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HIGH EXPANSION FOAM SYSTEMS 1976

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See Inside Back Cover for Official NFPA Definitions

Standard for

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

NFPA 11A – 1976

1976 Edition of NFPA 11A

This edition was adopted at the Annual meeting of the National Fire Protection Association held in Houston, TX, May 17-20, 1976 and supersedes the 1970 edition.

Changes other than editorial are denoted by a vertical line in the margin of the pages in which they appear.

Origin and Development of NFPA 11A

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. The 1970 edition of the Standard was approved by the American National Standards Institute as an American National Standard and designated ANSI Z286.2-1974. The 1976 edition will also be submitted for similar approval.

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Interpretation Procedure of the Sectional Committee on Protective Signaling Systems

Those desiring an interpretation shall supply the Chairman with five identical copies of a statement in which shall appear specific reference to a single problem, paragraph, or section. Such a statement shall be on the business stationery of the inquirer and shall be duly signed.

When applications involve actual field situations they shall so state and all parties involved shall be named.

The Interpretations Committee will reserve the prerogative to refuse consideration of any application that refers specifically to proprietary items of equipment or devices. Generally inquiries should be confined to interpretation of the literal text or the intent thereof.

Requests for interpretations should be addressed to the National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210.

Table of Contents

Chapter 1. General Information 11A-5

1-1 Scope 11A-5
1-2 Purpose 11A-5
1-3 History 11A-5
1-4 Description 11A-6
1-5 Definitions 11A-7
1-6 General Information and Requirements 11A-7
1-7 Personnel Safety 11A-8
1-8 Specifications, Plans and Approval 11A-11
1-9 Operation and Control of Systems 11A-12
1-10 Water, Foam Concentrate and Air Supply 11A-14
1-11 Foam Generating Apparatus Location 11A-16
1-12 Distribution Systems 11A-16
1-13 Maintenance and Instructions 11A-17

Chapter 2. Total Flooding Systems 11A-19

2-1 General Information 11A-19
2-2 Enclosure Specifications 11A-19
2-3 Foam Requirements 11A-20
2-4 Maintenance of Submergence Volume 11A-23
2-5 Overhaul 11A-23
2-6 Distribution 11A-23

Chapter 3. Local Application Systems 11A-24

3-1 General Information 11A-24
3-2 Hazard Specifications 11A-24
3-3 Foam Requirements 11A-24
3-4 Method 11A-25

Chapter 4. Portable Foam Generating Devices 11A-26

4-1 General Information 11A-26
4-2 Hazard Specifications 11A-26
4-3 Location and Spacing 11A-26
4-4 Foam Requirements 11A-26
4-5 Equipment Specifications 11A-27
4-6 Training 11A-27

Appendix A 11A-28

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 and Units.

1-5.1 Definitions. For purposes of clarification, the following general terms used with special technical meanings in this standard are defined:

1-5.1.1 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.

1-5.1.2 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*).

1-5.1.3 Foam Concentrate is a concentrated liquid foaming agent as received from the manufacturer.

1-5.1.4 Foam Solution is water into which foam concentrate has been introduced in the proper proportion.

1-5.2 Units. Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). Two units (litre and bar), outside of but recognized by SI, are commonly used in international fire protection. These units are listed in Table 1-5.2 with conversion factors.

1-5.2.1 If a value for measurement as given in this standard is followed by an equivalent value in other units, the first stated is to be regarded as the requirement. A given equivalent value may be approximate.

Table 1-5.2

Metric Conversion Factors

Name of Unit	Unit Symbol	Conversion Factor
litre	*l*	1 gal. = 3.785 *l*
cubic decimetre	dm^3	1 gal. = 3.785 dm^3
pascal	Pa	1 psi = 6894.757 Pa
bar	bar	1 psi = 0.068 95 Bar
bar	bar	1 bar = 10^5 Pa

For additional conversions and information see ANSI Z210.1-1973, Metric Practice Guide.

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.

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 shall be based upon the design BIL used rather than on the nominal line or ground voltage.

Possible design variations in the clearance required at higher voltages are evident in the table, where a range of voltages is indicated opposite the various 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.

TABLE 1-7.2

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)	mm
To 15	To 9	110	6	152
23	13	150	8	203
34.5	20	200	12	305
46	27	250	15	381
69	40	350	23	584
115	66	550	37	940
138	80	650	44	1118
161	93	750	52	1321
196-230	114-132	900	63	1600
		1050	76	1930
287-380	166-220	1175	87	2210
		1300	98	2489
		1425	109	2769
		1550	120	3048
500	290	1675	131	3327
		1800	142	3607
500-700	290-400	1925	153	3886
		2100	168	4267
		2300	184	4674

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 13–1975, 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 (13.8 bars) or 50 psi (3.5 bars) in excess of the maximum pressure anticipated, whichever is greated. *(See NFPA 13–1975, 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 a process trouble, likely to produce fire. *(See NFPA 72E–1974, Standard on Automatic Fire Detectors.)*

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 Fire 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 20–1976, *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 reserviced.

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 such 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 recharge 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 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.

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 13–1975, *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.

Chapter 2 Total Flooding Systems

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–1975, 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.

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 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 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 2-3.4

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 [60°C])**	3	2	5	3
Combustible Liquids (Flash Points of 140°F [60°C] 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 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 (m^3/min)
V = submergence volume — cubic feet (m^3)
T = submergence time — minutes
R_S = rate of foam breakdown by sprinklers — cfm (m^3/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 $m^3 \cdot min/l \cdot min$)
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.

*2-3.5.4 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.

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 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.

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.

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 1-10.4)*.

3-3.2.1 Reserve supplies shall be provided in accordance with 1-10.7.

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.

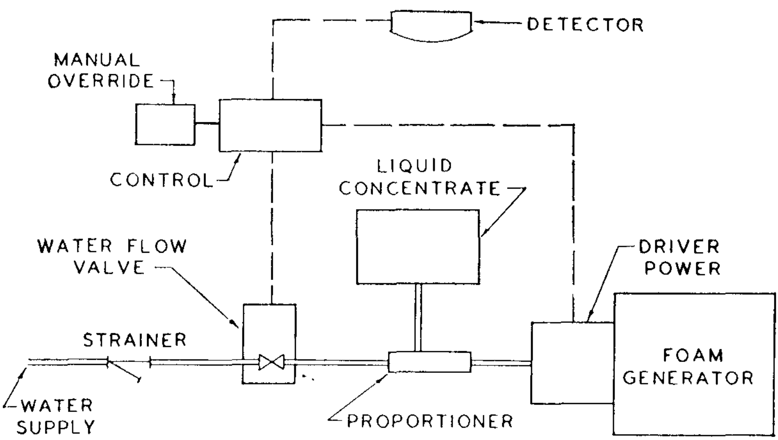

Fig. A-1-9.3(A). Block Diagram of Automatic High Expansion Foam System.

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.

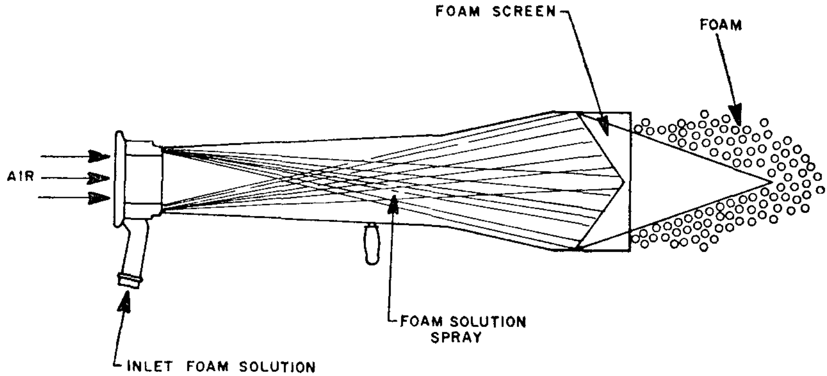

Fig. A-1-9.3(B). Aspirating Type Foam Generator.

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 (m^3/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