Report of Foam Committee

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The report of the Committee on Foam is in two parts. Part I proposes revisions to NFPA No. 11, Standard for Foam Extinguishing Systems-1972. Part II proposes revisions to NFPA No. 11B-T, Synthetic Foam and Combined Agent Systems, and the upgrading of No. 11B-T from tentative to official status.
This report has been submitted to the 23 voting members of the committee of whom 20 have voted affirmatively on Part I and none have voted negatively. Messrs. Ault, Miller and Robinson did not return ballots on Part I.

On Part II, 20 members voted affirmatively on recommended changes to No. 11B-T and none negatively. Eighteen members voted affirmatively on upgrading No. 11B-T to official status. Mr. Rivkind voted negatively and Mr. Mel- drum wishes to be recorded as not voting. Messrs. Ault, Miller and Robinson did not return ballots on Part II.

Part I
1973 Proposed Revisions to Standard on Foam Extinguishing Systems
NFPA No. 11 — 1972

1. Amend Foreword to read:

FOREWORD

Foam for fire protection purposes is an aggregate of air-filled bubbles formed from aqueous solutions and is lower in density than the lightest flammable liquids. It is principally used to form a coherent floating blanket on flammable and combustible liquids lighter than water and prevents or extinguishes fire by excluding air and cooling the fuel. It also prevents reignition by suppressing formation of flammable vapors. It has the property of adhering to surfaces, providing a degree of exposure protection from adjacent fires.

Foam may be used as a fire prevention, control or extinguishment agent for flammable liquid tanks or processing areas. Foam solution for these hazards may be supplied by fixed piped systems or portable foam generating systems. Foam may be applied by foam discharge outlets, which allow it to fall gently on the surface of the burning fuel, or it may be introduced by other means. Foam may also be
applied to these hazards by portable hose streams using foam nozzles, portable towers or large capacity monitor nozzles.

Foam may be supplied by overhead piped systems for protection of hazardous occupancies involving potential flammable liquid spills in the proximity of high value equipment, or in large areas. The application of foam for this type of hazard is in the form of a spray or dense "snowstorm." The foam particles coalesce on the surface of the burning fuel after falling from the overhead foam outlets spaced to cover the entire area at a uniform density. For systems required to meet both foam and water design criteria, refer to NFPA No. 16, *Foam Water Systems*.

Large spill fires of flammable liquids can be fought with mobile equipment, such as an airport crash truck or industrial foam truck equipped with agent and equipment capable of generating large volumes of foam at high rates. Foam for this type of hazard may be delivered as a solid stream or a dispersed pattern. Standards for airport crash trucks may be found in detail in NFPA No. 414.

While other extinguishing agents are also recognized for use on flammable liquid fires, it should be noted that for flammable liquid fires in large storage tanks, only foam has been found to be practical.

Foam does not break down readily, and when applied at an adequate rate, has the ability to extinguish fire progressively. As the application continues, foam flows easily across the burning surface in the form of a tight blanket, preventing re-ignition on the surfaces already extinguished.

Foam may also be used for heat radiation protection. Foam reduces heat transmission to solid surfaces on which it has been applied because of its reflectivity, cooling effect, and insulating characteristic. In the case of certain combustible surfaces these characteristics may prevent ignition.

Asterisks (*) indicate additional information in Appendix in correspondingly numbered paragraphs.
2. Amend Chapter 1 in its entirety to read:

CHAPTER 1. GENERAL INFORMATION

1000. Introduction.

1010. PURPOSE: This standard is intended for the use and guidance of those charged with designing, installing, testing, inspecting, approving, listing, operating or maintaining foam fire extinguishing systems, either portable or fixed for interior or exterior hazards.

1020. SCOPE: This standard covers the characteristics of foam-producing materials and the requirements for design, installation, operation and maintenance of equipment and systems. Minimum requirements are covered for flammable and combustible liquid hazards in local areas within buildings, for storage tanks, and for indoor and outdoor processing areas. Methods of testing systems are also included. This standard does not include requirements for synthetic and high expansion foam systems. (See subsection 1133.)

1100. Definitions.

1110. FLAMMABLE AND COMBUSTIBLE LIQUIDS.

1111. Flammable Liquids shall mean any liquid having a flashpoint below 140°F and having a vapor pressure not exceeding 40 lb/sq in. (absolute) at 100°F. Flammable liquids shall be divided into two classes of liquids as follows:

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

(i) Class IA shall include those having flashpoints below 73°F and having a boiling point below 100°F.

(ii) Class IB shall include those having flashpoints below 73°F and having a boiling point at or above 100°F.

(iii) Class IC shall include those having flashpoints at or above 73°F and below 100°F.

(b) Class II liquids shall include those having flashpoints at or above 100°F and below 140°F.

1112. Combustible Liquids shall mean any liquid hav-
ing a flashpoint at or above 140°F (60°C), and shall be known as Class III. They may be subdivided as follows:

(a) Class IIIA shall include those having flashpoints at or above 140°F (60°C) and below 200°F (93.4°C).

(b) Class IIIB shall include those having flashpoints at or above 200°F (93.4°C).

1120. Foam: Fire-fighting foam within the scope of this standard is a stable aggregation of small bubbles of lower density than oil or water, and shows tenacious qualities for covering and clinging to vertical or horizontal surfaces. It flows freely over a burning liquid surface and forms a tough, air-excluding continuous blanket to seal volatile combustible vapors from access to air. It resists disruption due to wind and draft, or heat and flame attack, and is capable of resealing in case of mechanical rupture. Fire-fighting foams retain these properties for relatively long periods of time.

1121. Air Foam or Mechanical Foam is made by mixing air into a water solution containing a foam concentrate by means of suitably designed equipment.

1122. Chemical Foam is made by the reaction of an alkaline salt solution (usually bicarbonate of soda) and an acid salt solution (usually aluminum sulphate) to form a gas (carbon dioxide) in the presence of a foaming agent which causes the gas to be trapped in bubbles to form a tough, fire resistant foam.

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

*113. Air Foam Concentrate. Air foam concentrate is a concentrated liquid foaming agent as received from the manufacturer.

1131. Protein-Foam Concentrates consist primarily of products from a protein hydrolysate, plus stabilizing additives and inhibitors to protect against freezing, to prevent corrosion of equipment and containers, to resist bacterial decomposition, to control viscosity, and to otherwise assure readiness for use under emergency conditions. They are diluted with water to form 3 percent to 6 percent solutions depending upon the type.

1132. Fluoroprotein-Foam-Concentrates are very similar to protein-foam concentrates as described above,
but with a synthetic fluorinated surfactant additive. In addition to an air-excluding foam blanket, they may also deposit a vaporization preventing film on the surface of a liquid fuel. They are diluted with water to form 3 percent to 6 percent solutions depending on the type.

1133. **Synthetic Foam Concentrates** are based on foaming agents other than hydrolysed proteins. They include:

1. **Aqueous Film Forming Foam (AFFF) Concentrates** are based on fluorinated surfactants plus foam stabilizers and are diluted with water to a 3 percent or 6 percent solution. The foam formed acts both as a barrier to exclude air or oxygen and to develop an aqueous film on the fuel surface capable of suppressing the evolution of fuel vapors. The foam produced with AFFF concentrate is dry-chemical-compatible and thus is suitable for combined use with dry chemicals. Guidance for use of these materials is given in NFPA No. 11B-T, *Synthetic and Combined Agent Systems*.

2. **High Expansion Foam Concentrates** (usually derived from hydrocarbon surfactant) are used in specially designed equipment to produce foams of foam-to-solution volume ratios of 100:1 to approximately 1000:1. This equipment may be air-aspirating or blower-fan type. Guidance for the use of these materials is given in NFPA No. 11A, *High Expansion Foam Systems*.

3. **Other Synthetic Concentrates** are also based on hydrocarbon surface active agents and are listed as wetting agents, or as foaming agents. Their use is usually limited to portable nozzle application to spill fires within the scope of their listings by nationally recognized laboratories. They produce foams which are usually rapid draining, do not have the burnback resistance of protein, fluoroprotein, and AFFF foams, and require higher application rates for extinguishment than the other types of foam.

1134. **Special "Alcohol Type" Foam Concentrates** form a foam which has an insoluble barrier in the bubble structure which resists breakdown at the interface of the fuel and foam blanket. They are used for fighting fires in water soluble and certain flammable or combustible liquids and solvents which are destructive to regular foams.
1135. Compatibility of Concentrates and Their Foams. Different types and brands of concentrates may be incompatible and shall not be mixed in storage. Foams generated separately from protein, fluoroprotein and AFFF concentrates, may be compatible to a degree and may be applied to a fire in sequence or simultaneously.

114. Foam Solution. Foam solution is a homogeneous mixture of water and foam concentrate in the proper proportion.

115. Foam Solution Proportioning Method. Foam solution is produced by continuous introduction of foam concentrate at the recommended ratio to water flow.

116. Foam Solution Premix Method. Foam solution is produced by premixing foam concentrate directly into the water in a storage tank.

120. Air Foam

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

(a) Foam Nozzle Inductor: A suitably designed venturi with “pick-up tube” is included in the foam nozzle construction so that foam liquid concentrate is drawn up through a short length of pipe or flexible tubing connecting the foam nozzle with the container of foam concentrate. The concentrate is thus automatically mixed with the water in recommended proportions.

(b) In-Line Inductor: A venturi inductor is located in the water supply line to the foam maker. This is connected by single or multiple lines to the source of foam concentrate. It is precalibrated and it may be adjustable.

(c) Pump Proportioner: (Around-the-pump proportioner.) The pressure drop between the discharge and suction side of the water pump of the system is used to induct foam concentrate into water by suitable variable or fixed orifices connected to a venturi inductor in a by-pass between the pump suction and the pump discharge.

(d) Metered Proportioning: A separate foam concentrate pump is used to inject foam concentrate into the water stream. Orifices and/or venturis control or measure the proportion of water to foam concentrate. Either manual
or automatic adjustment of foam concentrate injection by pressure or flow control may be utilized. Another type of proportioning uses a pump or diaphragm tank to balance the pressure of the water and the concentrate. Variable orifices proportion automatically through a wide range of solution requirements.

(e) Pressure Proportioning Tank: A suitable method is provided for displacing foam concentrate from a closed tank by water (with or without a diaphragm separator), using water flow through a venturi orifice.

(f) Coupled Water-Motor Pump: A suitably designed positive displacement pump in the water supply line is coupled to a second, smaller, positive displacement foam concentrate pump to provide proportioning.

*122. AIR FOAM GENERATING METHODS. The methods of generation of air foam recognized in this standard include:

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

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

(c) Foam Pump: A positive-displacement type pump is connected to a supply of foam solution. Part of the intake of this pump is open to the atmosphere so that when it is operated at the proper speed the air and solution are intimately mixed to form foam under pressure.

123. STORAGE OF AIR FOAM-CONCENTRATES. In order to insure the correct operation of any foam-producing sys-
tem, the chemical and physical characteristics of the ma-
terials comprising the system are taken into consideration
in its design. Since such systems may or may not be opera-
ted for long periods after installation, the choice of proper
storage conditions and maintenance methods will determine
to a large extent the reliability and the degree of excellence
of operation of the system when it is called upon to operate.

1231. Foam concentrate may be stored in the contain-
ers in which it is transported or it may be transferred to
large bulk storage tanks depending on the requirements of
the system. These foam concentrates are subject to freez-
ing and deterioration by prolonged storage at high tempera-
tures. For ready use they shall be stored within the listed
temperature limitations. The location of stored containers
requires special consideration to protect against exterior
deterioration due to rusting or other causes. Bulk storage
containers also require special design consideration.

130. Chemical Foam. Chemical foam is the oldest form of
fire fighting foam (ca. 1903) and is no longer in general use.
The excessive maintenance needed to insure reliability and
excessive manpower necessary during an emergency have
made this type of foam less desirable than air foam.

*131. Chemical Foam Powders. These are dry mix-
tures of powders used to generate chemical foam by their
interaction when mixed with water, at or near the point
where the chemical foam is needed. There are three types
of chemical foam powders: Dual powder charges, where the
alkaline salt portion of the chemical foam powder is packed
separately from the acidic salt portion of the charge and the
containers are marked “A” and “B” powders; Single pow-
der charges, where a single blend of all the chemical foam
powders needed to produce chemical foam is a single con-
tainer; Special “alcohol type” single powder charges, where
a single blend of specially formulated chemical foam powder
is packaged for use on fires involving water-miscible solv-
ents such as alcohol, etc. All types are packaged in dry
moisture-proof containers. Since chemical foam powders
are no longer in general use, replacement materials may not
be available from recognized vendors.

*132. Chemical Foam Generating Methods. The
methods of generation of chemical foam include:
(a) Continuous Foam Generators: An open funnel-shaped container (or dual containers) is positioned at the terminus of a water supply. It is so designed that when dry foam powder (or dual powders) is fed into it the water stream picks up the necessary amount for interaction to produce foam. Some types of continuous generators consist of separate containers for the acid and alkaline salts and the two solutions formed are kept separate until admixture in the system beyond the point of solution in water. The foam formed in either of the above systems is conducted in either piping or hoses to the hazard being protected.

(b) Stored Solution Systems: This is a "wet system" and employs the necessary reacting chemicals as separate water solutions of alkaline salts and acidic salts made and stored in containers separately piped to a central mixing point where foam is generated by their interaction. The resulting foam is piped to the hazard being protected.

*133. STORAGE OF CHEMICAL FOAM MATERIALS. Special design and handling are needed when storing chemical foam materials.

140. Use and Limitations of Foams. The uses of foams within the limits of this standard are listed below.

Characteristics and uses of other foams may be found in NFPA No. 11A, High Expansion Foam Systems, and NFPA No. 11BT, Synthetic Foam and Combined Agent Systems.

*141. The uses of foam are as follows:

(1) The principal use of foams is the extinguishment of burning liquids lighter than water.

(2) Ignition and fire may be prevented by applying foam blankets to spills or other hazardous areas.

(3) Foams may also be used to insulate and protect exposures from radiant heat. They also act to prevent ignition of open areas of flammable liquids if spread completely over an exposed surface. It is well to remember, however, that foam breakdown can render such a foam protective coating of no value to the fire fighter and frequent renewal may be necessary.

(4) Because of the water content, foams may be used to extinguish surface fires in ordinary combustible
142. The limitations of foam are as follows:

(1) Foams are not suitable extinguishing agents for fires involving gases, liquefied gases with boiling points below ambient temperatures such as butane, butadiene, propane, etc., or cryogenic liquids.

(2) Flowing liquid fires, such as overhead tank leakage or pressure leaks, are not readily extinguishable with foams. Other auxiliary agents compatible with foams should be provided in conjunction with foams for fighting fires of this nature.

(3) Foams shall not be used to fight fires in materials which react violently with water, such as metallic sodium and metallic potassium, etc. In certain magnesium fires, foams may be judiciously applied to help restrict burning and cool residual metal.

(4) Foam is a conductor and shall not be used on energized electrical equipment fires.

(5) Judgment must be used in applying foams to hot oils, burning asphalts or burning liquids which are above the boiling point of water. Although the comparatively low water content of foams can beneficially cool such fuels at a slow rate it can also cause violent frothing and "slop-over" of the contents of the tank.

(6) Certain wetting agents and some dry chemical powders may be incompatible with foams. If they are used simultaneously, an instantaneous breakdown of the foam blanket may occur. Precautions must be taken to ensure that such agents are fully compatible with the types of foams being used.

(7) Regular foams are not suitable for water soluble or polar solvent liquids. Special foams designed for these materials are available.

150. Specifications and Plans.

151. The specifications shall designate the authority having jurisdiction and indicate whether submittal of plans is required. They shall state that the installation shall conform to this Standard and meet the approval of the authority having jurisdiction. They shall include the specific tests that will be required to meet the approval of the authority.
having jurisdiction, and indicate how cost of testing is to be borne.

152. PLANS. Where plans are required, their preparation shall be entrusted only to fully experienced and responsible persons. They shall be submitted for approval to the authority having jurisdiction before foam systems are installed or existing systems modified. These plans shall be drawn to an indicated scale or be suitably dimensioned.

152.1. Plans shall contain or be accompanied by the following information, when applicable, to enable the authority having jurisdiction to evaluate the suitability of the system:

(a) Physical details of the hazard including the location, arrangement, and hazardous materials involved.
(b) Type and percentage of foam concentrate.
(c) Required solution application rate.
(d) Water requirements.
(e) Calculations showing required amount of concentrate.
(f) Hydraulic calculations. (See Chapter 7 of NFPA No. 13, Sprinkler Systems, for hydraulic calculation procedures.)
(g) Identification and capacity of all equipment and devices.
(h) Location of piping, detection devices, operating devices, generators, discharge outlets, and auxiliary equipment.
(i) Schematic wiring diagram.
(j) Explanation of any special features.

153. 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.

*160. Water Supplies.

161. QUALITY. The water supply to foam systems may be hard or soft, fresh or salt, but shall be of suitable quality so that adverse effects on foam formation or foam stability does not occur. No corrosion inhibitors, emulsion
breaking chemicals or any other additives shall be used without prior consultation with the foam concentrate supplier.

162. QUANTITY. The water supply shall be adequate in quantity to supply all the devices that may be used simultaneously. This includes not only the volume required for the foam apparatus but also water which may be used in other fire fighting operations, in addition to the normal plant requirements.

163. PRESSURE. The pressure available at the inlet to the foam system (foam generator, air foam maker, etc.) under required flow conditions shall be at least the minimum pressure for which the system has been designed.

164. SYSTEM DESIGN. The water system shall be designed and installed in accordance with recognized standards for such extinguishing systems. Where solids of sufficient size to obstruct openings in the foam equipment may be present strainers shall be provided. Hydrants furnishing the water supply for portable foam equipment shall be provided in sufficient number and be located as required by the authority having jurisdiction.

*170. Air Foam System Design.

171. AIR FOAM GENERATING AND PROPORTIONING SYSTEM DESIGN. Suitable approved equipment of the type described earlier in this standard shall be furnished in size and type in accordance with the detailed foam application requirements for the hazard to be protected as required by the authority having jurisdiction. This equipment shall include the necessary prime movers, foam concentrate proportioners and storage tanks, foam generators and foam piping and discharge devices.

1711. Foam systems shall be designed so that all components having moving parts can be periodically tested without discharging foam onto the hazard.

1721. DISCHARGE OUTLETS. Discharge outlets shall be designed and located to permit the distribution of the foam over the area to be protected. Discharge outlets may be in combination with mixing devices or may be separate devices.

173. SYSTEM PIPING.

1731. PIPE MATERIALS. Pipe within the hazard area
shall be steel, suitable for the pressure involved, but not less than standard weight, in accordance with current American Standards. Pipe specifications normal for water use shall be permitted outside the hazard area.

1732. VALVES. All valves shall be listed for fire protection use. Readily accessible drain valves shall be provided for low points in underground and aboveground piping. Valve specifications normal for water use shall be permitted outside the hazard or diked area. Automatic control valves, shutoff valves and strainers of approved types may be cast iron if outside the fire area, but shall be steel if within the fire area.

1733. FITTINGS. All pipe fittings shall be American Standard for the pressure class involved but not less than 125 lb standard. Iron fittings shall be malleable in dry sections of the piping exposed to possible fire. All fittings subject to stress in self-supporting systems shall be steel or malleable iron.

1734. INSTALLATION. Piping shall be so arranged as to reduce friction to a reasonable minimum. All piping shall be securely supported. All foam distribution piping shall be arranged to drain and shall have a pitch toward drain of 1/2 inch in each 10 feet. Foam system piping shall be normally empty and where exposed to corrosive influences it shall be protected against corrosion.

*1735. PIPE SIZES. Since effective protection depends on having an adequate volume of water (or solutions) at proper pressure, available at the foam-making devices, each system requires individual consideration as to the size of the piping. Friction losses in pipe and fittings carrying water or foam solutions shall be determined by the Hazen and Williams formula using a value of 120 for “c”. Pipe sizes shall be so selected as to produce the proper delivery rate at the discharge outlet. (See Chapter 7 of NFPA No. 13 for hydraulic calculation procedures.) For friction losses in piping carrying foam see A-3561.

1736. FLUSHING AFTER INSTALLATION. Water supply mains, both underground and aboveground, shall be flushed thoroughly at the maximum practicable rate of flow, before connection is made to system piping, in order to remove foreign materials which may have entered during
installation. The minimum rate of flow for flushing shall not be less than the water demand rate of the system, as determined by the system design and the available water supply. The flow shall be continued for a sufficient time to insure thorough cleaning. Disposal of flushing water must be suitably arranged. All foam system piping shall be flushed after installation, using its normal water supply with foam-forming materials shut off, unless the hazard cannot be subjected to water flow. Where flushing cannot be accomplished, cleanliness of pipe interiors shall be carefully examined visually during installation.

1737. Flushing After Use. Provision shall be made in the design to permit flushing of normally empty foam concentrate and solution piping with clean water after use.

174. Storage of Foam Concentrate Equipment.

1741. Storage Facilities. Storage of foam concentrates and equipment shall be in an accessible location not exposed by the hazard they protect. If housed, they shall be in a noncombustible structure.

1742. Reserve Supply of Foam-Concentrate. There shall be a readily available reserve supply of foam-producing materials sufficient to meet design requirements in order to put the system back into service after operation. This supply may be in separate tanks or compartments, in drums or cans on the premises, or available from an approved outside source within 24 hours.

1743. Off-Premises Storage. For outdoor nonautomatic systems, the authority having jurisdiction may permit the storage of foam-concentrate off the premises where these supplies are available at all times. Adequate loading and transportation facilities must be assured. Off-premises supplies shall be of the proper type for use in the systems of the given installation. At the time of a fire these off-premises supplies shall be accumulated in sufficient quantities, before placing the equipment in operation, to ensure uninterrupted foam production at the design rate for the required period of time.

180. Acceptance Tests. The completed system shall be inspected and tested by qualified personnel to determine that it is properly installed and will function as intended.
181. **Inspection and Visual Examination.** Foam systems shall be examined visually to determine that they have been properly installed. They shall be inspected for such items as conformity with installation plans, continuity of piping, removal of temporary blinds, accessibility of valves, controls and gages, and proper installation of vapor seals, where applicable. Devices shall be checked for proper identification and operating instructions.

182. **Pressure Tests.** All piping, except that handling expanded foam for other than subsurface application, shall be subjected to a two-hour hydrostatic pressure test at 200 psig or 50 psi, in excess of the maximum pressure anticipated, whichever is greater, in general conformity with NFPA No. 13, Installation of Sprinkler Systems. All normally dry horizontal piping shall be inspected for drainage pitch.

183. **Operating Tests.** Before acceptance, all operating devices and equipment shall be tested for proper function.

184. **Discharge Tests.** Where conditions permit, flow tests shall be conducted to ensure that the hazard is fully protected in conformance with the design specification, and to determine the flow pressures, actual discharge capacity, consumption rate of foam-producing materials, manpower requirements and other operating characteristics. The foam discharged shall be visually inspected to ensure that it is satisfactory for the purpose intended.

185. **System Restoration.** After completion of acceptance tests the system shall be flushed and restored to operational condition.

190. **Periodic Inspection, Testing and Maintenance.** All systems shall be thoroughly inspected by a competent inspector at regular intervals, at least annually, to ensure that they will remain in full operating condition. Regular service contracts with the manufacturer or installer are generally available.

191. **Foam-Producing Equipment.** Proportioning devices, their accessory equipment and foam-makers shall be inspected.

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

193. STRAINERS. Strainers shall be inspected and cleaned after each use and flow test.

194. DETECTION AND ACTUATION EQUIPMENT. Control valves including all automatic and manual actuating devices shall be tested at regular intervals.

195. AIR FOAM CONCENTRATES. Periodic inspection shall be made of air foam concentrates and their tanks or storage containers for evidence of excessive sludging or deterioration. Samples of concentrates should be referred to the manufacturer or qualified laboratory for quality condition testing. Quantity of concentrate in storage shall meet design requirements.

196. OPERATING INSTRUCTIONS AND TRAINING. Operating and maintenance instructions and layouts shall be posted at control equipment and at fire headquarters. 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.

3. Amend section 2520 to read:

2520. There shall be a quantity of foam-producing materials sufficient to supply the system in accordance with 33 and 34. For area and equipment protection, if the system discharges at a rate above the minimum specified, then the operating time may be reduced proportionately but shall not be less than seven (7) minutes.

4. Amend section 322 to read:

322. MINIMUM DISCHARGE TIMES: The system shall be capable of operation at the delivery rate specified in 411, for the tank to be protected, for the following minimum periods of time. If the apparatus available has a delivery rate higher than specified in 411, proportionate reduction in the time figures may be made, except that they shall not be less than 70 percent of the minimum discharge times shown.
5. Amend section 422 to read:

422. MINIMUM DISCHARGE TIME: The system shall be capable of operation at the delivery rate specified in 4110 for the following minimum periods of time. If the apparatus available has a delivery rate higher than that specified in 4110, proportionate reduction in the time figures may be made, except that they shall not be less than 70 percent of the minimum discharge times shown.

6. Amend section 522 to read:

522. OPERATING SUPPLY: There shall be a quantity of foam-producing materials sufficient to supply the system at the design rate for a period of ten (10) minutes. If the system discharges at a rate above the minimum specified in 611, then the operating time may be reduced proportionately, but shall not be less than seven (7) minutes.

7. Amend section 622 to read:

622. MINIMUM DISCHARGE TIMES: The equipment shall be capable of operation to provide primary protection at the delivery rates specified in 711 for the following minimum periods of time.

8. Amend the Appendix by redesignating all section numbers and references as indicated:

A-113. AIR FOAM CONCENTRATE: The "high expansion" type concentrate produces about 350 gals. of air foam per gallon of concentrate and 16 to 18 gals. of air foam per gallons of water. The "low expansion" type concentrate produces 120 to 200 gals. of air foam per gallon of concentrate and 8.5 to 11.5 gals. of air foam per gallon of water. These figures are representative of playpipe performance and delivery from fixed air foam makers of the low back-pressure type. Foam production from the high back-pressure type of foam maker varies with the back-pressure imposed.

A-115. PUMP SUCTION METHOD: This type of proportioner (Fig. A-115) consists of an eductor installed in the suction line to a water pump. To operate satisfactorily, the head on the water supply line must not be higher than that on the tank of air foam stabilizer.

The capacity of the proportioner may be varied from approximately 50 per cent to 200 per cent of the nominal or rated capacity as prescribed by the manufacturer.
Fig. A-115. Pump Suction Proportioner. To install: connect A to water suction line, connect B to suction side of pump. To operate foam system: close valve C, open valves D and E. To discharge plain water: close valves D and E, open valve C.

A-116. PREMIXED AIR FOAM SOLUTIONS: The manufacturer should be consulted regarding concentrate to be used in the preparation of premixed solution.

A-121 (a). FOAM NOZZLE INDUCTOR. Figure A-122 (a) shows this type of proportioner where one or more of the jets in the foam maker are utilized to draft the concentrate.

LIMITATIONS: The bottom of the concentrate container should not be more than 6 ft. below the level of the foam maker. The length and size of hose or pipe between the concentrate container and the foam maker should conform to the recommendations of the manufacturer.

A-121 (b). IN-LINE INDUCTOR: This inductor is for installation in a hose line, usually at some distance from
the foam maker or playpipe, as a means of drafting air foam concentrate from a container.

LIMITATIONS:

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

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

3. The elevation of the bottom of the concentrate container should not be more than 6 ft. below the inductor.

A-121. (b). PRIMARY - SECONDARY INDUCTION METHOD: This method of introducing air foam concentrate into the water stream en route to a fixed foam maker is illustrated in Fig. A-121 (b) (2).

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

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

LIMITATIONS:

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

2. The elevation of the bottom of the concentrate container should not be more than 6 ft. below the primary inductor.
A-115. Pump Suction Proportioner. To install: connect A to water suction line, connect B to suction side of pump. To operate foam system: close valve C, open valves D and E. To discharge plain water: close valves D and E, open valve C.

A-116. Premixed Air Foam Solutions: The manufacturer should be consulted regarding concentrate to be used in the preparation of premixed solution.

A-121 (a). Foam Nozzle Inductor. Figure A-122 (a) shows this type of proportioner where one or more of the jets in the foam maker are utilized to draft the concentrate.

Limitations: The bottom of the concentrate container should not be more than 6 ft. below the level of the foam maker. The length and size of hose or pipe between the concentrate container and the foam maker should conform to the recommendations of the manufacturer.

A-121 (b). In-Line Inductor: This inductor is for installation in a hose line, usually at some distance from
A-121 (c). **AROUND-THE-PUMP PROPORTIONER:** This device consists of an eductor installed in a bypass line between the discharge and suction of a water pump. A small portion of the discharge of the pump flows through this eductor and draws the required quantity of air foam concentrate from a container, delivering the mixture to the pump suction. Variable capacity may be secured by the use of a manually controlled multiported metering valve.

**LIMITATIONS:**

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

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

3. The bypass stream to the proportioner uses from 10 to 40 gpm of water depending on the size of the device and the pump discharge pressure. This factor must be recognized in determining the net delivery of the water pump.

![Diagram of Around-the-Pump Proportioner](image)

Fig. A-121(c). Around-the-Pump Proportioner.
A-121 (d). **Metered Proportioning**: By means of an auxiliary pump, foam compound is injected into the water stream passing through an inductor. The resulting foam solution is then delivered to a foam maker or playpipe. The inductor may be inserted in the line at any point between the water source and foam maker or playpipe.

To operate, the main water valve is opened and a reading of the pressure indicated on the duplex gage is taken. The bypass valve in the line between the suction and discharge of the foam concentrate pump should be opened fully and the pump started. By slowly closing the bypass valve to increase the discharge pressure of the foam concentrate, the second pointer on the duplex gage is brought to coincide with the indicated water pressure. When both gage hands are set at the same point, the proper amount of foam concentrate is being injected into the water stream.

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**LIMITATIONS:**

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

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

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

A-121 (e). PRESSURE PROPORTIONING TANK METHOD: The arrangement of these devices may take a variety of forms. A single tank or battery of tanks manifolded together may be used. There are also single tanks divided into two separate compartments by a bulkhead and dual tank arrangements.

Where single tanks or a battery of manifolded tanks are used, it is necessary to interrupt foam production while recharging. With the compartmented tank or dual tank arrangement, continuous operation can be secured. The smaller devices are portable for use with hose streams.

The device illustrated in A-121 (e) shows an arrangement of 2 tanks with a proportioner so installed that it can draw air foam stabilizer from either tank.

Each compartment has a screw cap on top for charging with concentrate and a screw cap at the bottom for draining the water from the compartment upon exhaustion of the foam compound. Above each compartment is a valve which when opened permits the introduction of concentrate from that tank into the water stream.

To operate, the valve on one tank is opened. When the supply of concentrate in this compartment has been exhausted, the valve is closed and the valve on the other tank is opened. The exhausted compartment is then drained of water and refilled. This operation can be repeated continuously to provide an uninterrupted foam stream. Recharging must be done promptly and within the time required to exhaust one of the tanks. The operating range of this device is from 75 psi to 125 psi.

LIMITATIONS:

1. The capacity of these proportioners may be varied from approximately 50 per cent to 200 per cent of the rated capacity of the device.

2. The pressure drop across the proportioner ranges from 5 to 30 psi depending on the volume of water flowing within the capacity limits given above.
3. The length of time these devices will operate before recharging is necessary is given on the nameplate as a function of the water flowing through the eductor. This time may vary from 2 or 3 minutes for a small unit, up to 15 minutes or longer for the larger units.

4. After each use, these units must be completely emptied and recharged.

A-121 (f). COUPLED WATER MOTOR PUMP: This device consists of two positive displacement rotary pumps mounted on a common shaft. Water delivered to the larger pump causes it to drive the smaller pump which is used to draft concentrate from a container and deliver it to the water discharge line from the larger pump. By proportioning the sizes of the two pumps, the correct volume of concentrate is delivered to the water stream.

LIMITATIONS: The pressure drop across this proportioner is 25 per cent at 100 psi at maximum flow. The volume of water flow governs the volume of stabilizer de-
livered into the water stream. It is manufactured in only two sizes. The smaller will proportion within acceptable limits between 60 and 180 gpm. The larger will proportion between 200 and 1000 gpm with concentrate concentrations between 6½ and 5½ per cent. It has no limitations in respect to pressure.

Fig. A-121(f). Coupled Water Motor Pump Proportioner.

A-122 (a). FIXED FOAM MAKERS FOR AIR FOAM: In installations such as dip tanks, quench tanks, etc., as illustrated, the foam maker may be installed in connection with a vessel of concentrate from which the concentrate is drawn by the flowing water passing through the foam maker. Such devices may be automatically or manually operated by controlling a single valve.
Fig. A-122(a). Schematic diagram showing protection of dip tanks with air foam system. Foam liquid concentrate storage in vessel beside dip tank.

A-122 (a). AIR FOAM HOSE STREAM NOZZLES:

Fig. A-122(a). Air Foam Playpipe.
A-122 (c). **Air Foam Pumps:** Fig. A-122c illustrates a pressure foam pump. This is a truck or trailer mounted unit driven by a gasoline engine. It consists of three positive displacement rotary pumps whose discharge capacities are proportioned to one another. These pumps are driven through suitable gears from the same shaft. Water is admitted at (8) to the water pump (1). Air foam concentrate is drawn through hose (9) by pump (2) and delivered to the discharge side of the water pump. The mixture of water and concentrate is directed to the open suction of a churn pump (4) having a nominal capacity of 2,000 gpm. This pump also draws in air through the open suction and the mixture of air, water and concentrate is converted to a homogeneous mixture of air foam in the pump and discharged through outlet (6) or through the two 2½-in. hose connections (5).

This machine delivers foam through the foam outlet or the 2½-in. hose connections at any pressure up to 60 psi, and its operation is practically independent of pressure variations in the lines or in the water suction inlet. It delivers from 500 gpm to 2,000 gpm of foam at a constant expansion of 4.

**Limitations:** This air foam pump will stall if operated with all outlets closed. The pressure available at the foam discharge depends on the speed at which the engine is operated which in turn controls the volume of foam delivered; e.g., at the minimum output rate of the device (500 gpm) only about 40 psi foam pressure is available.
Fig. A-122(c). Air Foam Pump.


(a). Dual foam powder produces 8 to 12 gals. of foam per pound of powder consumed, depending on the apparatus used and the conditions of use. Modern dual generators produce from 11 to 16.5 gals. of foam per gallon of water consumed.

(b). Single foam powder produces 7 to 11.5 gals. of foam per pound of powder consumed, depending on the apparatus used and the conditions of use. Modern single powder generators produce from 10 to 19.5 gals. of foam per gallon of water consumed.
The special foam powder produces 5 to 7.5 gals. of foam per pound of powder consumed depending on the apparatus used and the conditions of use. Modern single powder generators using this material produce from 6.5 to 11.5 gals. of foam per gallon of water consumed.

This special foam powder is effective on fires involving water soluble solvents among which are the following:

<table>
<thead>
<tr>
<th>Alcohols</th>
<th>Ethers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methyl alcohol</td>
<td>Ethyl ether</td>
</tr>
<tr>
<td>Ethyl alcohol</td>
<td>Isopropyl ether</td>
</tr>
<tr>
<td>Propyl alcohols</td>
<td>Amyl ether</td>
</tr>
<tr>
<td>*Butyl alcohols</td>
<td>Dioxane</td>
</tr>
<tr>
<td>*Diacetone alcohol</td>
<td>Ethyl Cellosolve</td>
</tr>
<tr>
<td>*Esters</td>
<td>Butyl Cellosolve</td>
</tr>
<tr>
<td>Methyl acetate</td>
<td>*Carbitol</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>*Butyl Carbitol</td>
</tr>
</tbody>
</table>

*These represent borderline cases in which the material destroys ordinary foam to some extent. A higher than usual rate of regular foam application is necessary to achieve effectiveness ordinarily encountered on petroleum products.

Ordinary foam powder is suitable for use on fires involving iso-octyl alcohol.

Where materials other than those listed require protection, the manufacturer of foam-producing materials should be consulted as to type of foam and rate of application necessary to secure extinguishment.

**Note:** 1. The foam produced by powders referred to in (a) and (b) disintegrates rapidly when applied to most water soluble solvents such as certain alcohols, ketones, ethers, etc., and is not considered effective in the extinguishment of fires involving these liquids.

**Note:** 2. Foam expansion depends on a number of factors, among which are:

- a — Type of foam powder.
- b — Water temperatures.
- c — Atmospheric temperatures.

The values given above are for water temperatures between 50° and 70°F. Low water temperatures retard the chemical reaction. Warm water may result in higher expansion at the expense of the quality of the foam.

A-132 (a). **Continuous Foam Generators:** Figures A-132(a) (1) and A-132(a) (2) show the two types of
chemical foam generators.

The water pressure at the inlet to the generator should preferably be between 75 and 125 psi. Operation is, however, possible with a minimum of 50 psi at the generator inlet.

The back pressure created by hose or piping attached to the discharge side of the generator should not exceed 40 per cent of the generator inlet pressure.

A-132 (a). FOAM HOSE STREAMS: Ample hose should be provided for foam development. The nozzle throat sizes are much larger than those commonly used for water. The manufacturer should state the correct size and length of hose and size of nozzle for each chemical foam unit.

Where water temperatures are less than 50°F., the mixing tubes used with two powder generators should be increased in length to conform with the recommendations of the manufacturer. Similarly, the length of hose used on the discharge side of single powder generators should likewise be increased. The size of nozzle tip used should also be as recommended by the manufacturer.

A-132 (a). CENTRALIZED FIXED PIPING SYSTEMS:

Fig. A-132(a)(1). Typical chemical foam generator system layout of the single powder type.

Diagram not to scale. Foam generator houses should be located well away from tanks. Dikes not shown.
Fig. A-132(a)(2). Typical chemical foam generator system layout of the two powder type.

Fig. A-132(a)(3). Dual Powder Generator System with Powder in Bins.
Fig. A-132(a)(4). Single hopper chemical foam generator of the single powder type.

Fig. A-132(a)(5). Dual hopper chemical foam generator of the two powder type.
A-132 (b). Stored Solution Systems:

Fig. A-132(b)(1). An automatic chemical foam system of the stationary unit type protecting a dip tank and drain board.

In the case of stored solution systems, where the acid solution ("A" solution) and bicarbonate solution ("B" solution) are properly prepared for use in equal volumes, 0.5 gal. of "A" solution plus 0.5 gal. of "B" solution (a total of one gallon of solutions) produces about eight gals. of foam.

A-132 (b)(2). Wet Storage Chemical Foam Systems:

Fig. A-132(b)(2). Typical two solution (acid and basic) chemical foam system layout. Discharge line layout similar to that for two powder type shown in A-1452B.
A-132 (b). Experience shows that foam solutions now in use work best at temperatures not less than 50° nor above 100°F. Storage at high temperatures favors decomposition of the sodium bicarbonate solution.

A-132 (b). This usually requires a twin duplex pump or two identical pumps operated from a common prime mover.

A-133. DUAL POWDER GENERATOR SYSTEM WITH POWDER IN BINS:

The facilities must be laid out so as to provide ample working space in which to handle portable containers of powder, to open the containers, to deliver the powder to the generators, and to dispose of the empty containers without interrupting the flow of chemicals to the generators. Pails of powder should be piled not over five high. If the system is a dual powder system, the pails should be arranged so that both “A” and “B” powder pails can be handled without confusion. Clear access to the generator house should be provided so that additional supplies can be brought in if needed.

A-141 (3). USE OF FOAM TO PREVENT FIRE: For example, a tank truck or tank car wreck should be covered by foam before ignition takes place. Spills in garages, airplane hangars, etc., may be effectively handled in the same manner.

A-142. LIMITATIONS: Foam is not considered a suitable extinguishing agent for fires involving liquefied compressed gases, e.g., butane, butadiene, propane, etc. Tanks containing refrigerated or cryogenic liquids generally should not be protected by foam. Application of foam may result in severe boiling and increased vapor release due to the latent heat of the water as it drains from the foam. Increased vapor release will increase the severity of a fire and prevent development of a foam blanket.

Judgment must be used in applying foam to vessels containing hot oils, asphalts, etc., which are above the boiling point of water either normally or due to an exposure fire and to vessels containing high viscosity oils, such as Bunker C fuel oil, which have been burning for extended periods. The water in the foam may cause violent frothing of the contents and even the forceful expulsion of a portion of the contents.
Foam hose streams are not recommended for use on fires involving electrical equipment where the foam could come in contact with energized equipment.

Foam is not suitable for use on materials which will react violently with water (e.g., metallic sodium) or which produce hazardous materials by reacting with water.

Certain wetting agents are incompatible with some foams. Dry chemical powder extinguishing agents may in general exhibit the same reaction.

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

A-160. WATER SUPPLIES:

QUALITY: Ordinary water supplies, whether fresh or salt, hard or soft, have no significant effect on the quality or volume of foam produced. There may be unusual circumstances where the water will contain minerals, silt, organic matter or trade wastes which will affect foam quality. Possible variation in quality of process cooling water which is also to be used for foam systems should be considered. The manufacturer and the authority having jurisdiction should be consulted.

TEMPERATURE: Foam chemicals work best when water temperatures are not less than 50°F nor more than 100°F. Optimum results are obtained at temperatures from 60°F to 70°F. Low water temperatures retard the chemical reaction so that longer mixing time must be provided. High water temperatures produce foam which is more susceptible to breakdown.

Air foam production is much less sensitive to variations in water temperature than chemical foam production, but is best when water temperatures are between 40°F and 100°F.

A-164. STRAINERS: Where the water is clear, a simple strainer should be provided. Where the water is moderately contaminated, self-cleaning strainers accessible for cleaning during the emergency should be used. Dual
type strainers, or the equivalent, may be necessary if water supplies are badly contaminated. Strainers may be installed in the water supply line or as part of the foam apparatus. Strainers may also be required near foam makers served by long pipe lines where scale may exist.

A-170. AIR FOAM SYSTEM DESIGN.

A-1735. PIPE SIZE: The water pressure of the inlet to air foam makers should preferably be not less than 50 psi. Operation is, however, possible with water pressure as low as 30 psi.

Fig. A-146. Schematic arrangement of air foam protection for storage tanks.

Liquid storage indicated lower left of illustration is stabilizer storage.

A-300. GENERAL: These systems are for the protection of outdoor process and storage tanks. They include the protection of such hazards in manufacturing plants as well as large oil farms, oil refineries and chemical plants. The systems are usually designed for manual operation but, in whole or in part, may be automatic in operation. Foam systems are the preferred protection for large outdoor tanks of flammable liquids.
A-302(b). **TYPE I DISCHARGE OUTLETS**: Among the approved Type I discharge outlets are:

1. Porous asbestos tube (see Fig. A-302A).
2. Foam trough along the inside of tank wall (see Fig. A-302B).

![Fig. A-302A. Cross-section Moeller Tube Chamber. Tube is designed to unroll and fall to oil level. Foam flows through interstices in tube.](image)

9. **Add new section A-133 to appendix to read:**

A-133. **STORAGE OF CHEMICAL FOAM MATERIALS.** Where water solutions of the acidic and alkaline salts necessary for the production of chemical foams are stored separately in tanks (wet storage), provision is made for factors of corrosion, solution deterioration, contamination, and system restoration after use. Materials of fabrication in contact with the solutions are carefully chosen. Facilities are provided for periodically testing the solutions for deterioration under long storage (especially the bicarbonate content of the alkaline solution). Prevention of contamination of the tank contents by foreign substances and methods for speedily recharging the tanks with solutions after the system has been used are also taken into consideration. Where dry foam powders are stored in the containers in which they are transported or where bulk storage of the powders is relied upon, the containers must be kept tightly closed in a cool dry storage area. Inspection of powders is periodically conducted. Water and moisture exposure of chemical foam powders and temperature exposure fluctuation of all components of chemical foam systems above 120°F or below 50°F is carefully avoided.
INTRODUCTION

1. Purpose

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

2. Scope

This Standard includes minimum requirements for foam systems using synthetic foaming agents in conjunction with airfoam generating devices and such systems used in combination with other agents.

3. General

This Standard is applicable to the design, installation and use of synthetic foams and combined agents for application to Class B fire hazards. This Standard applies to systems using synthetic foams as distinguished from protein based foams which are the subject of NFPA No. 11, Foam Extinguishing Systems, and high expansion foam which are the subject of NFPA No. 11A, High Expansion Foam Systems. Synthetic foam concentrates can be classified in two categories: Aqueous Film Forming Foam (AFFF) and hydrocarbon surfactant type foams.

AQUEOUS FILM FORMING FOAM (AFFF) CONCENTRATE — This concentrate consists of a fluorinated surfactant with a foam stabilizer which is diluted with fresh or sea water in 3 or 6% proportion. The foam formed acts both as a barrier to exclude air or oxygen and to develop an aqueous film on the fuel surface capable of suppressing the evolution of fuel vapors. AFFF concentrates are normally used in conventional foam-making devices suitable for pro-
Producing protein foams, and may also be applied through fixed or variable pattern water spray nozzles. Such equipment shall be listed for this use.

The foam produced by AFFF concentrate is dry-chemical compatible and thus is suitable for combined use with dry chemicals. Protein and fluoroprotein foam concentrates and AFFF concentrates are incompatible and should not be mixed, although foams separately generated with these concentrates are compatible when applied at the normal rates to a fire in sequence or simultaneously.

Hydrocarbon Surfactant Type Foam Concentrates — These foam concentrates normally consist of a hydrocarbon surfactant which is diluted with water in a solution at various rates from 1 to 6 percent of the water discharge. Depending upon composition of the foam concentrate, the resulting foam can be utilized as a wetting agent for Class A fires or as an emulsifier for use on fires in Class B combustibles which are insoluble in water and ordinarily stored at atmospheric temperatures and pressures.

Hydrocarbon surfactant type foam concentrates are normally used in conventional foam-making devices suitable for producing protein foams, but such equipment shall be approved for this use. The foam produces a layer of foam bubbles which excludes air similar to the action of other foams. In general hydrocarbon surfactant foams will reduce the effectiveness of other foams when applied to other hydrocarbon fuel fires. They do not form aqueous films on the surface of hydrocarbon fuels, but may form an unstable emulsion at the foam-fuel interface. Hydrocarbon surfactant type foam concentrates are usually incompatible and should not be mixed. Hydrocarbon surfactant type foam concentrates are incompatible with protein, AFFF and fluoroprotein concentrates and should not be allowed to mix. Compatibility with dry chemical agents should be established by test.
Part I.

Aqueous Film Forming Foams (AFFF)

CHAPTER 1. GENERAL INFORMATION AND REQUIREMENTS

1100. General Information

1110. Scope: Chapter 1 contains general information, and the design and installation requirements for features that are generally common to all AFFF systems.

1120. Mechanisms of Extinguishment: AFFF extinguishes fire by cooling, by retarding vapor release through surface film formation and foam coverage, and by excluding air from the fuel.

1130. Use and Limitations: While AFFF is finding application in a variety of fire fighting problems, this Standard is presently limited to considering specific types of hazards involving flammable liquids.

1131. Uses: AFFF systems are used primarily to protect liquid hydrocarbon fuels.

1132. Limitations: AFFF is not considered a suitable extinguishing agent for fires involving liquefied compressed gases, e.g., butane, butadiene, propane, etc. Tanks containing refrigerated or cryogenic liquids generally should not be protected by AFFF. Application of AFFF may result in severe boiling and increased vapor release due to the latent heat of the water as it drains from the foam. Increased vapor release will increase the severity of a fire and prevent development of a foam blanket.

Judgment must be used in applying AFFF to vessels containing hot oils, asphalts, etc., which are above the boiling point of water either normally or due to an exposure fire and to vessels containing high viscosity oils, such as Bunker C fuel oil, which have been burning for extended periods. The water in the AFFF may cause violent frothing of the contents and even the forceful expulsion of a portion of the contents.

AFFF hose streams are not recommended for use on fires involving electrical equipment where the foam could come in contact with energized equipment.

AFFF is not suitable for use on materials which will react violently with water (e.g., metallic sodium) or which produce hazardous materials by reacting with water.
AFFF is not recommended for use on polar solvents unless specific tests with the solvent in question have proven its suitability.

Certain wetting agents are incompatible with some AFFF agents.

The possibility and extent of agent damage must be evaluated in the choice of any extinguishing system. In certain cases, such as tanks or containers of edible oils, cooking oils, or other food processing, or where contamination through the use of AFFF could increase the loss potential substantially, the authority having jurisdiction should be consulted as to the type of extinguishing agent preferred.

1140. Types of Systems: The type of systems recognized in this standard include

1. Fixed Piping Systems (including Premixed Solution Types).
2. Portable Foam Generating Devices (including Hose Reel or Hose Rack Units and Combined Agent Systems).

1200. Specifications, Plans and Approval.

1210. Preliminary Approval: It is good practice for the owner or his designated representative (architect, contractor, etc.) to review the basic hazard with the authority having jurisdiction to obtain guidance and preliminary approval of the proposed protection concept.

1220. Purchasing Specifications: Specifications for AFFF systems shall be drawn up with care and with the advice of the authority having jurisdiction. To ensure a satisfactory system, the following items should be in the specification.

1221. The specification should designate the authority having jurisdiction and indicate whether submittal of plans is required.

1222. The specification should state that the installation should conform to this Standard and meet the approval of the authority having jurisdiction.

1223. The specification should 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.

1230. Plans: The preparation of plans shall be entrusted only to fully experienced and responsible persons.

1231. These plans shall be drawn to an indicated scale or be suitably dimensioned, and shall be made so that they can be easily reproduced.
1232. These plans shall contain sufficient detail of the hazard to enable the authority having jurisdiction to evaluate the effectiveness of the system. The details of 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 AFFF concentrate; water requirements, including type of water; 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 AFFF 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.

1233. Only listed or approved equipment and devices shall be used in these systems.

1240. Approval of Plans: Plans shall be submitted to the authority having jurisdiction for approval before installation.

1241. 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.

1250. 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.

1251. The following data are considered essential to the evaluation of performance of AFFF systems:

1. Static water pressure.
2. Stabilized flowing water pressure
   a. At control valve
   b. At remote reference point in system.
3. The concentration of AFFF liquid in the foam solution.
4. Where conditions permit foam discharge, a visual inspection of the foam shall be made to ensure that it is satisfactory for the purpose intended.

The static water pressure, the flowing water pressure and the AFFF liquid concentration shall be within the operating limits recommended by the authority having jurisdiction.
General Information

Note: AFFF solution concentration may be measured by refractometric means (see Appendix A 1251) or it may be calculated from solution and concentrate flow rates. Solution flow rates may be calculated by utilizing recorded inlet and/or end-of-system operating pressures. The rate of concentrate flow may be measured by timing a given displacement from the storage tank.

1252. All piping up to each foam generating device 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.

1253. Other tests which may be applied to the system are shown in Chapter 6.

1300. Operation and Control of Systems.

1310. 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.

1320. Operating Devices: Operating devices include foam generators, valves, proportioners, eductors, discharge controls, and shutdown equipment.

1321. Operation shall be controlled by listed or approved mechanical, electrical, hydraulic or pneumatic means. When operation is automatic, an adequate and reliable source of energy shall be used. The need for an alternate power supply shall be determined by the authority having jurisdiction.

1400. Water Supply.

1410. Quantity: Water shall be available in sufficient quantity and pressure to supply the AFFF system simultaneously with the demands of other fire protection equipment. Premixed solution type systems need not be provided with a continuing water supply.

1420. Quality: Consideration should be given to the suitability of the water for production of foam from AFFF concentrates. The presence of corrosion inhibitors, antifreeze agents, marine growths, oil, emulsion breaking chemicals, or other contaminants may result in reduction of foam volume or stability. If the quality and type of the water is questionable, the manufacturer of the AFFF concentrate shall be consulted.
1430. Storage: Water supply or premixed solution shall be protected against freezing.

1500. AFFF Concentrate Supply.

1510. Quantity: The amount of AFFF concentrate in the system shall be at least sufficient for the largest single hazard protected or group of hazards which are to be protected simultaneously.

1520. Quality: The AFFF concentrate supplied with the systems shall be that listed for use with the equipment. The performance of the system is dependent upon the composition of the AFFF concentrate as well as other factors. Different brands or types of AFFF concentrate should not be mixed without advice of the concentrate manufacturer of their interchangeability and compatibility and of the equivalency of generated foam.

1530. Reserve Supply: There shall be a readily available reserve supply of AFFF concentrate sufficient to meet design requirements in order to put the system back into service after operation. This supply may be in separate tanks or compartments, in drums or cans on the premises, or available from an outside source within 24 hours.

1540. Storage Requirements: In-service and reserve supplies of AFFF 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.

1550. AFFF Concentrate Storage Tank: Bulk liquid storage tanks for AFFF concentrate shall be fabricated from corrosion-resisting materials. Tanks located in hazardous areas should be of non combustible construction.

1600. AFFF Concentrate Proportioning Equipment.

1610. Proportioning Equipment Types: The satisfactory volumetric proportioning of AFFF concentrate into water in recommended proportions may be accomplished by most of the methods now used for other foam concentrates, but shall be listed for this use.

1700. Foam Generating and Agent Application Equipment.

1710. Foam Generating Equipment Types: The methods of foam production selected should be carefully weighed considering techniques of employment best suited to the equipment concerned and the rates and patterns of discharge desired.
1800. General Requirements for AFFF Foam Extinguishing Systems.

1810. Basic Design Requirements: In any designed system, portable or fixed, means shall be provided to promptly deliver the agent at or above the required minimum rates per square foot of protected area and for the prescribed minimum discharge time. The design of AFFF systems for particular hazards must comply with the applicable portions of NFPA Standards such as No. 11, 16, 409 and 414.

1811. Pipe and Fittings and Systems Equipment: The system piping, pumps, valves, and other equipment in continuous contact with the AFFF concentration shall be of corrosion-resisting materials compatible with the AFFF concentrate used. Consideration shall be given to possible galvanic effects when dissimilar metals are joined. The remainder of the system that is normally dry may be of standard weight (Schedule 40) black or galvanized steel pipe and fittings.

1812. Arrangement and Installation of Piping and Fittings: Piping shall be installed in accordance with applicable NFPA Standards as modified herein.

1. All piping shall be hydraulically designed to produce the desired rate of flow at the discharge devices. Care shall be taken to avoid possible restrictions due to foreign matter, faulty fabrication and improper installation.

2. Where solids of sufficient size to obstruct openings in the foam equipment may be present, strainers shall be used.

1813. 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.

1900. System Maintenance.

1910. System Inspection: At least annually, all AFFF systems shall be thoroughly inspected and checked for proper operation. This should include performance evaluation of the AFFF concentrate and/or premix solution quality. (See Chapter 6.) Deviation of results exceeding 25% from those recorded in acceptance testing should be discussed immediately with the manufacturer. Regular service contracts are recommended.

1911. The goal of this inspection and testing shall be to ensure that the system is in full operating condition and that it will remain in that condition until the next inspection.
1912. The design should permit safe operation of the protected hazard during any necessary testing procedures.

1913. The inspection report, with recommendations, shall be filed with the owner.

1914. Between the regular service contract inspections or tests, the system shall be inspected by competent personnel, following an approved schedule.

1915. Systems shall be flushed and inspected and any strainers inspected and cleaned after each use or test.

1920. Instructions: All persons who may be expected to inspect, test, maintain or operate AFFF systems shall be thoroughly trained and kept thoroughly trained in the functions they are expected to perform.

CHAPTER 2. FIXED SPRAY FOAM SYSTEMS

2100. General Information.

2110. Scope: This Chapter is concerned with systems in which AFFF is applied to flammable and combustible liquid hazards by means of overhead spray foam systems. For information concerning the use of AFFF in foam-water sprinkler systems, including standard sprinkler systems, and foam-water spray systems see NFPA No. 16, Foam Water Sprinkler and Foam Water Spray Systems.

2120. Definitions.

2121. Fixed Foam System: A spray foam system is a special system, pipe-connected to a source of foam-producing solution, and is equipped with spray nozzles for foam generation and its distribution over the area to be protected.

2130. Systems Components Design.

For details on system design, piping, alarms, and plans and specifications see Chapters 2 and 5 of NFPA No. 11, Foam Extinguishing Systems.
2200. Rate of Agent Application.

The design discharge rate for all overhead systems of this type shall be not less than 0.16 gallons per minute per square foot of protected hazard.

2300. Supply of AFFF Concentrate.

2310. General: The supplies maintained shall be the sum of the quantities defined in 2320, 2330 and 2340.

2320. Minimum Discharge Time.

2321. For area and equipment protection the duration of AFFF discharge shall be a minimum of 10 minutes. If the system discharges at a rate above the minimum, the minimum discharge time may then be reduced proportionately but shall not be less than seven minutes.

2322. For inside tanks of less than 400 square feet of liquid surface the duration of AFFF discharge shall be a minimum of 5 minutes. If the system discharges at a rate above the minimum, the minimum discharge time may then be reduced proportionately but shall not be less than 3.5 minutes.

2323. Operating Supply: There shall be a quantity of AFFF concentrate sufficient to supply the system at the design rate for a period of ten (10) minutes. If the system discharges at a rate above the minimum specified in Section 220 then the operating time may be reduced proportionately but shall not be less than seven (7) minutes.

2330. Requirements to Fill Pipelines: A quantity of AFFF concentrate sufficient to produce foam or foam solutions to fill the feed lines actually installed between the source and the most remote hazard shall also be provided. Where water flow will continue after the foam-producing material is depleted and displace the solution or foam from the lines to the hazard, no added quantity is required by this paragraph.

2340. Reserve Supply of AFFF Concentrate: There shall be a readily available reserve supply of foam-producing materials sufficient to meet design requirements in order to put the system back into service after operation. This supply may be in separate tanks or compartments, in drums or cans on the premises or available from an approved outside source within 24 hours.
CHAPTER 3.

HOSE NOZZLES AND MONITOR NOZZLES.

3100. General.

3110. Scope and Application.

3111. This chapter relates to systems in which the AFFF agent is applied through fixed or portable monitor or hose nozzles.

3112. Systems of this type are most effective when they are designed to provide rapid distribution of AFFF over the fuel surface.

Hose nozzles and oscillating monitor nozzles are suitable when used alone for extinguishment of spill fires, fires in open dip tanks, etc. Foam hose streams can be used for floating roof rim fire extinguishment when used from the tank wind girder or roof.

3120. Definitions.

1. FOAM HOSE STREAM: A foam stream from a hose nozzle which can be held and directed by hand. The nozzle reaction usually limits the solution flow to about 300 gpm.

2. FOAM MONITOR STREAM: A large capacity foam stream from a nozzle which is supported in position and which can be directed by one man.

3. FIXED MONITOR: A device which delivers a foam stream and is mounted on a stationary support. The monitor may be fed solution by permanent piping or hose.

4. PORTABLE MONITOR: A device which delivers a foam stream and is on a movable support so that it can be transported to the fire scene.

3200. Foam Application.

3210. Rates: In determining total solution flow requirements, consideration should be given to potential foam losses from wind and other factors.

The minimum delivery rates for primary protection based on the assumption that all agent reaches the area being protected shall be as follows:

3211. For liquid hydrocarbons:

For fuel fire protection the foam solution delivery rate of AFFF systems shall be at least 0.10 gpm/sq. ft. of the surface to be protected.

Note: Flammable liquids having a boiling point of less than 100° F may require higher rates of application. Suitable rates of application should be determined by test.
3300. Supply of AFFF Concentrate.

3310. General: The supplies maintained shall be the sum of the quantities defined in 3320, 3330 and 3340.

3320. Minimum Discharge Times: The equipment shall be capable of operation at the delivery rate specified in 3210 for a period of 10 minutes.

3330. Requirements to Fill Pipe Lines: A quantity of AFFF concentrate sufficient to produce foam or foam solutions to fill the feed lines actually installed between the source and the most remote hazard shall also be provided. Where water flow will continue after the foam-producing material is depleted and displace the solution or foam from the lines to the hazard, no added quantity is required by this paragraph.

3340. Reserve Supply of AFFF Concentrate: There shall be a readily available reserve supply of foam-producing materials sufficient to meet design requirements in order to put the system back into service after operation. This supply may be in separate tanks or compartments, in drums or cans on the premises, or available from an approved outside source within 24 hours.
CHAPTER 4. COMBINED AGENT SYSTEMS

4100. General.

4110. Scope and Application: This chapter relates to systems in which AFFF is applied to a hazard simultaneously or sequentially with dry powder. Systems of this type, combining the rapid fire extinguishing capabilities of dry chemicals (as well as their ability to extinguish three dimensional fires) with the sealing and securing capabilities of aqueous film forming foam, are of particular importance for protection of flammable liquid hydrocarbon hazards. Compatibility of the combined agents is required.

Systems in use today are generally self-contained portable units, and the application of each agent is separately controlled so that the agents can be used individually, simultaneously or sequentially as the situation requires.

4120. Limitations: The manufacturers of the dry chemical and AFFF concentrate to be used in the system should confirm that their products are mutually compatible and satisfactory for this purpose.

No test data or experience with systems combining other agents, such as carbon dioxide or halogenated liquids, with AFFF has been reported.

Limitations imposed on either of the agents used in the system for the use of that agent alone must also be applied to the combined agent system.

4200. Combined Agent Systems for Flammable and Combustible Hydrocarbon Hazards.

4210. Rates: Minimum delivery rates for protection of a hazard, based on the assumption that all agent reaches the protected area, shall be as follows:

4211. For combined agent systems utilizing AFFF and dry chemical:

1. AFFF solution shall be delivered at a rate of 0.10 gpm per sq. ft. of area to be protected.

2. The ratio of dry chemical discharge rate to AFFF discharge rate (lbs. dry chemical per second/lbs. AFFF solution per second) should be in the range of 0.6:1 to 5:1.

4220. Supply of Agents:

4221. General: The supply of AFFF maintained shall be the sum of the quantities defined in 4222 and 4223. The supply of dry chemical maintained shall be the sum of the quantities defined in 4222 and 4224.
4222. **Minimum Discharge Times:** The equipment should be capable of operation for a period of about one minute for each agent at the delivery rates specified in 4210. The authority having jurisdiction may increase or decrease this requirement depending on the type of hazard involved.

4223. **Reserve Supply of AFFF Concentrate:** There shall be a readily available reserve supply of AFFF concentrate sufficient to meet design requirements in order to put the system back into service after operation. This supply may be in separate tanks or compartments, in drums or cans on the premises, or available from an approved outside source within 24 hours.

4224. **Reserve Supply of Dry Chemical:** There shall be a reserve supply of dry chemical and expellant gas kept on hand which is sufficient for one complete recharge of the system according to design requirements. This reserve supply of dry chemical shall be stored in a constantly dry area and the dry chemical shall be contained in metal drums or other containers which will prevent the entrance of moisture even in small quantities. Prior to charging the dry chemical chamber, the dry chemical shall be carefully checked to determine that it is in free-flowing powdery condition, and the pressure or weight of the expellant gas container shall be checked as stipulated by the manufacturer to determine that it is above the required minimum.
CHAPTER 5.

FIXED SYSTEMS FOR OUTDOOR STORAGE TANKS

5100. General.

Storage tank protection experience with AFFF is limited to automatically actuated, specially designed systems on tanks up to 40 feet in diameter. Sufficient data are not available for the design of fixed systems for outdoor storage tanks.

CHAPTER 6. TESTS

6100. General Information.

6110. Systems approval testing: Tests required for systems approval are shown in paragraph 1250 of this standard. The tests shown in this chapter may also be used if required by the authority having jurisdiction.

6120. System Maintenance: The tests shown in this chapter should be used in annual inspections for evaluation of the AFFF concentrate and/or premix solution quality.

6200. Properties Tested: The properties to be tested include:

1. Foam expansion.
2. Foam drainage rate.
3. Aqueous film forming capability.

6300. Performance Requirements.

6310. Foam Expansion and Foam Drainage Rate: When tested according to the procedures of A6310 the AFFF expansion and drainage rate should satisfy the minimum requirements of the manufacturer of the concentrate.

6320. Film Formation: When tested according to the procedures of A6320 a surface film shall be formed which is capable of preventing a sustained ignition of the fuel.
CHAPTER 1. GENERAL INFORMATION

1100. General Information. These are synthetic foaming agents, generally based on hydrocarbon surface active agents, which are capable of extinguishing flammable and combustible liquid fires under specific conditions. Some of these are listed or approved as wetting agents, and others as foaming agents.

There is little recorded and reported test and experience data for this type of foam and no specific recommendation for its use can be made. Its use is usually limited to portable nozzle application to spill fires where generous rates can be used. Such foams are usually rapid draining, and do not demonstrate the good burnback resistance of protein foams, the rapid control and extinguishment rates of the AFFF agents, nor the stability on hydrocarbon fuels of the AFFF and fluoroprotein foams.
APPENDIX

A1251. Refractometric Method for Analysis of Concentration of AFFF Solutions:

This test is made to determine the level of AFFF concentrate in the solution being supplied to the foam makers. Analysis of premixed, stored solutions is also performed in this manner. The test is based on using a hand refractometer to measure the refractive index of the solution which varies proportionally with the concentration.

The first step in this procedure is to prepare a calibration curve. This has been found necessary because the source of water and brand or mixture of AFFF concentrate will affect the results. Using water from the system source of supply and AFFF concentrate from the tank, or from original sources when premixed stored solutions are tested, standard solutions of 3, 6 and 9 percent are made up by pipetting 3, 6 and 9 milliliters of AFFF concentrate respectively into three 100 milliliter graduates and then filling to 100 ml mark with the water. After thorough mixing a refractive index reading is taken of each standard. This is done by placing a few drops of the solution on the refractometer prism with a medicine dropper, closing the cover plate and observing the scale reading at the dark field intersection. A plot is made on graph paper of scale reading against the known AFFF solution concentration. This plot then serves as a calibration curve for this particular foam test series. The refractive index of the foam solution being tested is then measured, and the concentration of the solution can be obtained by reference to the calibration curve.

Apparatus needed.

a. 3 — 100 milliliter graduates
b. Mohr measuring pipette (10 milliliter capacity)
c. 1 — 100 milliliter beaker
d. 1 — 500 milliliter beaker
e. 1 — refractometer (Hand refractometers such as made by American Optical and others with a scale range of 1.3330 to about 1.3720 are convenient for this use).

A1520. AFFF concentrates are available which are listed for use at 3% or 6% concentration by the nationally recognized testing laboratories; see, for example U.L. Standard 1092. In addition, MIL-F-24385 and Amendments contains requirements for 6% AFFF for U.S. military procurement purposes.
A6310. Methods for the Determination of AFFF Expansion and 25% Drainage Time:

The treatment of a foam after it has left a nozzle has an important bearing on its physical properties. It is, therefore, extremely important that the foam samples taken for analysis represent as nearly as possible the foam reaching the burning surface in normal fire fighting procedure. Foam for analysis from a straight stream should be collected from the center of the ground pattern formed with the nozzle aimed for maximum reach. Similarly, for dispersed stream application foam should be sampled from the center of the resulting ground pattern area with the nozzle set for dispersed stream operation. In order to standardize and facilitate the collecting of foam samples, a special collector is used as shown in Figure 1. This
collecter is also to be used for sampling foam from fixed systems in which case it is carefully positioned as given above.

The collector should be placed at the proper distance from the nozzle to be in the center of the pattern to be sampled. The nozzle should be placed in operation with the foam pattern off to one side of the collector or with the collector shielded until equilibrium is reached and then swung over onto the center of the backboard. When sufficient foam volume has accumulated to fill the sample containers (usually only a few seconds), a stop watch should be started to provide the zero time for the drainage tests described later and then the foam pattern should be directed off to one side again. Immediately after the nozzle has been swung away from the board, the sample containers are removed, the top struck off with a straight edge, and all foam wiped off from the outside of the container. The sample is then ready for analysis.

The standard container for holding AFFF for these measurements is a one liter capacity graduated cylinder. Either transparent plastic (polypropylene, Nalgene TPX) or glass cylinders may be used. However, the standard graduations on the plastic ones may be missing below 100 ml and this is usually in the desired working range. For this reason 10 ml graduation marks will probably have to be marked on the cylinders below 100 ml. In addition each cylinder shall be cut off at the 1000 ml mark to ensure a fixed volume of foam as a sample.

1. **FOAM EXPANSION DETERMINATION.**

The following apparatus is used in determining the foam expansion:
- 2 — 1 liter graduated cylinders as described above.
- 1 — foam collector.
- 1 — scale or balance, 1000 gram capacity, weighing to nearest gram.

The aqueous film forming foam samples obtained in the graduates as previously described should be weighed to the nearest gram. The expansion of the foam sample is calculated by the following equation:

\[
\text{Expansion} = \frac{1,000 \text{ ml}}{\text{full wt. minus empty weight (grams)}}
\]

2. **FOAM DRAINAGE TIME DETERMINATION.**

The rate at which the liquid drops out from the foam mass is the
drainage rate and is a direct indication of degree of stability and the viscosity of the foam. A single value used to express the relative drainage rates of different foams is the "25 percent Drainage Time." It is the time in minutes that it takes for 25 percent of the total liquid contained in the foam in the sample containers to drain out. This test is performed on the same sample as used in the expansion determination. Dividing the net weight of the foam sample by four will give the 25 percent volume in milliliters of liquid contained in the foam.

The following apparatus is used in determining the foam's drainage time:

a. 1 — stop watch.
b. 2 — 1 liter graduated cylinders as used in foam expansion measurement.

In order to find the time for the 25 percent volume to drain out, the AFFF sample container should be placed on a level surface at a convenient height and at one minute time intervals the level of accumulated solution in the bottom of the cylinder should be noted and recorded on the work sheet. The interface between the liquid on the bottom and the foam above is easily discernible and easy to read. In this way a time-drainage volume relationship is obtained and after the 25 percent volume has been exceeded, the 25 percent drainage time is interpolated from the data.

A sample calculation of expansion and drainage time is as follows:

The net weight of the foam sample in the graduated cylinder has been found to be 200 grams. Since one gram of foam solution occupies a volume of essentially one ml the total volume of foam solution contained in the given sample is 200 ml.

\[
25\% \text{ Volume} = (0.25) \left( \text{total volume of solution} \right) = \frac{\text{Volume of solution}}{4} = \frac{200 \text{ ml}}{4} = 50 \text{ ml}
\]

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

<table>
<thead>
<tr>
<th>Time (Minutes)</th>
<th>Drained Solution Volume (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1.0</td>
<td>20</td>
</tr>
<tr>
<td>2.0</td>
<td>40</td>
</tr>
<tr>
<td>3.0</td>
<td>60</td>
</tr>
</tbody>
</table>
It is seen that the 25 percent volume of 50 ml lies within the 2 to 3 minute period. The increment to be added to the lower value of two minutes is found by interpolation of the data:

\[
\frac{50 \text{ ml}(25\% \text{ Volume} ) - 40 \text{ ml}(2 \text{ min. Volume})}{60 \text{ ml}(3 \text{ min. Volume}) - 40 \text{ ml}(2 \text{ min. Volume})} = \frac{10}{20} = 0.5
\]

Therefore, the 25 percent drainage time is found by adding 2.0 min. + 0.5 min. and gives a final value of 2.5 min.

In the handling of rapidly draining foams it must be remembered that they lose their liquid rapidly and the expansion determination must be carried out with speed and dispatch in order not to miss the 25 percent drainage volume. It is recommended that the expansion determination be deferred until the drainage curve data has been recorded. The stop watch is started at the time the foam container is filled and continues to run during the time required for recording drainage rate data.

A6320. Method for Determination of Film Forming Capability:

In this test a quantity of foam is placed upon the surface of cyclohexane (a hydrocarbon liquid). The foam is swept from the surface by insertion of a conical screen, and the exposed fuel surface is tested for the presence of an aqueous film by probing with a flame. If film is present the fuel will not sustain ignition; in the absence of film sustained ignition will occur.

A stainless steel beaker of 1000 milliliter capacity (about 4½-inch diameter, 5 inch depth) is equipped with two metal clips at the upper edge. These clips serve to secure an 80 mesh stainless steel conical screen (5 inches height, 4¾-inch diameter) during the test. The procedure is as follows:

1. Place 600 ml of 98 percent (minimum) cyclohexane into the stainless steel beaker.
2. Fill the remainder of the stainless steel beaker with freshly generated foam.
3. Insert the conical screen, closed end of cone down, through the foam. This sweeps the foam aside and exposes an apparently bare cyclohexane surface. Fasten the cone with the metal clips to secure it.
4. After one minute hold a flame ½ inch above the cyclohexane surface. Accumulated fuel vapor may flash, but if aqueous film has formed it will prevent any sustained ignition of the cyclohexane.