not be used. The hose size and length shall be selected with consideration to the hydraulics of the entire system. Such hose shall be stored in an arrangement that will permit immediate use and be protected against the weather.

4-5.2 Electric Power Supply and Connections. Power supply and connections needed for operation of the generator shall be adequate to transmit the required power, and shall be selected with consideration to the intended use. All power cables shall be sufficiently rugged to withstand abuse in service, be impervious to water and shall contain a ground wire. Unless electric connectors are waterproof, care shall be taken to prevent them from being immersed in water.

4-6 Training.

4-6.1 Successful extinguishment of fire with portable foam generating devices is dependent upon the individual ability and technique of the operator. All personnel likely to use this equipment shall be properly trained in its operation and in the necessary fire fighting techniques.
Appendix A

The following notes, bearing the same number as the text of the Standard for High Expansion Foam Systems to which they apply, contain useful explanatory material and references to standards.

This Appendix is not part of this NFPA Standard, but is included for information purposes only.

A-1.9.3 Operating Devices. A block diagram of typical automatic high expansion foam system is shown in Fig. A-1.9.3(A).

Foam Generators. At the present time foam generators for high expansion foam are of two types depending on the means for introducing air, namely, by aspirator or blower. In either case, the properly proportioned foam solution is made to impinge at appropriate velocity on a screen or porous or perforated membrane or series of screens in a moving air stream. The liquid films formed on the screen are distended by the moving air stream to form a mass of bubbles or high expansion foam. The foam volume varies from about 100 to 1000 times the liquid volume depending on the design of the generator. The capacity of foam generators is generally determined by the time required to fill an enclosure of known volume by top application within 1 to 5 minutes.

Fig. A-1.9.3(A). Block Diagram of Automatic High Expansion Foam System.

Foam Generators — Aspirator Type. These may be fixed or portable. Jet streams of foam solution aspirate sufficient amounts of air which is then entrained on the screens to produce foam. (See Fig. A-1.9.3(B).) These usually produce foam with expansion ratios not over 250:1.

Fig. A-1.9.3(B). Aspirating Type Foam Generator.

Foam Generators — Blower Type. These may be fixed or portable. The foam solution is discharged as a spray onto screens through which an air stream developed by a fan or blower is passing. The blower may be powered by electric motors, internal combustion engines, air, gas, or hydraulic motors or water motors. The water motors are usually powered by foam solution. (See Fig. A-1.9.3(C).)

A-1.10.5 Fire Performance Test. The purpose of this test is to provide a reproducible fire situation where foam should be required to move a substantial distance at a slow rate to the fire. The time to move this distance and to fill to the top of the test combustibles is the FOAM TRANSIT TIME. The effect of the transit time is to give age to the foam during the period of its slow movement from foam generator to fire.

The test should be conducted in an open top pen or building of suitable construction and suitable dimensions. To prevent the velocity of foam movement from being too high, the width of the pen or building times 100 should give a figure not smaller than the capacity in cfm (m³/min) of the foam generator used in the test. The height of the size of the pen or building should be about 10 ft (3m). If the fluidity of the foam permits, the height may be less. However, the foam should not flow over the
Fig. A-1-9.3(C). Blower Type Foam Generator.

Foam should be produced by a generator in which the expansion ratio is equal to or greater than that produced by the generator proposed for installation.

The test fire should be a stack of eight standards 4 ft x 4 ft (1.22m x 1.22m) hardwood pallets dried to a moisture content between 5 and 8 percent, set on suitable noncombustible supports not over 24 in. (610mm) above the floor. Beneath the pallets should be a 10 sq ft (0.93m²) pan containing 1 gal. (3.8l) of heptane or naphtha floating on water. The surface of the flammable liquid should be approximately 19 in. (305mm) below the bottom boards of the bottom pallet.

The first test of each series should be a timed fill without a fire to determine the foam transit time. The location of the leading edge of the foam as it progresses across the floor of the pen or building should be timed at suitable intervals. Also, the time should be noted when the foam reaches the edge of the pan. This data will permit estimating, with reasonable accuracy, the location of the leading edge of the foam 3 minutes before the foam should reach the edge of the pan. Thereafter, during each fire test, the heptane should be ignited when the foam reaches that point corresponding to 3 minutes in advance of reaching the pan. In this manner the fire is given a reproducible 3-minute preburn. This fill test can be terminated when the foam has filled to the top of the wood pallets, and the time determined as the foam transit time.

The minimum foam transit time should be 12 minutes (150 percent of maximum submergence time, 8 minutes, from Table 2.3.4). To be considered successful under the foam transit time condition, the foam should give adequate control of the test fire. The foam generator should be run for a maximum of 30 minutes. Adequate control should be interpreted as the absence of active burning within the test stack while the stack is covered with foam.

Foam Concentrate Proportioning Systems. Some typical proportioning systems are shown in NFPA 11, Standard for Foam Extinguishing Systems.

A-1-11.2 Resistance of Foam Generators to Fire Exposure. To determine its ability to withstand fire exposure from the hazard area a generator, its associated piping and electrical wiring, protected in accordance with the manufacturer's recommendations, should be started and operated after a 5-minute exposure 10 ft (3m) above a 50-sq ft (4.65m²) gasoline fire using 100 gal. of fuel (379l). The test fire should be shielded to ensure flame impingement on the generator.

A-1-13.1.4 Weekly recorded inspections of high expansion foam systems should be made. Items to be checked include the following, as applicable:

Foam Control Room, Including Foam Concentrate Supply System:
(a) Foam concentrate pumps, tanks, and lines checked for leaks or damage? Concentrate level in tanks normal?
(b) Concentrate pumps operating properly?
(c) All manually operated shutoff valves for the system properly positioned and locked?
(d) Central panel lights operating properly?
(e) All disconnects in control panel in ON position?
(f) Water supply pressure normal?
(g) Batteries fully charged? Liquid level normal?
(h) Fire alarm and trouble alarms tested? Silence switches in normal position?
(i) All supervised functions checked for proper operation?
Electric Foam Generators:
(j) All disconnect switches in the ON position and locked?
(k) Water pressure on sprinkler risers normal?
(l) Water flow alarms tested?
(m) All manually operated shutoff valves locked open?
(n) All closures operating properly?

A-2-3.4 Submergence Time — Vulnerability of Structure. It is imperative that the integrity of primary structural members be maintained under fire exposure (which in sprinklered structures normally support the sprinkler system). Light unprotected bar joist and other similar types of supports are especially vulnerable to damage by fast developing fires as compared to that of heavy steel construction. So also is heavy unprotected steel framing more vulnerable than fire-resistant (concrete) or protected structural members.

A-2-3.5 Tests with foams of above 400:1 expansion ratio have shown that extinguishment times for flammable liquid fires increased significantly at rates of foam rise less than 3 feet per minute. It is expected that at some expansion ratio below 400:1 lower rates of foam rise would be adequate, but insufficient tests have been conducted to identify this ratio.

A-2-3.5.1 Sample Calculation of Total Generator Capacity.

Given:
Building Size — 100 feet × 200 feet × 30 feet high
Building Construction — Light bar joist, Class I steel deck roof, adequately vented. Masonry walls with all openings closable.
Sprinkler Protection — Wet system, 10 feet × 10 feet spacing, 0.25 gpm/sq ft density.
Occupancy — Vertically stacked unbanded rolled Kraft paper 25 feet high.

Assume:
Fire will open 50 sprinkler heads. Foam leakage around closed doors, drains, etc., hence, \( C_L = 1.2 \).

Calculation:

Foam Depth
Depth = 25 × 1.1 = 27.5 feet
(This is greater than minimum cover of 2 feet.)

Submergence Volume
\( V = 100 \times 200 \times 27.5 = 550,000 \) cubic feet

Submergence Time
\( T = 5 \) minutes (from Table 2-3.4)

Rate of Foam Breakdown by Sprinklers
\( S = 10 \) cfm/gpm (from Section 2-3.5.2)
\( Q = \text{No. of heads} \times \text{area/head} \times \text{density} \)
\( = 50 \times (10 \times 10) \times 0.25 = 1250 \) gpm
\( R_s = S \times Q = 10 \times 1250 = 12,500 \) cfm

Normal Foam Shrinkage
\( C_N = 1.15 \) (from Section 2-3.5.3)

Leakage
\( C_L = 1.2 \) (assumption)

Total Generator Capacity

\[ R = \left( \frac{V}{T} + R_s \right) \times C_N \times C_L \]
\[ R = \left( \frac{550,000}{5} + 12,500 \right) \times 1.15 \times 1.2 \]
\[ R = 169,000 \text{ cfm} \]

The number of generators required will depend upon the capacity of the generators available.

Sample Calculation Using SI Units.

Building Size — 30.5 meters × 61 meters × 9.1 meters high.
Sprinkler Protection — Wet System 3 meter × 3 meter spacing, 10.2 liters per minute per sq meter density.
Occupancy — Vertically stacked unbanded rolled Kraft paper 7.6 meters high.

Calculation:

Foam Depth
Depth = 7.6 × 1.1 = 8.4 meters

Submergence Volume
\( V = 30.5 \times 61 \times 8.4 = 15,565 \) cubic meters

Submergence Time
\( T = 5 \) minutes (from Table 2-3.4)
Rate of Foam Breakdown by Sprinklers

\[
S = 0.0748 \text{ m}^3/\text{min}/\text{l}\cdot\text{min} \quad \text{(see 2-3.5.2)}
\]

\[
Q = \text{No. of Heads \times area/head \times density}
= 50 \times (3 \times 3) \times 10.2 = 4731 \text{ l/min}
\]

\[
R_s = S \times Q = 0.0748 \times 4731 = 354 \text{ m}^3/\text{min}
\]

Normal Foam Shrinkage

\[
C_N = 1.15 \quad \text{(see 2-3.5.3)}
\]

Leakage

\[
C_L = 1.2 \quad \text{(assumption)}
\]

Total Generator Capacity

\[
R = \left( \frac{V}{T} + R_s \right) \times C_N \times C_L
\]

\[
R = \left( \frac{15,565}{5} + 354 \right) \times 1.15 \times 1.2
\]

\[
= 4784 \text{ m}^3/\text{min}
\]

A-2-3.5.2 Rate of Breakdown by Sprinklers. Where sprinklers are present in an area to be protected by high expansion foam, simultaneous operation will cause breakdown of the foam. The rate of breakdown will depend upon the number of sprinklers operating and the subsequent total rate of water discharge. The number of sprinklers expected to operate will depend upon various factors as outlined in NFPA 13, Standard for Installation of Sprinkler Systems.

A-2-3.5.4 Foam Leakage. It is essential that uncontrolled leakage be reduced to an absolute minimum through the use of foam-tight barriers at all openings below the effective hazard control level or depth, contemplating the increased rate of foam escape as its fluidity is increased by anticipated sprinkler discharge.

Such leakage through drains, trenches, under doors, around windows, etc., can be minimized by use of suitable automatic closures, sealing agents, or mechanisms. Additional generator capacity should be added to compensate for the aggregate losses where foam escapement cannot be effectively controlled.

A-2-4 Maintenance of Submergence Volume. The choice of a total flooding foam system for protection of a hazard does not necessarily imply that it is expected that the system will completely extinguish the fire, or even so nearly extinguish it as to render the fire incapable of regaining the offensive. Rather, the effect sought might often be speedy control with minimum damage to contents not involved in the fire.

When high expansion foam is establishing or has established control of a fire, care must be exercised that control is not lost. The following points should be kept in mind. Depending upon the particular fire, some or all might be vital.

(a) All should be aware of the necessity for tight closure. Employees, brigade members, and the fire department should move rapidly to close any openings through which foam is being lost. Improvised closures can be made of practically any available material such as screening, plastic, plywood, hardboard.

(b) If the material involved is liable to deep-seated fires, such as furniture, packaged material, fibers, rolls of paper, etc., particular care must be exercised in opening up the areas and removing the foam. Even where only surface fire is thought possible as in flammable liquids, smoldering Class A material may cause reignition.

(c) A "soaking" period should elapse before foam is removed. This may be as long as an hour and should be predetermined based upon the fuel in the area.

A-2-5 Overhaul. The following points should be considered during overhaul operations:

(a) All foam and sprinkler systems which are shut off should have men standing by valves to turn them back on if this should become necessary.

(b) Foam supplies should be replenished if depleted.

(c) Hand hose lines should be charged and manned. Personal protective equipment should be donned. Self-contained breathing apparatus should be worn in the "ready" position so there will be no delay in putting it in service.

(d) Foam should be removed first from the fire area and should be coordinated with overhaul and salvage operations. The total loss will be kept to a minimum if thoughtless operations are avoided. The fire is under control; undue haste to extinguish the last ember may greatly increase the loss.

(e) Caution should be taken in entering previously foam-filled areas, particularly in structures with pits or openings in the floor.

(f) The area should be well ventilated but openings through which foam might be lost should be kept to a minimum and manned for closing if this should become necessary.

(g) Consideration should be given to disposal of the foam to prevent any undue hazard to adjacent areas.