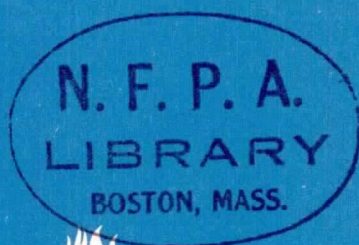


NFPA No.

11A

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# HIGH EXPANSION FOAM SYSTEMS 1970



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NATIONAL FIRE PROTECTION ASSOCIATION  
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**AUTHORITY HAVING JURISDICTION:** The organization, office or individual responsible for "approving" equipment, an installation, or a procedure.

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This material has been developed in the interest of safety to life and property under the published procedures of the National Fire Protection Association. These procedures are designed to assure the appointment of technically competent Committees having balanced representation from those vitally interested and active in the areas with which the Committees are concerned. These procedures provide that all Committee recommendations shall be published prior to action on them by the Association itself and that following this publication these recommendations shall be presented for adoption to the Annual Meeting of the Association where anyone in attendance, member or not, may present his views. While these procedures assure the highest degree of care neither the National Fire Protection Association, its members, nor those participating in its activities accepts any liability resulting from compliance or non-compliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text.

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**Standard for**  
**High Expansion Foam Systems**  
**(Expansion Ratios from 100:1 to 1000:1)**

**NFPA No. 11A —1970**

**1970 Edition of No. 11A**

This Standard was developed by the NFPA Subcommittee on High Expansion Foam Systems. It was approved by the Committee on Foam and submitted as a tentative standard to the members at the 1968 Annual Meeting held in Atlanta. During the year 1968 several comments and suggested amendments were received. The Committee on Foam considered all recommendations and included many of them in a revised edition. The Revised Tentative Standard NFPA No. 11A-TR, was adopted at the 1969 NFPA Annual Meeting in New York City. After one more year of tentative status the Standard was officially adopted without change at the NFPA Annual Meeting in Toronto, Ontario in May 1970.

**Origin and Development of No. 11A-TR**

Work on this Standard commenced in 1964. Several drafts were prepared by the Subcommittee and processed at committee meetings held in subsequent years. The subcommittee's draft was approved by the Foam Committee at its New York meeting in December of 1967. Thereafter, the material was published in the 1968 NFPA Technical Committee Reports for study and evaluation by the NFPA membership and others interested. It was approved as a Tentative Standard at the 1968 Annual Meeting.

During 1968 it was further revised and was submitted and adopted as a revised tentative standard at the 1969 Annual Meeting. After one more year as a tentative standard, it was officially adopted without revision at the 1970 Annual Meeting.

## Committee on Foam

**Thomas L. Culbertson, Chairman,**

Esso Research and Engineering Co., P.O. Box 101, Florham Park, N.J. 07932  
(rep. American Petroleum Institute)

**R. L. Tuve, Secretary,**

Consultant, Materials Division, U. S. Naval Research Laboratory, Code 6004,  
4555 Overlook Ave., S.W. Washington, D.C. 20390

**Theron Arras, Ohio Inspection Bureau**

**C. F. Averill, National Automatic Sprinkler & Fire Control Assn.**

**Royal A. Brown, National Paint, Varnish & Lacquer Assn.**

**Batt. Chief Thomas J. Burke, Fire Marshals Assn. of North America.**

**Layard Campbell, National Automatic Sprinkler & Fire Control Assn.**

**J. B. Corcoran, Edison Electric Institute**

**K. G. Easey, Fire Extinguisher Manufacturers Institute of Canada**

**P. E. Johnson, Factory Mutual Research Corp.**

**Samuel I. Kalkstein, Fire Equipment Manufacturers Assn.**

**Arthur Lagadinos, New England Insurance Rating Assn.**

**C. H. Lindsay, Elmira, N. Y.**

**Norman B. Lockwood, American Petroleum Institute**

**D. N. Meldrum, National Foam System, Inc.**

**James O'Regan, O'Regan-Gagliardo Associates**

**L. E. Rivkind, The Mearl Corp.**

**H. S. Robinson, Oil Insurance Assn.**

**R. M. L. Russell, Factory Insurance Assn.**

**M. E. Suchomel, Underwriters' Laboratories, Inc.**

**D. H. Way, Union Carbide Corp.**

**Ira Wilder, U. S. Naval Applied Science Laboratory.**

### Alternates.

**A. Curl, Fire Extinguisher Manufacturers Institute of Canada. (Alternate to K. G. Easey.)**

**Harry Lein, Fire Equipment Manufacturer Assn. (Alternate to Samuel I. Kalkstein.)**

**H. B. Peterson, U. S. Naval Research Laboratory. (Alternate to R. L. Tuve.)**

**B. E. Sherwood, Oil Insurance Assn. (Alternate to H. S. Robinson.)**

**W. J. Swingler, Factory Insurance Assn. (Alternate to R. M. L. Russell.)**

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

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**Standard for**  
**High Expansion Foam Systems**  
**(Expansion Ratios From 100:1 to 1000:1)**

**NFPA No. 11A — 1970**

**FOREWORD**

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.

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:

1. When generated in sufficient volume, it can prevent air, necessary for continued combustion, from reaching the fire.
2. 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 per cent by volume.
3. 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.
4. 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.
5. 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 should be given consideration in judging the acceptability of specific installations.

Asterisks (\*) indicate additional information in Appendix in correspondingly numbered paragraphs.



## INTRODUCTION

### 1. Purpose

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

### 2. Scope

This Standard includes minimum requirements for 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 this equipment to consult with an experienced and competent fire protection engineer in order to effectively discharge their respective duties.

**3. Definitions.** For purposes of clarification, the following general terms used with special technical meanings, in this Standard, are defined:

**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.

**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 Section A-143).

**FOAM CONCENTRATE** is a concentrated liquid foaming agent as received from the manufacturer.

**FOAM SOLUTION** is water into which foam concentrate has been introduced in the proper proportion.

## CHAPTER 1. GENERAL INFORMATION AND REQUIREMENTS

### 11. General Information

**111. Scope.** Chapter 1 contains general information, and the design and installation requirements for features that are generally common to all high expansion foam systems.

**112. 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.

**113. 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.

1131. Some important types of hazards that high expansion foam systems may satisfactorily protect include:

1. Ordinary combustibles
2. Flammable liquids
3. 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.

1132. High expansion foam systems should not be used on fires in the following hazards unless competent evaluation, which may include tests, indicates acceptability:

1. Chemicals, such as cellulose nitrate, which release sufficient oxygen or other oxidizing agents to sustain combustion.
2. Energized unenclosed electrical equipment (see Sub-Section 1215.)
3. Water-reactive metals such as sodium, potassium, NaK.
4. Hazardous water-reactive materials, such as triethylaluminum and phosphorous pentoxide.

**114. Types of Systems.** The types of systems recognized in this Standard include:

Total Flooding Systems  
Local Application Systems  
Portable Foam Generating Devices

**115. 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 Sub-Section 1151.

1151. 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.

## **12. Personnel Safety**

**121. 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.

1211. Personnel working in a hazard area and with no responsibility for fire fighting should 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 should be given to move the hand over the nose and mouth to minimize discomfort in breathing within the foam.

1212. Where possible the relative location of foam discharge points to building exits shall be arranged to facilitate evacuation of personnel.

1213. To re-enter a foam-filled building, a coarse water spray should be used to cut a path in the foam. Personnel should 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.

1214. **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.

1215. Unenclosed electrical apparatus shall be de-energized upon system actuation unless by competent evaluation it has been deemed unnecessary.

**\*122. Electrical Clearances.** All foam system components such as piping, duct work, and generators, shall be located so as to

maintain standard clearances from live electrical parts in the occupancy (see Appendix for a table of clearances).

### **13. Specifications, Plans and Approval**

**131. 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.

1311. The specifications shall designate the authority having jurisdiction and indicate whether submittal of plans is required.

1312. The specifications shall state that the installation shall conform to this Standard and meet the approval of the authority having jurisdiction.

1313. 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.

**132. Plans.** Where plans are required, their preparation shall be entrusted only to fully experienced and responsible persons.

1321. These plans shall be drawn to an indicated scale or be suitably dimensioned, and shall be made so that they can be easily reproduced.

1322. 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. 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.

**NOTE:** See Chapter 7 of NFPA No. 13 for hydraulic calculation procedures.

**133. Approval of Plans.** Where plans are required, they shall

be submitted to the authority having jurisdiction for approval before work starts.

1331. 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.

**134. 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.

1341. Such tests should include a discharge of foam if possible. This foam should be checked visually for desired quality. If actual discharge is not permitted, the supplier or installer should check air flow and liquid flow in a manner satisfactory to authority having jurisdiction. All piping up to each foam generator shall be subjected to a 2-hour hydrostatic pressure test at 200 psi or 50 psi in excess of the maximum pressure anticipated, whichever is greater, in general conformity with the NFPA Standard for the Installation of Sprinkler Systems (No. 13). Operating instructions provided by the supplier and the proper identification of devices shall be checked.

## **14. Operation and Control of Systems**

**141. 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.

**142. Detection of Fires.** Fires or conditions likely to produce fire may be detected by human senses or by automatic means.

1421. Automatic detection shall be used except when otherwise approved by the authority having jurisdiction.

1422. 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.

1423. An adequate and reliable source of energy shall be used in detection systems. The need for an alternate power supply shall be determined by the authority having jurisdiction.

**\*143. Operating Devices.** Operating devices include foam generators, valves, proportioners, eductors, discharge controls, and shutdown equipment.

1431. 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 need for an alternate power supply shall be determined by the authority having jurisdiction.

1432. 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.

1433. 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.

1434. 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.

1435. 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 Section 141 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 should be designed so that complete emergency actuation can be accomplished from one location.

1436. 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.

1437. All manual operating devices shall be identified as to the hazards they protect.

**144. Supervision.** Supervision of automatic detection and actuation equipment is advisable where the possible loss may be high because of any delay of actuation and/or where the detection or control systems are so extensive and complex that they cannot be readily checked by visual or other inspection. Where supervision is provided it should be so arranged that there will be immediate indication of failure. The extent and type of supervision shall be approved by the authority having jurisdiction.

**145. Alarms and Indicators.** Alarms and/or indicators shall be installed to indicate the operation of the system, alert personnel and indicate failure of any sprinkler device or equipment. They may be audible or visual. Such devices shall be of such a type and should be provided in such numbers and such locations as are necessary to accomplish satisfactorily their purpose subject to approval of the authority having jurisdiction.

**1451.** An alarm or indicator shall be provided to show that the system has operated, personnel response may be needed, and the system shall be reserviced.

**1452.** Alarms should be provided to give ample warning of discharge where hazard to personnel may exist.

**1453.** 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.

## **15. Water, Foam Concentrate and Air Supply.**

**151. 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.

**152. Water Quality.** Consideration should 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. If the quality of the water is questionable, the manufacturer of the foam equipment shall be consulted.

**153. Water Storage.** Water supply shall be protected against freezing.

**154. 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 Section 236 and 332).

**155. 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 such suitable test based on fire performance, is described in A-165.

**156. Foam Concentrate Reserve Supply.** Sufficient foam concentrate should be kept on hand for at least one complete recharge of the system based on desired 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.

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

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

**159. Air Supply.** Air from outside the hazard area shall be used for foam generation unless the calculated foam generation 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.

**1591.** Vents shall be located to avoid recirculation of combustion products into the air inlets of the foam generators.

## **16. Foam Generating Apparatus Location.**

**161. Foam Generating Apparatus Location.** 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.

**162. Protection Against Exposure.** Foam generating equip-



ment should 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.

## **17. Distribution Systems**

**171. 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 should be given to possible galvanic effects when dissimilar metals are joined, especially in piping which carries foam concentrate.

**172. Arrangement and Installation of Piping and Fittings.** Piping shall be installed in accordance with practices outlined in NFPA No. 13.

**1721.** All piping systems shall be designed using hydraulic calculations to assume 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.

**1722.** 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.

**173. 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.

**1731.** Valves shall not be easily subject to mechanical, chemical, or other damage.

**174. 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.

**1741.** 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 should be taken to ensure positive operation.

1742. Ducts shall be designed and installed so that undue turbulence is avoided and the foam discharge rate is in accord with the design requirements. Bends and excessive lengths should be avoided.

## **18. Maintenance and Instructions.**

**181. 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 should 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.

1811. 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.

1812. Suitable discharge tests should be made when any inspection indicates their advisability.

1813. The inspection report, with recommendations, shall be filed with the owner.

1814. Between the regular service contract inspection or tests, the system shall be inspected by competent personnel, following an approved schedule.

1815. Strainers should be inspected and cleaned after each use and test.

**182. 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.

1821. Any troubles or impairments shall be corrected at once by competent personnel.

**183. 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.

1831. Training programs approved by authority having jurisdiction shall be established.

## CHAPTER 2.

### TOTAL FLOODING SYSTEMS

#### 21. General Information

**211. 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.

**212. 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.

**2121.** 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. Three dimensional fires in flammable liquids (falling or flowing under pressure) having flash points below 100°F 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.

**2122.** 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.

**213. 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.

#### 22. Enclosure Specifications

**221. 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.

**2211.** 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 should be tested to assure proper performance.

2212. 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 should not exceed 1000 feet per minute 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, etc., 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.

## 23. Foam Requirements

231. **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.

232. **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 over this hazard. For flammable or combustible liquids, the required depth over the hazard may be considerably greater and shall be determined by tests.

233. **Submergence Volume.** Submergence volume is defined as (1) the depth as specified in Section 232 multiplied by the floor area of the space to be protected or (2) in the case of unsprinklered rooms of 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 submerged volume. The volume occupied by stored material shall not be deducted when determining the submergence volume unless approved by the authority having jurisdiction.

\*234. **Submergence Time.** Recommended times to achieve submergence volume for various types of hazards and building construction are shown in Table I. Shorter submergence times may be required depending on the factors included in Section 235.

**TABLE I**  
**Maximum submergence time for**  
**High Expansion Foam Measured**  
**from start of Foam Discharge\* (Minutes)**

Hazard	Light or Unprotected Steel Construction		Heavy or Protected or Fire Resistive Construction	
	Sprinklered	Not Sprinklered	Sprinklered	Not Sprinklered
Flammable Liquids (Flash Points below 140°F)**	3	2	5	3
Combustible Liquids (Flash Points of 140°F and above)**	4	3	6	4
Low Density Combustibles i.e., Foam Rubber Foam Plastics Rolled Tissue or Crepe Paper	4	3***	6	4***
High Density Combustibles i.e., Rolled Paper -Kraft or Coated-Banded	7	5***	8	6***
High Density Combustibles i.e., Rolled Paper -Kraft or Coated-Unbanded	5	4***	6	5***
Rubber Tires	7	5***	8	6***
Combustibles, in cartons, bags, fiber drums	7	5***	8	6***

\* 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 I.

\*\* Polar solvents are not included in this table. Flammable liquids having boiling points less than 100°F 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. or where fire spread through combustible contents is very rapid.

**235. 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 I, making compensation for normal foam shrinkage, foam leakage, and breakdown effects of sprinkler discharge.

\*2351. The minimum rate of discharge or total generator capacity shall be calculated from the following formula:

$$R = \left( \frac{V}{T} + R_s \right) \times C_N \times C_L \text{ where:}$$

$R$  = rate of discharge — cfm

$V$  = submergence volume —  
cubic feet

$T$  = submergence time —  
minutes

$R_s$  = rate of foam breakdown  
by sprinklers — cfm

$C_N$  = compensation for normal  
foam shrinkage

$C_L$  = compensation for leakage

2352. The factor ( $R_s$ ) for compensation for breakdown by sprinkler discharge should be determined by test. In the absence of specific test data, the following formula shall be used:

$R_s = S \times Q$  where:

$S$  = Foam breakdown in cfm per gpm of sprinkler discharge.  
 $S$  shall be 10 cfm/gpm.

$Q$  = Estimated total discharge from maximum number of sprinklers expected to operate — gpm.

2353. 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.

2354. 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.

**236. 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 Section 154).

2361. Reserve supplies shall be provided in accordance with Section 156.

**\*24. Maintenance of Submergence Volume.** To ensure adequate control or extinguishment, 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.

**241. Method.** The submergence volume may be maintained by continuous or intermittent operation of any or all of the generators provided.

2411. 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.

**\*25. Overhaul.** As is true with other total flooding extinguishing systems, control established by the system may be lost by improper overhaul procedures.

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

## CHAPTER 3. LOCAL APPLICATION SYSTEMS

### 31. General Information

**311. 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.

**312. 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.

**313. 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.

## **32. Hazard Specifications**

**321. Extent of Hazard.** The hazard shall include all areas to which or from which fire may spread.

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

## **33. Foam Requirements**

**331. General.** General sufficient foam shall be discharged at a rate to cover the hazard to a depth of at least two feet.

**332. Quantity.** Sufficient foam concentrate and water shall be provided to permit continuous operation of the entire system for at least 12 minutes (see Section 154).

**3321.** Reserve supplies shall be provided in accordance with Section 156.

**34. 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

### 41. General Information

**411. 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.

**412. 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.

### 42. Hazard Specifications

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

### 43. Location and Spacing

**431. 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.

### 44. Foam Requirements

**441. 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.

**442. Simultaneous Use of Portable Foam Generating Devices.** Where simultaneous use of two or more devices is possible, suffi-

cient 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.

#### **45. Equipment Specifications**

**451. 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 should be stored in an arrangement that will permit immediate use and be protected against the weather.

**452. 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 should be taken to prevent them from being immersed in water.

#### **46. Training**

**461.** 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-122. Clearance to Live Electrical Apparatus**

**General.** 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.

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

**Clearance.** Clearance shall not be less than that given in the following Table.

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

Up to electrical system voltages of 161 kv the design BIL kv and corresponding minimum clearances, phase to ground, have been established through long usage.

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

**Table A-122**  
**Clearance From High Expansion Foam Equipment**  
**To Live Uninsulated Electrical Components**

Nominal Line Voltage kv	Nominal Voltage To Ground kv	Design BIL kv	Minimum Clearance inches
15	9	110	6
23	13	150	8
34.5	20	200	12
46	27	250	15
69	40	350	23
115	66	550	37
138	80	650	44
161	93	750	52
196-230	114-132	{ 900 1050	{ 63 76
287-380	166-220	{ 1175 1300 1550	{ 87 98 120
500	290	{ 1675 1800	{ 131 142
500-700	290-400	{ 1925 2100 2300	{ 153 168 184

Possible design variations in the clearance required at higher voltages are evident in the Table, where a range of voltages is indicated opposite the vari-

ous BIL test values in the high voltage portion of the Table. However, the clearance between uninsulated energized parts of the electrical system equipment and any portion of the high expansion foam system shall not be less than the minimum clearance provided elsewhere for electrical system insulations on any individual component.

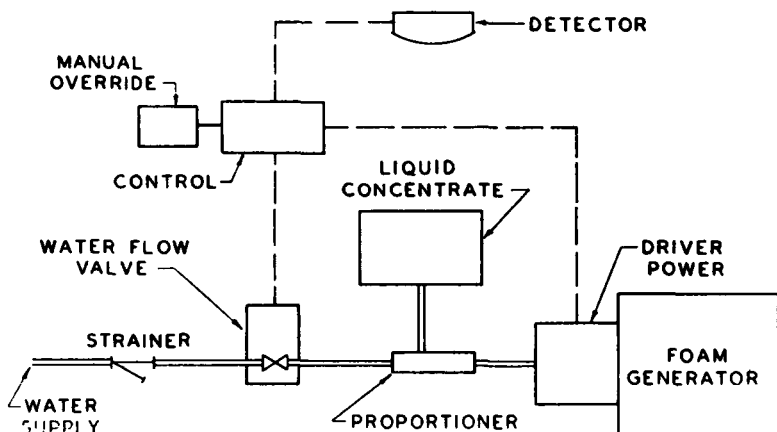
**NOTE:** BIL values are expressed as kilovolts (kv), the number being the crest value of the full wave impulse test that the electrical equipment is designed to withstand.

**A-143. Operating Devices.** A block diagram of typical automatic high expansion foam system is shown in Fig. A-143-1.

**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.

**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-143-2). These usually produce foam with expansion ratios not over 250:1.

**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-143-3.)



**Fig. A-143-1. Block Diagram of Automatic High Expansion Foam System.**