NFPA No.

11

FOAM EXTINGUISHING SYSTEMS 1972

NFPA®

$2.25

NATIONAL FIRE PROTECTION ASSOCIATION
International
60 Batterymarch Street, Boston, Mass. 02110

5M-6-72-FP-WIN
Printed in U.S.A.

Official NFPA Definitions

Adopted Jan. 23, 1964: Revised Dec. 9, 1969. Where variances to these definitions are found, efforts to eliminate such conflicts are in process.

SHALL is intended to indicate requirements.

SHOULD is intended to indicate recommendations or that which is advised but not required.

APPROVED means acceptable to the authority having jurisdiction. The National Fire Protection Association does not approve, inspect or certify any installations, procedures, equipment or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure or use. The authority having jurisdiction may also refer to the listings or labeling practices of nationally recognized testing laboratories,* i.e., laboratories qualified and equipped to conduct the necessary tests, in a position to determine compliance with appropriate standards for the current production of listed items, and the satisfactory performance of such equipment or materials in actual usage.

*Among the laboratories nationally recognized by the authorities having jurisdiction in the United States and Canada are the Underwriters' Laboratories, Inc., the Factory Mutual Research Corp., the American Gas Association Laboratories, the Underwriters' Laboratories of Canada, the Canadian Standards Association Testing Laboratories, and the Canadian Gas Association Approvals Division.

LISTED: Equipment or materials included in a list published by a nationally recognized testing laboratory that maintains periodic inspection of production of listed equipment or materials, and whose listing states either that the equipment or material meets nationally recognized standards or has been tested and found suitable for use in a specified manner.

LABELED: Equipment or materials to which has been attached a label, symbol or other identifying mark of a nationally recognized testing laboratory that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling is indicated compliance with nationally recognized standards or tests to determine suitable usage in a specified manner.

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

Statement on NFPA Procedures

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

Standard for

Foam Extinguishing Systems

1972 Edition of No. 11

The 1972 edition of the Standard on Foam Extinguishing Systems incorporates changes adopted at the 1972 Annual Meeting as recommended by the Committee on Foam.

Committee on Foam

R. L. Tuve, *Chairman*

The Johns Hopkins University, Applied Physics Laboratory,
8621 Georgia Ave., Silver Spring, Md. 20910

Theron Arras, Insurance Services Office of Ohio

Wayne E. Ault, National Automatic Sprinkler & Fire Control Assn.

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

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

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

Layard Campbell, National Automatic Sprinkler & Fire Control Assn.

J. R. Corcoran, Edison Electric Institute.

K. G. Easey, Fire Equipment Manufacturers Assn.

Robert E. Havener, Fire Equipment Manufacturers Safety & Service Institute

P. E. Johnson, Factory Mutual Research Corp.

Arthur Lagadinos, Insurance Services Office — New England Region

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

Norman R. Lockwood, American Petroleum Institute.

Jack P. McLaughlin, Union Carbide Corporation

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

E. E. Miller, Factory Insurance Assn.

R. F. Murphy, American Petroleum Institute.

James O'Regan, Feecon Corporation.

L. E. Rivkind, The Mearl Corp.

H. S. Robinson, Oil Insurance Assn.

Eugene Stauffer, Fire Equipment Manufacturers Assn.

M. R. Suchomel, Underwriters' Laboratories, Inc.

Ira Wilder, Federal Water Quality Administration.

Alternates

Thomas L. Culbertson, American Petroleum Institute (Alternate to R. F. Murphy)

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

H. B. Peterson, (Alternate to R. L. Tuve)

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

W. J. Swingler, Factory Insurance Assn. (Alternate to E. E. Miller)

Kenneth Zuber, Walter Kidde & Co. (Alternate to Eugene Stauffer)

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

Origin and Development of No. 11

NFPA committee activity in this field dates from 1921 when the Committee on Manufacturing Risks and Special Hazards prepared standards on foam as a section of the general Standard on Protection of Fire Hazards Incident to the Use of Volatiles in Manufacturing Processes. Subsequently the standards were successively under the jurisdiction of the Committee on Manufacturing Hazards and the Committee on Special Extinguishing Systems, prior to the present committee organization. The present text supersedes the edition of 1970 and prior editions adopted in 1922, 1926, 1931, 1936, 1942, 1950, 1954, 1959, 1960, 1963 and 1969.

CONTENTS.

Standard for

Foam Extinguishing Systems

NFPA No. 11 — 1972

FOREWORD.

Foam is an aggregate of tiny gas-filled or air-filled bubbles, lighter than the lightest oils, which is used to form a fluid blanket floating on the surfaces of flammable liquids to smother the fire by excluding the air and also by stopping further formation and reignition of combustible gases. Because foam contains water dispersed in very thin films, it also has cooling properties.

Foam has the property of adhering to surfaces, combining a blanketing effect and a cooling effect for fire extinction and protection against adjacent fires. Foam has been used successfully to extinguish fires in flammable liquids, not only through the use of portable hand fire apparatus but also through other manual, automatic and semiautomatic means whereby foam may be applied to specific hazards or hazardous occupancies in industrial plants, in flammable liquid processing and refining operations, and to flammable liquid storage tanks.

While other extinguishing agents are also recognized as approved for use on flammable liquid fires, it should be noted that for flammable liquid fires in large storage tanks, only foam has to date been found practicable. Records show successful extinguishment of fires in oil tanks up to 140 ft. diameter.

Foam does not dissipate readily, and when applied at the proper 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 reignition on the surfaces already extinguished.

Foam may be used in cases where water supplies are limited, since the total quantity of extinguishing material has a volume many times that of the water used.

In addition to the application of foam through fixed piping systems, foam may also be applied to advantage in many cases in the form of foam hose streams or through portable applicators or foam towers. This standard also covers these methods of foam application.

It should be noted that foam may be displaced by water as ordinarily applied from sprinklers or hose streams; and if floating upon a tank of oil, it may also be displaced by debris falling into the tank and causing overflow, the overflow carrying off the foam. The blanket, however, has the ability to reseal itself if it should be broken by falling debris. It is also quite tenacious, remains where applied, and is not readily dissipated by heat. Tests have shown that extinguishment of dip tank fires, by foam applied at standard rates, is not adversely affected by the simultaneous application of water from a standard sprinkler system.

In the absence of more suitable extinguishing media, foam may be used effectively on ordinary combustible materials (wood, paper, etc.).

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

NOTE: Flammable Liquid shall mean any liquid having a flash point below 140° F (60° C) and having a vapor pressure not exceeding 40 pounds per square inch absolute (2068.6 mm) at 100° F (37.8° C).

Combustible Liquid shall mean any liquid having a flash point at or above 140° F (60° C).

Liquids shall be divided into three classes based upon flash point determinations as defined below:

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

CLASS IA shall include those having flash points below 73° F (22.8° C) and having a boiling point below 100° F (37.8° C).

CLASS IB shall include those having flash points below 73° F (22.8° C) and having a boiling point at or above 100° F (37.8° C).

CLASS IC shall include those having flash points at or above 73° F (22.8° C) and below 100° F (37.8° C).

CLASS II shall include those having flash points at or above 100° F (37.8° C) and below 140° F (60° C).

CLASS III shall include those having flash points at or above 140° F (60° C).

CHAPTER 1. GENERAL REQUIREMENTS AND INFORMATION.

110. Introduction.

111. PURPOSE: This standard covers the minimum requirements for the installation and use of foam systems and portable apparatus for fire protection and extinguishment and is prepared to cover the design, installation, operation and maintenance of such equipment and for the guidance of inspection departments and others charged with the inspection, supervision or local approval of installations of this type.

112. SCOPE: This standard covers the installation of foam systems ranging from automatic or manual systems on small dip tanks, or the simplest form of protection on a small isolated storage tank in an industrial property to elaborate systems for the protection of refineries, oil storage farms, fuel storage and handling installations at airports, or chemical manufacturers. For shipboard installations, consult General Rules and Regulations for Vessel Inspection, U.S. Coast Guard.

113. DEFINITIONS FOAM — FOAM QUALITY: Fire fighting foam shall be an aggregation of small bubbles of lower specific gravity than oil or water, and shall show tenacious qualities for covering and clinging to vertical or horizontal surfaces. It shall have high water retention ability and be relatively stable, retaining its properties for long periods of time. Fire fighting foam shall flow freely over a burning liquid surface and form a tough air-excluding continuous blanket to seal volatile combustible vapors from access to air. This foam cover shall be dense and long lasting, resisting disruption due to wind and draft, or heat and flame attack, and be capable of resealing in case of mechanical rupture.

1131. PROTEIN-FOAM CONCENTRATES: These 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. Current formulations are used at recommended nominal concentrations of 3 percent and 6 percent of the solution discharge. Both types can be used to produce a suitable mechanical foam but the manufacturer of the foam-making equipment should be consulted as to the correct concentrate to be used in any particular system (the proportioners installed must be properly designed and/or set for the concentration being used). Mixing foam liquids of different types or different manufacture should not be done unless it is established that they are completely interchangeable. Some foam liquid concentrates produce a dry-chemical-compatible foam.

1132. FLUOROPROTEIN - FOAM - CONCENTRATES: These concentrates are very similar to protein-foam concentrates as described above but with a synthetic fluorinated surfactant additive. They form an air excluding foam blanket and may also deposit a vaporization-inhibiting film on the surface of a liquid fuel. These concentrates are used at recommended nominal concentrations of 3 percent and 6 percent of the water discharge. Both types can be used to produce a suitable mechanical foam, but the manufacturer of the foam-making equipment should be consulted as to the correct concentrate to be used in any particular system (the proportioners installed must be properly designed and/or set for the concentrate being used). Mixing foam liquid concentrates of different types or different manufacture should not be done unless it is established that they are completely interchangeable. Compatibility of the foams produced using fluoroprotein-foam concentrates with any dry chemical agent programmed for use on a fire in sequence or simultaneously should be established by test.

Fluoroprotein foam concentrates and their attendant systems are also subject to the provisions contained in this standard without deviation.

1133. SYNTHETIC FOAMS: These foams are based on foaming and foam stabilizing agents other than hydrolyzed proteins. Basic types include:

a. Aqueous Film Forming Foam (AFFF) Concentrates. These concentrates generally are based on fluorinated surfactants plus foam stabilizers and are diluted with water to a 3 percent or a 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 blanket produced should be of such thickness as to be visible before fire fighters place reliance on its permanency as a vapor suppressant. AFFF concentrates meeting U. S. Military Specification MIL-F-24385 (NAVY) have been found to be satisfactory for extinguishing fires involving hydrocarbon fuels. AFFF concentrates are normally used in conventional foam-making devices suitable for producing protein foams, but converting protein-foam-producing equipment for use with AFFF concentrates should not be accomplished without consultation with the manufacturer of the equipment and a thorough flushing of the foam tank and complete system. The foam produced with 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 and can be applied to a fire in sequence or simultaneously.

b. High Expansion Foam Concentrates. These concentrates are used in especially designed equipment to produce foams of foam-to-solution volume ratios of 100:1 to approximately 1000:1. Guidance for the use of these materials is given in NFPA No. 11A, High Expansion Foam Systems.

c. Other Synthetic Foams. There are other 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 at extraordinary application rates. Since there is little recorded and reported test and experience data for this type of foam no specific rcommendations for their use can be made. Their 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 resistance to petroleum fuel attack of the AFFF and fluoroprotein foams.

1134. OTHER SPECIAL PURPOSE FOAMS: For fighting fires in liquids which are either water soluble or which otherwise chemically destroy foams made from the above referenced materials, special foaming concentrates have been developed which can be foamed mechanically or chemically and which form an insoluble barrier at the interface of fuel and foam blanket. Commonly called alcohol-type or polar-solvent type foams, they vary considerably in chemical composition, in acceptable methods of proportioning, useful concentration limits and other operational parameters. Systems using these agents require special design consideration. The foam concentrates should not be intermixed among themselves or with other types of concentrates unless it has been previously established that they are completely compatible.

114. CHEMICAL FOAM AND MEANS OF PRODUCING IT: 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.

*1141. STORED SOLUTION SYSTEMS: As in the case of the portable 2½-gallon foam extinguisher, these solutions may be made and stored separately until they are mixed when the foam is needed. Such systems may vary in size from small automatic tip-over devices to solution storage tanks of many thousands of gallons from which the solutions flow by gravity or air pressure or are pumped simultaneously to produce the foam.

*1142. CONTINUOUS FOAM GENERATORS: These generators require a water supply into which dry-foam-producing chemicals are added, the generators being designed to mix the chemicals and water to produce a discharge of foam or foam solutions. There are two types of these generators. One type uses a single foam-producing dry chemical, foam being produced immediately at the generator outlet. The other type uses two dry chemicals constituting each of the two principal ingredients, the two solutions formed in this type of generator being kept separate until mixed beyond the generator.

1143. PRESSURE TYPE FOAM GENERATORS: These are closed devices containing the mixture of chemicals necessary for producing foam but having provision for the admission of the requisite water when foam is needed, the water valves being controlled either manually or automatically.

*1144. FOAM HOSE STREAMS: Hose streams from any of these chemical foam units are provided through the use of hose and open nozzle on the discharge side.

*1145. FOAM POWDER: Chemical foam powder comes in three types:

(a) Two separate dry powders, marked "A" and "B," to be mixed with water in two solution foam generators. The foam produced is suitable for fires involving ordinary hydrocarbon flammable liquids.

(b) A single blend of all the dry chemicals needed to produce foam when mixed with water, for use in single powder foam generators. Otherwise, the ingredients and use are the same as 1145 (a).

(c) A special single blend of all the dry chemicals needed to produce "alcohol" type foam when mixed with water, for use in single powder foam generators. This foam is intended for use on fires involving water soluble solvents† such as certain alcohols (e.g., methyl, ethyl, isopropyl), esters (e.g., ethyl acetate), ketones (e.g., acetone, methyl ethyl ketone), ethers (e.g., isopropyl ether, diethyl ether), etc., which break down the ordinary foams discussed in 1141, 1145 (a), 1145 (b), and 115. It is also suitable for use on fires in liquid hydrocarbons.

†NOTE: The term "Water Soluble Solvents" refers to those liquids which, because they are wholly or partially soluble in water, or for some other reason act as "foam breakers" to destroy the foam produced by ordinary foam chemicals or ordinary air foam stabilizers. For convenience the term "water soluble solvent" will be used throughout this standard to designate materials for which "alcohol" type foam powder is required for extinguishment.

115. AIR FOAM (Mechanical Foam) AND MEANS OF PRODUCING IT: This type of foam is produced by the addition of a foaming agent (a liquid) to water to make it capable of foaming in the presence of air, which is usually incorporated by the mechanical action of jets in a fixed foam maker or portable playpipe. The foaming agent or air foam liquid, as it is usually called, will be referred to as "concentrate" throughout this Standard. Ordinary air foam may not be suitable for use on fires involving water-soluble solvents (see Note 1145 (c)). However, special alcohol-type air foams are available for use on such water-soluble solvents (see A-1145 (c)). The efficiency of such "alcohol" type foams on liquid hydrocarbons may vary with

different foam concentrates and foam-making devices. For such use the recommendations of the manufacturer and the authority having jurisdiction should be followed.

*1151. FIXED FOAM MAKERS FOR AIR FOAM: These are approved in a variety of sizes for the connection of water inlet pipe and foam outlet pipe. When water under pressure and containing the proper percentage of concentrate passes through the foam maker, air is aspirated in proper amount and foam is continuously formed.

1152. HIGH BACK PRESSURE FOAM MAKER: A type of in-line inductor, utilizing the venturi principle for aspirating air into a stream of foam solution to form foam under pressure. Sufficient energy is conserved in this device so that the resulting foam may be conducted through piping or hoses to the hazard being protected.

1153. PRESSURE FOAM GENERATOR: A mixing chamber into which measured quantities of foam solution and air is pumped under pressure so that foam is generated which may be conducted through piping or hoses to the hazard being protected.

*1154. AIR FOAM PUMPS: This method of producing air foam under pressure involves the use of rotary, positive-displacement pumps to automatically proportion and mix the air, water, and stabilizer. These self-contained pumps may be placed in a central pump house and the foam distributed to the protected tanks through a manifold or they may be used as portable equipment.

*1155. AIR FOAM HOSE STREAM NOZZLES: An air foam nozzle is a special playpipe or nozzle incorporating a foam maker to aspirate air into the solution, thus producing air foam. These are approved in a variety of sizes and may be of a type that picks up foam stabilizer directly from a container or of a type that operates on a stream of solution consisting of water into which the stabilizer has been introduced at another point.

1156. AIR FOAM CONCENTRATE: A concentrated liquid foaming agent or foam-producing material. Depending on its concentration and nature, it is used in a proportion from three percent to six percent in water as recommended by the manufacturer and as approved by the authority having jurisdiction. There are two fundamental types of air foam concentrates: "low expansion" and "high expansion". Special "alcohol" type, low expansion type foam concentrate is available according to the requirements of the particular water-soluble solvent to be protected.

NOTE: It is important that different concentrates not be mixed unless it is known that they are compatible and suitable for the equipment available.

*1157. AIR FOAM SOLUTION: A homogeneous mixture of water and foam concentrate in the proper proportion. It shall be stored premixed or a suitable approved proportioner shall be provided for continuous introduction of air foam concentrate in adequate ratio into the water stream at or enroute to the foam maker. Air foam solution may be produced by the following means:

(a) PREMIX METHOD.

(1) By premixing a suitable air foam concentrate directly into the water in a booster or other storage tank.

(b) PROPORTIONER AT THE MAIN PUMP.

(1) Pump Suction Method—By inducting the concentrate into the water pump through a fixed or variable orifice proportioner located in the suction line of the pump.

(2) Around-the-Pump-Proportioner — By means of a venturi inducting proportioner located in a bypass between the pump discharge and the pump suction.

(c) PROPORTIONER BETWEEN THE MAIN PUMP AND THE FOAM MAKER.

(1) Pressure Proportioning Tank Method — By forcing concentrate into the water stream by water displacement and venturi induction. This device is commonly called a Proportioning Tank or Pressure Proportioner and is located between the water pump or hydrant and the foam maker or foam nozzle.

(2) In-Line Inductor — By inducting the concentrate through approved single or multiple inductors located in the water line to the foam maker.

(3) Primary-Secondary Induction Method — By bypassing a portion of the water through a branch line containing a primary inductor to pick up the concentrate, the entire mixture in the branch line being then inducted back

into the main water line through a secondary inductor in the foam maker.

(4) Pressure Side Proportioner — By forcing concentrate into the flowing water stream through an approved pressure side proportioner by means of a concentrate pump.

(5) Water Motor Proportioner — By means of a displacement type concentrate pump operated by a displacement water motor.

(d) PROPORTIONER AT THE FOAM MAKER.

(1) Single Built-In Inductor in the Foam Maker — By picking up the concentrate from a container at atmospheric pressure by an inductor in the foam maker. In this system the foam maker may be mounted directly on the concentrate container.

120. Uses and Method of Application.

121. GENERAL PURPOSES —The principal use for foam is the extinguishment of fires involving flammable liquids. It may also be used effectively to provide exposure protection and to prevent fires.

NOTE: In the absence of more suitable extinguishing media, foam may be used effectively on ordinary combustible materials (wood, paper, etc.).

1211. Extinguishment of fire by foam is accomplished primarily by the smothering action of the fluid blanket. As the foam is applied to the burning surface, it flows easily to effect a complete seal over the entire area, cutting off the oxygen, and also tends to prevent the further formation of combustible gases. The water content of the foam is extremely important in preventing breakdown of the foam by heat and in accomplishing a degree of cooling.

1212. Exposure protection of an exceptionally high order is provided by the application of foam blankets. The heat resistance of foam as defined in this standard is very high and heat transmittal is exceptionally low.

*1213. Prevention of fire may also be provided by applying foam blankets to spills or other hazardous areas to prevent ignition.

*122. LIMITATIONS: Foam has certain limitations of use which must be recognized (see Appendix).

130. System Requirements.

131. FOAM CHEMICALS — Foam-producing materials for chemical or air foam must not be readily subject to deterioration when properly stored and must produce a foam conforming to requirements of 113.

*132. MIXING — Means shall be provided for thoroughly mixing the foam-producing materials to form a suitable foam before it reaches the surfaces to which it is to be applied. Mixing devices may be in combination with discharge outlets, with supply tanks (self-contained chemical engines) or may be separate devices.

NOTE: This does not exclude the use of some of the discharge piping to perfect the final mixing.

133. DISCHARGE OUTLETS.

1331. Discharge outlets shall be so provided, designed and located as to permit the delivery of the foam over the area to be protected, the distributor used being particularly adapted to the local conditions.

1332. Discharge outlets may be in combination with mixing devices or may be separate devices.

*134. WATER SUPPLIES: All foam systems except stored solution systems depend for their successful operation upon a source of water. This shall be available at suitable pressure and quality and in adequate quantity.

1341. QUANTITY: The water supply shall be adequate in quantity to supply all the devices served in the same fire area. This includes not only the volume required for the foam apparatus but also water which may be used in other fire fighting operations, superimposed on the normal plant requirements.

Secondary water supplies available for use of fire department pumpers (and other water sources) should be considered for foam producing facilities or for water hose streams for exposure protection.

1342. PRESSURE: The pressure available at the inlet to the foam apparatus (foam generator, air foam maker, etc.) under required flow conditions shall be at least the minimum pressure for which the apparatus has been designed and approved. This pressure shall be measured or calculated under the duty conditions anticipated to obtain at the time of the emergency (see 1341).

1343. QUALITY: The water supply shall be of suitable quality so as to have no adverse effect on foam formation or foam stability. No corrosion inhibitors, freezing point depressants or any other additives should be used without prior consultation with the foam liquid or powder supplier. Use of unauthorized additives may materially reduce the effectiveness of foam systems.

*1344. STRAINERS: Strainers capable of removing from the water all solids of sufficient size to obstruct openings in the foam apparatus shall be provided.

1345. DESIGN: The water system shall be designed and installed in accordance with principles recognized in standards for such extinguishing systems.

(a) HYDRANTS: Hydrants furnishing the water supply for portable foam generators and portable air foam apparatus shall be provided in such number and be located as required by the authority having jurisdiction.

140. Storage of Foam-Producing Materials.

141. LOCATION, BUILDING: Where a central foam house (including foam pump house, generator house or portable equipment storage building) is provided for equipment and foam materials, the building shall be a detached, noncombustible structure situated in an accessible location not seriously exposed by the hazard it protects. Where acceptable to the authority having jurisdiction, space in an existing building may be used if the room is of fire-resistive construction with standard cutoff from all other portions of the building.

142. LOCATION, PORTABLE MATERIALS: Where the materials are entirely portable, and distributed about the premises, the authority having jurisdiction should be consulted as to the location and housing. (See also 145 and 146 for additional requirements for the storage of various foam-producing materials.)

143. OFF-PREMISES STORAGE: The authority having jurisdiction may permit the storage of foam-producing materials off the premises, where these supplies are suitable for use in the equipment of the installation, and are im-

mediately available at all times. Adequate loading and transportation facilities must be assured. Not over 50 per cent of the supplies required for the given installation may be stored off the premises. Extreme care must be exercised in making sure the off-premises supplies are of the proper type for use in the facilities of the given installation. At the time of a fire these off-premises supplies should be accumulated in sufficient quantities, before placing the equipment in operation, to insure foam production at an adequate rate without interruption until extinguishment is effected.

*144. WET STORAGE CHEMICAL FOAM SYSTEMS.

1441. Where two-solution storage is used, the solutions should be stored and contained in tanks conforming to the NFPA Standard for Water Tanks for Private Fire Protection (No. 22) so far as they may apply, due consideration being given to the specific gravity of the foam-producing solutions. Metal tanks used for storing corrosive liquids shall be protected from corrosion in a reliable and permanent manner.

*1442. Suitable provision shall be made when necessary for maintaining the supply of foam-producing solutions at temperatures that will not inhibit normal chemical action.

1443. Means should be provided for the agitation or circulation of the liquids to assure uniform solutions. "B" chemical solution should not be agitated for more than 5 minutes, nor more frequently than once a year except when adding new quantities of chemicals or water.

1444. Facilities separate from the storage tanks shall be provided for dissolving and preparing the chemicals to permit prompt restoration of the system to operating condition after use.

NOTE: This may be accomplished by the use of generators.

*1445. Pumps should be of a positive displacement type and shall be so arranged as to deliver the required quantities of the solutions in the proper proportions.

1446. Suitable means shall be provided for making full pump capacity tests with water.

145. Dry Storage Chemical Foam Systems.

1451. Dry foam-producing chemicals shall be stored in approved containers in a location not subject to abnormal deterioration, subject to the approval of the authority having jurisdiction.

*1452. Centralized Fixed Piping Systems.

(a) Storage In Containers Of Large Capacity: Where systems require more than 10,000 lbs. of foam-producing chemicals, it is recommended that at least 50 per cent of the entire supply of such chemicals be stored in containers of large capacity which permit of prompt and uninterrupted feeding of the generators, with a minimum of manpower. Such containers shall be of moisture-proof construction throughout to assure the storage of powder over long periods without abnormal deterioration. They may be of the fixed or movable type and shall be arranged to allow prompt and continuous flow of powder to the generators, without waste. The arrangement of powder containers and generators shall be such as to provide for easy access to powder for periodic inspection.

(b) Storage in Portable Containers: Such storage may be employed if sufficient manpower is available at all times to feed the generators at the rate required by the system. In many cases a local fire department may be called upon to provide the necessary manpower and water supply.

*146. Air Foam Systems.

1461. The supply of concentrate may be stored in the original shipping containers, in pressure proportioning tanks or in special tanks designed for the purpose. The concentrate should not be stored at temperatures lower than that for which it is approved nor above 120°F. It shall be stored in a location free of excessive moisture to avoid external corrosion of containers and other equipment.

150. Piping Installation Requirements.

151. Materials.

1511. Piping: Piping 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 or diked area.

1512. VALVES: All valves are to be of a type approved for the purpose used. Lever operated gate valves are not acceptable. 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.

1513. FITTINGS: All pipe fittings shall be American Standard for the pressure class involved but not less than 125 lbs. standard. Iron fittings shall be malleable in dry sections of the piping exposed to possible fire. Automatic control valves, shut-off valves and strainers of approved types may be cast iron if outside the fire area. All fittings subject to stress in self-supporting systems shall be steel or malleable iron.

152. PIPE SIZE: As effective protection depends on having an adequate volume of water (or solutions), at proper pressure, available at the foam-making apparatus, 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 should be so selected as to produce the proper delivery rate at the discharge outlet. Friction losses in piping carrying foam are not susceptible to simple calculation, and the recommendations of the manufacturer of the device should be followed.

153. INSTALLATION: Installation shall conform to the applicable NFPA Standards as modified herein.

154. FLUSHING.

1541. UNDERGROUND PIPING: Underground mains 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 should not be less than the water demand rate of the system which is determined by the system design and the water supply available. The flow should be continued for a sufficient time to insure thorough cleaning. In connection with flushing operations, consideration shall be given to means for disposal of the water discharged.

1542. System Piping: After installation, all system piping shall be flushed where practicable by placing the system in operation using its normal water supply, but with the foam supply shut off. Otherwise, cleanliness of the pipe interiors shall be determined during installation by visual examination.

1543. Flushing After Use: Provision shall be made in the design to permit flushing with clean fresh water after use.

155. Test Gage: A test gage connection shall be provided on each side of each chemical foam generator, air foam proportioner, and system pump and at each lateral control valve.

160. Plans and Specifications.

161. Requirements: Foam system layout and installation should be entrusted to none but fully experienced and responsible persons. Before fixed foam systems or portable equipment are installed or existing equipment remodeled, complete working plans and specifications should be submitted for approval to the authority having jurisdiction. Any material deviation from the approved standards, will require special permission from the authority having jurisdiction. Plans shall be drawn to any indicated scale, show all essential details and shall be made so they can be easily reproduced to provide the necessary copies or prints. The authority having jurisdiction may require, for approval, tests of available water supply, complete computations showing pressure drop in all system piping, friction loss calculations on liquid lines and a detailed layout of the entire hazard to be protected.

1611. Hydraulic characteristics of foam proportioners and of foam makers as determined by tests shall be supplied by the manufacturer to the user and the authority having jurisdiction (including the range of operating conditions required for the proposed installation), to permit determination of the adequacy of the hydraulics of the proposed protection.

162. Test Results To Be Supplied: For the following equipment, equipment manufacturers shall supply test results to the owner and to the authority having jurisdiction:

1621. Single Line Chemical Foam Generators:

(a) Water rate at 100 psi inlet water pressure.

(b) When operating at 100 psi inlet water pressure and water temperature at 70°F., the powder rate, foam expansion and foam quality, using the stated foam powder and delivering to the foam pipe layout given in the table under A3422, and also when delivering to the foam pipe and hose stream layout (with nozzle size stated) given in the table under A3422.

(c) If the pipe line layout differs from that specified in A3422, either by the use of longer pipe lines or by the use of pipe sizes other than those specified in A3422, or if the water rating of the generator at 100 psi inlet water pressure exceeds that specified, then test data for the proposed layout shall be obtained and submitted.

1622. Chemical Foam Solution Generators.

(a) Water rate at 100 psi inlet water pressure.

(b) When operating at 100 psi inlet water pressure and water temperature of 70°F., the powder rate, foam expansion and foam quality, using stated foam powder and delivering against a back pressure of 40 psi (40 per cent of the inlet water pressure).

(c) If the proposed layout will result in a back pressure in excess of 40 per cent of inlet water pressure, test data for operation against such higher outlet pressure shall be obtained and submitted.

1623. Air Foam.

(a) Solution Proportioners. — When operating at water pressures of 50 and 100 psi on the supply side of the proportioner the following data:

(1) Water rate.

(2) Solution rate.

(3) Pressure on each side of the proportioner.

(4) Such other test data as may be required to determine the adequacy of the design of the system.

(b) Foam Makers.

(1) Water rates and foam production of the foam makers at 50 to 100 psi at the foam makers.

(2) Such other test data as may be required to determine the adequacy of the design.

170. Approvals.

171. All plans and specifications pertinent to the installation shall be approved by the authority having jurisdiction prior to installation. The authority having jurisdiction shall be consulted as to devices and material. All equipment shall be approved for the particular application intended. Before requesting final approval of a foam system by the authority having jurisdiction, the installing company should furnish a written statement to the effect that the work has been completed and tested in accordance with approved plans and specifications.

180. Acceptance Tests.

181. PRESSURE TESTS: All piping except that handling expanded foam shall be subjected to a 2-hour hydrostatic pressure test at 200 lbs. per sq. in. or 50 lbs. 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). All normally dry horizontal piping shall be checked to determine if proper drainage pitch is provided.

182. OPERATING TESTS: Before acceptance, fixed foam systems shall be subjected to such tests as may be required by the authority having jurisdiction. Wherever practicable these tests shall include operation of all devices and equipment installed as part of the system.

*183. DISCHARGE TESTS: Approval and acceptance of foam systems may be subject to flow tests where conditions permit, in order to insure that the hazard is fully protected in conformance with the design specification, and to determine the flow pressures, solution discharge rates, consumption rate of foam producing materials, manpower requirements and other operating characteristics.

184. VISUAL EXAMINATION: Foam systems shall be examined visually to determine that they have been properly installed. Checks shall be made for such items as conformity with installation plans, continuity of piping, tightness of fittings, removal of temporary blank flanges, accessibility of valves and controls, and proper installation of vapor seals, where applicable. Devices shall be checked for proper identification and instructions.

190. Maintenance.

191. WATER SUPPLIES: Proper precautions should be taken to insure that water supplies are kept turned on and are in full operating condition at all times in accordance with other standards governing water supplies for fire protection equipment.

192. STRAINERS: Strainers should be thoroughly inspected and cleaned after each operation or flow test. Inspection and cleaning should be performed at intervals of not more than six months.

193. PIPING: All piping shall be examined at regular intervals to determine its condition. The frequency of inspections will be dependent upon local conditions and should include tests to detemine that proper drainage pitch is maintained for piping. Pressure tests of normally dry piping outdoors shall be made annually. At such time as hydrostatic tests are conducted on the foam piping, swing joints at the base of the tank risers shall be checked to assure that the joints still have flexibility to take care of shock and movement.

194. CONTROL VALVES AND DEVICES: Automatic control valves and heat-actuated devices shall be tested at least twice a year by qualified inspectors acceptable to the authority having jurisdiction.

NOTE: An inspection contract with the installer of the equipment for test and examination at regular periods is advisable.

1941. Manual tripping devices and valves, including O.S. and Y. gate and post indicator valves, shall be operated at least twice a year.

195. SYSTEM RESTORATION AFTER USE.

1951. Where normally opened valves are closed following system operation or test, suitable procedures should be instituted to insure that they are reopened and that the system is promptly and properly restored to full normal operating condition. Drain flow tests should be made after valves are reopened.

1952. After each operation, devices mixing foam chemicals and making foam shall be cleaned and inspected.

196. INSPECTION OF FOAM-PRODUCING MATERIALS.

1961. Periodic inspection should be made of stored chemicals, powder, air foam concentrate, etc., and their containers.

197. OPERATING AND MAINTENANCE INSTRUCTIONS: Operating and maintenance instructions and layouts shall be posted at control equipment and at fire headquarters. Selected plant personnel should be trained and assigned the task of operating and maintaining the equipment.

CHAPTER 2. FIXED FOAM EXTINGUISHING SYSTEMS FOR INDOOR FLAMMABLE LIQUID HAZARDS

20. General

2010. Scope and Application

2011. This section relates to foam fire extinguishing systems which are intended as the primary protection for specific hazards located in rooms and buildings, or general protection for the contents of the room or building and may or may not include the structure.

2012. These systems are particularly applicable to the indoor storage and handling of flammable liquids having a flash point below 140°F. and heated combustible liquids. Typical applications would be in storage areas, areas subject to large spills, process equipment, pump rooms, open tanks, such as dip tanks, quench tanks, mixing tanks, etc., which may be found in chemical plants, solvent extraction plants, distillation plants, and refineries.

2013. This section does not cover foam-water sprinkler or foam-water spray systems (see NFPA No. 16) or high expansion foam systems (see NFPA No. 11A).

2020. Definitions.

2021. SPRAY 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 discharge and distribution over the area to be protected.

2022. DISCHARGE DEVICES: Discharge devices generally fall into two categories; those producing foam in a spray or dispersed pattern, and those producing foam in a compact low velocity stream.

(a) Devices which discharge foam in a spray pattern terminate in a deflector or screen which dispenses the foam.

(b) Devices which discharge foam as a compact low velocity stream may or may not have deflectors or stream directors included as an integral part of the device. These devices may take such forms as open pipe fittings, directional flow nozzles, or small foam-making chambers with open outlets.

(c) These discharge devices in approved forms are available in a number of patterns with variations in discharge capacity. Such devices may or may not have the foam maker included as an integral part.

2030. Limitations.

NOTE: For general limitations see 122.

2031. Foams should not be used on water soluble solvents in depth exceeding one inch, through spray foam discharge devices. Alcohol type foams can be used when the system is specially designed for this application and approved by the authority having jurisdiction.

2040. Foam Quality.

2041. Foam delivered from spray foam systems shall quickly form a cohesive foam blanket and spread rapidly around obstructions. Foams discharged from such systems, and meeting these requirements, have exhibited "expansions" ranging from 4 to 8; and "25 percent drainage time" values, ranging from 0.30 minute to 1 minute.

2042. Foam discharge from devices producing a compact low velocity stream shall have characteristics within the limits shown in Fig. A-601G.

21. System Description

2110. A system consists of detection devices, an adequate water supply, supply of foam producing materials, suitable proportioning equipment, a proper piping system, foam makers, and discharge devices designed to adequately distribute the foam over the hazard.

2111. These systems are of the open outlet deluge type in which foam discharges from all outlets at the same time, covering the entire hazard within the confines of the system.

2112. Self-contained systems are those in which all components and ingredients, including water, are contained within the systems. Such systems usually have a water supply tank that is pressurized by air or compressed gas, and the release of this pressure into the system puts it in operation. These systems may also be pressurized by the chemical reaction of solutions that are mixed at the time of system operation.

2120. Automatic Operation

2121. In an automatic system there are fire detection devices which may be any of a number of listed detectors. These detectors usually activate the system by operating the water control valve or other actuating device. All other equipment is so interconnected that it is also activated so that properly mixed foam solution is supplied to the foam makers and foam distributed over the hazard.

2122. Automatic detection equipment, whether pneumatic, hydraulic or electric, shall be provided with complete supervision so arranged that failure of equipment or loss of supervising air pressure or loss of electric energy will result in positive notification of the abnormal condition. Small systems for localized hazards may be unsupervised subject to approval of the authority having jurisdiction.

2123. Automatic detection equipment of electric type and any auxiliary equipment of electric type, if in hazardous areas,* shall be expressly designed for use in such areas.

2124. In some special cases it may be desirable to arrange the system to shut off automatically after a predetermined operating time. This feature would be subject to approval of the authorities having jurisdiction.

22. System Design

2210. These systems shall be designed for automatic operation, supplemented by auxiliary manual tripping means.

2220. In systems designed for general area protection of rooms or buildings where spray foam devices are used, the discharge outlets should generally be located as high as possible in the area, and spaced in accordance with their discharge patterns so that the system covers the entire protected area.

2221. When floor type outlets are used, they should be located and spaced so the foam will flow as rapidly as possible over the area.

2230. Open tanks of flammable liquids may be protected by "tank side" nozzles discharging foam at low velocity directly on the liquid surfaces, or by means of "foam spray" nozzles mounted above the tank.

2240. Protection for specific pieces of equipment may be

*See National Electrical Code (NFPA No. 70, USA Standard **CI-1698), Article 500 and other Articles in Chapter 5, thereof.**

provided by overhead application or by directional discharge devices directed at the equipment. Where the basic objective of the system is extinguishing a spill fire on the floor, enveloping the equipment in the foam discharge has the added advantage of providing an insulating effect to protect the equipment from heat exposure while the fire is being extinguished.

2241. There should be a minimum of one (1) discharge outlet per 100 square feet of protected area unless listing of discharge devices indicates a larger spacing is permitted. These outlets should be located so as to provide good distribution throughout the protected area. However, an added advantage is gained by locating the outlets so that foam discharge envelops the equipment within the protected area. These outlets are located in plan and elevation to provide the most effective protection of the hazard.

2250. In some hazard arrangements it may be desirable to design systems utilizing combinations of the system designs described in 2220, 2230, and 2240.

2260. Where air-foam concentrate lines to the protective-system injection points are run underground or where they run aboveground for more than 50 feet, air-foam liquid concentrate in these lines shall be maintained under pressure to assure prompt foam application and to provide a means of checking on the tightness of the system.

Pressure may be maintained by a small auxiliary pump, or by other suitable means.

2270. Equipment items, such as storage tanks, proportioners, pumps, and control valves shall be installed where they will be accessible, especially during a fire emergency in the protected area and where there will be no exposure from the protected hazard. Automatically controlled valves shall be as close to the hazard protected as accessibility permits so that a minimum of piping is required between the automatic-control valve and the discharge devices. Consideration should be given to provisions of remotely located post-indicator or other shut-off valves to permit system water-supply control under abnormal conditions.

2280. Size of System. Systems may be used to protect one or more hazards or groups of hazards using the same supply of foam concentrate and water.

2281. The size of a single system should be kept as small as practicable, giving consideration to water supplies and other factors affecting the reliability of the protection.

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

23. Rate of Application.

2310. For Liquid Hydrocarbons.

2311. For area protection, the discharge of foam outlets shall provide a solution rate of at least 0.16 gpm per square foot of the area protected.

2312. Where there are intervening horizontal surfaces that would collect foam, such as large tanks, mezzanines or decks, etc., these should be taken into consideration in arriving at the design discharge rate.

2313. Where open top tanks are protected by discharge outlets located on the tank, the rate of application shall be 0.16 gpm per square foot of liquid surface.

2314. When small open tanks are protected by spray foam system, close attention must be given to the percentage of the system discharge which actually enters the tank, to assure that the required application rate is being achieved.

2320. Water soluble and certain flammable and combustible liquids and polar solvents which are destructive to regular foams require the use of "alcohol" type foams. Systems using these foams require special engineering consideration and may require that higher application rates be used. In all cases, the manufacturer of the foam concentrate and the foam-making equipment should be consulted as to the limitations and for recommendations based on listings or specific fire tests.

24. Operating Time.

2410. For area and equipment protection, the duration of foam discharge shall be a minimum of 10 minutes.

2420. For Tanks of Less Than 400 Square Feet Liquid Surface.

2421. For overhead spray foam discharge outlets, the duration of foam discharge shall be a minimum of 5 minutes.

2422. For tank mounted foam discharge outlets, the duration of foam discharge shall be a minimum of 3 minutes.

2423. Where the normal freeboard is such that if the discharge time would cause a significant quantity of foam to overflow and be wasted, the authority having jurisdiction should be consulted.

2424. Suitable overflow facilities should be provided to maintain a constant freeboard of not less than 2 inches, or 4 inches for tanks of more than 25 square feet in area (see NFPA No. 34).

2430. When a system has been designed to have a delivery rate higher than that specified under 23, a proportionate reduction in the discharge times given in 2410 and 2420 may be made.

2440. For tanks of 400 square feet and larger liquid surface area, apply the operating time rules for outdoor tanks.

25. Supply of Foam Producing Materials.

2510. Total supply of foam-producing materials shall be the sum of the quantities defined in 2520 and 2530.

2520. There shall be a quantity of foam producing materials sufficient to supply the system in accordance with 23 and 24.

2530. Reserve Supply. There shall be a reserve supply of foam-producing materials in accordance with 326.

26. System Piping.

2610. System piping shall be hydraulically calculated and sized in order to obtain reasonably uniform foam distribution and to allow for loss of head in water supply piping. Adjustment in pipe sizes to provide uniform discharge should be based on a maximum variation of 15 percent from the assumed average discharge per discharge device provided that the total system design delivers the design application rate. Hydraulic calculations shall be made in accordance with the applicable paragraphs of NFPA No. 16.

2611. Pipes shall be securely supported and where protecting hazards in rooms where explosions are possible, pipes should be hung from other supports than the roof so that if the roof lifts, the piping will not be broken or disarranged.

2612. Foam distribution piping shall be arranged to drain and should have a pitch toward drain ½ in. in 10 feet.

2613. HANGERS: All hangers must be of approved types. Tapping or drilling of load bearing structural members should not be generally permitted. Attachments may be made to existing steel or concrete structures and equipment supports. Where systems are of such a nature that the standard method of supporting pipe for protection purposes cannot be used, the piping shall be supported in such a manner as to produce the strength equivalent to that afforded by such standard means of support.

2614. INSTALLATION: The installation standards for foam system piping shall be the applicable sections of the NFPA Standard for the Installation of Sprinkler Systems (No. 13) except as herein modified. Welding in accordance with ANSI Code for Pressure Piping is permissible when it can be done without introducing fire hazards. Special care should be taken to insure that the openings are fully cut out and that no obstructions remain in the waterway. The supply piping to foam outlets which protect a hazard in a fire area shall not pass over another hazard in the same fire area.

27. Alarms.

2710. A local alarm, actuated independently of water flow, to indicate operation of the automatic detection equipment shall be provided on each system. Central station or proprietary station water-flow alarm service is desirable but provision of this service does not necessarily waive the local-alarm requirement.

2720. Outdoor water-motor or electric-alarm gongs, responsive to system water flow, may be required by the authority having jurisdiction.

2730. Under conditions where central station or proprietary station water-flow alarm service is not available, it may be advisable to connect electrical alarm units to public Fire Department Headquarters or nearest Fire Department Station or other suitable place where aid may be readily secured.*

2740. A suitable trouble alarm shall be provided for each system to indicate failure of automatic detection equipment (including electric supervisory circuits) or other such devices or equipment upon which the system operation is dependent.

*See the NFPA Standards on Central Station Protective Signaling Systems (No. 71), on Local Protective Signaling Systems (No. 72A), on Auxiliary Protective Signaling Systems (No. 72B), on Remote Station Protective Signaling Systems (No. 72C), and on Proprietary Protective Signaling Systems (No. 72D).

28. Plans and Specifications.

2810. The designing and installation of these systems should be entrusted to only fully experienced and responsible persons. Before such systems are installed, complete working plans and specifications shall be submitted for approval to the authority having jurisdiction. Working plans shall be drawn to scale, show all essential details, and be so made that they can be easily reproduced to provide the necessary copies. Information required includes the design purpose of the system; discharge densities and period of discharge; hydraulic calculations; details of tests of available water supply; detailed layout of the piping and of the heat-responsive operating equipment; type of discharge devices to be installed; location and spacing of discharge devices; pipe-hanger installation details; location of draft curtains; an accurate and complete layout of the buildings or hazards to be protected; and other pertinent data to provide a clear explanation of the proposed design.

2811. In addition to the items listed in 2810, plans and specifications shall indicate the quantity and type of air foam producing material to be stored, including the quantity in reserve; and the concentration designation, such as 3 percent or 6 percent.

2820. The specifications shall include the specific tests that may be required to meet the approval of the authority having jurisdiction and should indicate how costs of preparing the area, testing, and cleanup is to be borne.

2830. Complete plans and detailed data describing pumps, drivers, controllers, power supply, fittings, suction and discharge connections, and suction conditions shall be submitted by the engineer or contractor to the authority having jurisdiction for approval before installation.

2831. Charts showing head, delivery, efficiency and brake horsepower curves of pumps shall be furnished by the contractor.

2832. Controllers governing the starting of electric driven concentrate pumps shall be of approved types. Where control equipment listed by a nationally recognized testing laboratory for fire-protection service is not available, suitable listed industrial-control equipment with adequate interrupting capacity in accordance with NFPA Standard for the Installation of Centrifugal Fire Pumps (No. 20) may be used.

CHAPTER 3.

FIXED SYSTEMS FOR EXTERIOR STORAGE TANKS

300. General.

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

NOTE: Tanks containing combustible liquids (at or above 140° F. flash point) are not, as a rule, required to be protected by foam. Foam protection for combustible liquids may be desirable where abnormal situations exist, such as storage of high value stocks or liquids heated above their flash point.

302. DEFINITIONS:

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

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

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

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

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

(f) SEMI-FIXED INSTALLATIONS:

(1) The type in which tanks are equipped with fixed discharge outlets connected to piping which terminates at a safe distance from the tanks. The fixed piping installation may or may not include a foam maker. Neces-

sary foam-producing materials are transported to the scene after the fire starts and are connected to the piping.

(2) The type in which foam-producing solutions are piped from a central foam house through the area, the solution being delivered through hose lines to portable foam towers which are erected after the fire starts (Chapter 4); or applied by hose streams (Chapter 5).

310. Foam Application.

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

3110. TO TANKS CONTAINING LIQUID HYDROCARBONS:

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

(b) For dry powder chemical foam generator systems the water rate to the generators shall be at least 0.1 gpm/sq. ft. of liquid surface area of the tank to be protected.

(c) For chemical foam systems with stored solutions, delivery rate shall be at least 0.05 gpm of "A" solution and 0.05 gpm of the "B" solution for each square foot of liquid surface of the tank to be protected.

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

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

3111. TO TANKS CONTAINING OTHER FLAMMABLE AND COMBUSTIBLE LIQUIDS REQUIRING SPECIAL FOAMS: Water soluble and certain flammable and combustible liquids and polar solvents which are destructive to regular foams require the use of "alcohol" type foams. Systems using these foams require special engineering consideration. Conditions other than routine may require that higher application rates be used. In all cases, the manufacturer of

the foam concentrate and the foam-making equipment should be consulted as to the limitations and for recommendations based on listings or specific fire tests.
The following are minimum recommended application rates:

TYPE OF LIQUID	SOLUTION RATE gpm/sq. ft.
Methyl and ethyl alcohol	0.1
Acrylonitrile	0.1
Ethyl acetate	0.1
Methyl ethyl ketone	0.1
Acetone	0.15
Butyl alcohol	0.15
Isopropyl ether	0.15

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

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

Solution transit time, that is the elapsed time between injection of the foam concentrate into water and the induction of air, may be limited, depending on the characteristics of the foam concentrate, the water temperature, and the nature of the hazard protected. The maximum solution transit time of each specific installation shall be within the limits established by the manufacturer.

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

320. Supply of Foam-Producing Materials.

*321. GENERAL: Supplies to be maintained shall be the sum of the quantities defined in 323, 324, 325 and 326.

322. MINIMUM DISCHARGE TIMES: The system shall be capable of operation at the delivery rate specified in 311, for the tank to be protected, for the following minimum periods of time. If the apparatus available has a delivery rate higher than specified in 311, proportionate reduction in the time figures may be made.

FOR TANKS CONTAINING LIQUID HYDROCARBONS	TYPE OF FOAM DISCHARGE OUTLET TYPE I	TYPE II
Lubricating oils; dry viscous residuum (more than 50 seconds Saybolt-Fural at 122 F); dry fuel oils, etc., with flash point above 200°F	15 min.	25 min.
Kerosene; light furnace oils, diesel fuels, etc. with flash point from 100°F to 200°F	20 min.	30 min.
Gasoline; naphtha, benzol and similar liquids with flash point below 100°F	30 min.	55 min.
Crude petroleum	30 min.	55 min.

FOR TANKS CONTAINING OTHER FLAMMABLE AND COMBUSTIBLE LIQUIDS REQUIRING SPECIAL FOAMS

"Alcohol" type foams require gentle application by Type I devices unless listed as suitable for application by Type II devices. The operation time shall be 30 minutes at the specified application rate, unless the manufacturer of the foam concentrate has established by fire test that a shorter time can be permitted.

3221. Dry Powder Chemical Foam Generator Consumption Rates: For the purpose of the above tables, it shall be assumed that dry powder generators (dual or single powder type) consume 1.25 lbs. of powder per gallon of water. Where "listings" of dry powder generators and powder by nationally recognized testing laboratories show powder consumption less than 1.25 lbs. per gallon of water, such lower figure may be used when the generator is used in the manner on which the listing was based.

323. Requirements for Tanks: The quantity of foam-producing material shall be determined by multiplying the total flow in gallons per minute for each tank by the appropriate time in 322. The largest resulting value shall determine the quantity required.

*324. Supplementary Foam Hose Stream Requirements: Approved foam hose stream equipment shall be provided in addition to tank foam installations as supplementary protection for small spill fires. The minimum number of fixed or portable hose streams required shall be as specified in the following table, and shall be conveniently located to provide protection of the area. For the purpose of this requirement, the equipment for producing each foam hose stream shall have a solution rate of at least 50 gpm.

Hose stream delivery quantities shall be in addition to quantities required for tank areas. Additional foam-producing materials shall be provided to permit operation of the hose stream equipment simultaneous with tank foam installations specified for the period set forth in the following table:

Diameter of largest tank	Minimum number of hose streams required	time* Minimum operating
up to 35 ft.	1	10 min.
over 35 to 65 ft.	1	20 min.
over 65 to 95 ft.	2	20 min.
over 95 to 120 ft.	2	30 min.
over 120 ft.	3	30 min.

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

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

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

326. RESERVE SUPPLY OF FOAM-PRODUCING MATERIALS: 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.

330. Foam Discharge Outlets

*331. FIXED DISCHARGE OUTLETS: For the protection of a flammable liquid contained in a storage tank, discharge outlets shall be attached to the tank. Where two or more discharge outlets are required, the outlets shall be equally spaced around the tank periphery and each outlet shall be sized to deliver foam at approximately the same rate. Fixed discharge outlets shall be securely attached at the top of the shell and so located or connected as to preclude the possibility of the tanks overflowing into the foam lines. They shall be securely attached so that displacement of the roof is not likely to subject them to serious damage.

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

TANK DIAMETER — FEET (or equivalent area)	MINIMUM NUMBER DISCHARGE OUTLETS
up to 80	1
over 80 to 120	2
over 120 to 140	3
over 140 to 160	4
over 160 to 180	5
over 180 to 200	6

NOTE: It is suggested that for tanks above 200 feet in diameter, at least one additional discharge outlet be added for each additional 5000 sq. ft. of liquid surfaces. Since there has been no experience with foam application to fires in oil tanks over 140 feet in diameter, requirements for foam protection on tanks above this size are based on extrapolation of data from successful extinguishments in smaller tanks. Tests have shown that foam can travel effectively across at least 100 feet of burning liquid surface. On large tanks, sub-surface injection may be used to reduce foam travel distances.

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

*3311. OPEN TOP FLOATING ROOF TANKS: Fixed outlets are not required on open top floating roof tanks. These tanks have an excellent fire record. Their design has been for the purpose of fire prevention as well as for conservation of product. It is usually possible to utilize trained personnel to extinguish fires in the annular ring using portable equipment. There are locations, however, where fixed protection may be desired because of value of products stored, remoteness of installation, or lack of firefighting personnel. Suggested methods for providing fixed foam systems for open top floating roof tanks will be found in the Appendix.

3312. COVERED FLOATING ROOF TANKS: Fixed outlets are not required on covered floating roof tanks. These tanks have an excellent fire record. The possibility of fire is greatly reduced in comparison with other types because of the Faraday cage type construction of covered floating roof tanks.

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

332. PORTABLE TOWERS: It is desirable that at least one portable tower be provided as supplementary protection in the event that a fixed discharge outlet is damaged by an explosion within the tank (see Chapter 4).

*333. SEMI-SUBSURFACE INJECTION METHOD: Information for the use of this method will be found in the Appendix.

334. HORIZONTAL ATMOSPHERIC AND PRESSURE TANKS: Fixed outlets are not recommended discharging into horizontal or pressure tanks.

340. Foam System Piping

341. GENERAL REQUIREMENTS:

3411. All piping inside of dikes, and within 50 feet of tanks not diked, should be buried under at least one foot of earth but may be permitted above ground if properly supported and protected against mechanical injury.

3412. Piping which is normally filled with liquids, such as the suction pipes, shall be protected from freezing when necessary.

3413. Piping from the dike or within 50 feet of tanks not diked to the tank foam discharge outlet shall be designed to absorb the upward force and shock due to a tank roof rupture. Preferably, use steel pipe and all-welded construction. One of the following designs may be used:

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

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

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

3414. One flanged or union joint shall be provided in each riser within five feet of the ground to permit hydrostatic testing of the piping system up to this joint. With all welded construction, this may be the only joint that can be opened.

3415. In systems with semi-fixed equipment, the foam or solution laterals shall terminate in connections which are at a safe distance from the tanks; outside of dikes and at least 50 feet from tanks of 50 feet diameter or less, and one tank diameter from the shell of larger tanks. The inlets to the piping shall be fitted with corrosion-resistant metal connections provided with plugs or caps.

*342. PIPE LINES CARRYING FOAM: Pipe lines carrying chemical or air foam shall be of such sizes and lengths as to deliver on the surface protected the required quantity of foam of standard quality. The size and length of discharge line used beyond foam-making equipment should be in accordance with the conditions under which the device has been tested and listed.

343. VALVES IN SYSTEMS: All valves, except hydrant valves, should be of the O.S. and Y. or post indicator type. The laterals to each foam chamber shall be separately valved outside the dike in fixed installations. Control valves to divert the foam or solutions to the proper tank may be in the central foam house or may be at points where laterals to the protected tanks branch from main feed line. Control valves shall be located outside dikes and not less than the following distances from the shell of the tank which they serve: 50 ft. for tanks less than 50 ft. in diameter: one diameter for tanks 50 ft. in diameter or larger. except that control valves may be permitted at less than the above distances where adequately protected, subject to the approval of the authority having jurisdiction. Where two or more air foam proportioners or chemical foam generators are installed in parallel discharging into the same outlet header, valves shall be provided between the outlet of each device and the header. The water line to each air foam proportioner or chemical foam generator inlet should be separately valved.

344. FOAM SYSTEM HYDRANTS: Centralized fixed piping systems should be provided with hydrant outlets for foam hose streams for supplementary use on spill fires, supplying portable towers, etc. In lieu of foam (or solution) hydrants, water hydrants and portable generators or other devices acceptable to the authority having jurisdiction may be provided. The minimum number of hydrants, each with at least one outlet, shall be located 50 to 250 feet distance from the shells of tanks protected, as set forth below:

Tank Diameter — Feet	Minimum Number of Hydrants Required
Up to 65	1
65 and over	2

350. Subsurface Foam Injection To Tanks Containing Liquid Hydrocarbons.

*351. GENERAL: Subsurface injection systems are not suitable for protection of products such as alcohols, esters, ketones, aldehydes, anhydrides, etc. Liquid hydrocarbons that contain such products which are foam destructive may require higher application rates. The manufacturer of the foam system should be consulted for recommendations.

NOTE: For pertinent information regarding fire fighting operations, see Appendix A351.

*3511. FOAM-PRODUCING MATERIALS AND EQUIPMENT: Foam-producing materials and equipment for subsurface injection shall be listed for this purpose. Fluoroprotein foam concentrates will provide satisfactory subsurface injection performance.

352. RATES: The minimum delivery rate shall be 0.1 gpm/sq. ft. of liquid surface area of the tank to be protected.

353. SUPPLY OF FOAM-PRODUCING MATERIALS: The minimum total supplies to be maintained shall be the sum of the quantities defined for Type II Foam Discharge Outlets, 323, 324, 325, and 326.

354. SUPPLEMENTARY FOAM HOSE STREAM AND HYDRANT REQUIREMENTS: The minimum requirements for foam hose streams and hydrants shall be as specified in 324 and 344.

355. FOAM DISCHARGE OUTLETS: The discharge outlet into the tank may be the open end of a foam delivery line or product line. Outlets shall be sized so that foam generator discharge pressure and foam velocity limitations are not exceeded. The foam velocity at the point of discharge into the tank contents shall not exceed 10 feet per second for Class IB liquids and shall not exceed 20 feet per second for other type liquids unless actual tests prove higher velocities are satisfactory. (See Appendix A-3561).

Where two or more outlets are required, they should be equally spaced around the tank periphery and each outlet should be sized to deliver foam at approximately the same rate. For even foam distribution, outlets may be shell connections or may be fed through a pipe manifold within the tank from a single shell connection. Shell connections may be made in manway covers rather than installing additional tank nozzles.

3551. Tanks shall be provided with discharge outlets as set forth below.

	MINIMUM NUMBER OF DISCHARGE OUTLETS REQUIRED	
TANK DIAMETER — FEET	CLASS IB LIQUIDS	CLASSES IC, II & III LIQUIDS
Up to 80	1	1
Over 80 to 120	2	1
Over 120 to 140	3	2
Over 140 to 160	4	2
Over 160 to 180	5	2
Over 180 to 200	6	3
Over 200 add one inlet for each additional	5000 sq. ft.	7500 sq. ft.

NOTE 1: Class IA Liquids require special consideration.

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

NOTE 3: The heaviest fuels which have been extinguished by subsurface injection correspond in viscosity to number 6 fuel oils. In addition to the control provided by the smothering effect of the foam and the cooling effect of the water in the foam which reaches the surface, fire control and extinguishment may be further enhanced by the rolling of cool product to the surface. No known tests have been conducted on products having a higher viscosity than a number 6 fuel oil.

3552. FOAM DISCHARGE OUTLET ELEVATION: Foam discharge outlets should be located above an established water bottom, if possible. Otherwise, if it is established that there is a water bottom in the tank above the foam discharge outlets, it should be drained to below the point of foam injection prior to putting the foam system into operation. If this is not accomplished, efficiency will be reduced as a result of dilution of the foam, prolonging or preventing extinguishment.

356. FOAM SYSTEM PIPING

*3561. PIPELINES CARRYING FOAM: The sizes and lengths of discharge pipe or lines used beyond the foam-maker shall be such that the back pressure is within the range of pressures under which the device has been tested and listed by nationally recognized testing laboratories.

3562. VALVES IN SYSTEMS: In addition to the requirements specified in 3430, each foam delivery line shall be provided with a valve and check valve unless the latter is an integral part of the high back-pressure foam-maker or pressure foam generator to be connected at time of use. When product lines are used for foam, product line valving shall be arranged to ensure foam enters only the tank to be protected.

CHAPTER 4. PORTABLE TOWER SYSTEMS FOR EXTERIOR STORAGE TANKS

400. General.

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

NOTE 1: Generally, portable towers are to be regarded as limited in use. Portable tower systems require accessibility to tankage, and an adequate number of men to place and maintain the apparatus in operation; and in some cases, special truck units for the ready transportation of the equipment to the location of the fire. The adequacy of a portable tower system, subject to the approval of the authority having jurisdiction, shall be based upon the number and availability of the men and equipment to extinguish a possible fire. On tanks over 200 ft. diameter, the use of portable foam towers may not be practical, due to the amount of equipment and number of men needed to meet requirements.

NOTE 2: Tanks containing combustible liquids (at or above 140° F. flash point) are not, as a rule, required to be protected by foam. Foam protection for combustible liquids may be desirable where abnormal situations exist, such as storage of high value stocks or liquids heated above their flash point.

*402. DEFINITIONS:

(a) PORTABLE FOAM TOWER: A device which is brought to the scene of the fire, erected and placed in operation for delivering foam to the burning surface of a tank after the fire starts. Portable foam towers may be equipped with either Type I or Type II discharge outlets.

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

410. Foam Application.

411. RATES: The minimum rate of delivery to portable foam towers shall be as specified in 311.

420. Supply of Foam-Producing Materials.

421. GENERAL: The supplies to be maintained shall be the sum of the quantities defined in 4230, 4240, 4250 and 4260.

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.

FOR TANKS CONTAINING LIQUID HYDROCARBONS	TYPE OF PORTABLE FOAM TOWER	
	Type I	Type II
Lubricating oils, dry viscous residuum (more than 50 seconds Saybolt-Furol at 122°F), dry fuel oils, etc., with flash point above 200°F	25 min.	35 min.
Kerosene, light furnace oils, diesel fuels, etc., with flash point from 100°F to 200°F	30 min.	50 min.
Gasoline, naphtha, benzol and similar liquids with flash point below 100°F	55 min.	65 min.
Crude petroleum	55 min.	65 min.

FOR TANKS CONTAINING OTHER FLAMMABLE & COMBUSTIBLE LIQUIDS REQUIRING SPECIAL FOAMS:

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

4221. Dry Powder Chemical Foam Generator Consumption Rates: For the purpose of the above tables, it shall be assumed that dry powder generators (dual or single powder type) consume 1.25 lbs. of powder per gallon of water. Where listings of dry powder generators and powder by nationally recognized testing laboratories show powder consumption less than 1.25 lbs. per gallon, such lower figure may be used when the generator is used in the manner on which the listing was based.

423. Requirements for Tanks: The quantity of foam-producing material shall be determined by multiplying the total flow in gallons per minute for each tank by the appropriate time in 422. The largest resulting value shall determine the quantity required.

424. Supplementary Foam Hose Stream and Hydrant Requirements: The minimum requirements for hose streams and hydrants shall be as specified in 324 and 344.

425. Requirements to Fill Pipe Lines: These shall be the same as specified in 325.

426. Reserve Supply of Foam-Producing Materials: There shall be a reserve supply of foam-producing materials the same as specified in 326.

430. Foam Towers.

*431. Numbers Required: Towers shall be available in the proper number and size as to deliver foam on the burning liquid surface at a rate to meet the requirements of 411 and as set forth below:

TANK DIAMETER — FEET (or equivalent area)	MINIMUM NUMBER FOAM TOWERS
up to 80	1
over 80 to 120	2
over 120 to 140	3
over 140 to 160	4
over 160 to 180	5
over 180 to 200	6

Note 1: When two or more towers are required, they should be sized to deliver foam at approximately the same rate.

Note 2: Since there has been no experience with foam application to fires in oil tanks over 140 feet in diameter, requirements for foam protection on tanks above this size are based on extrapolation of data from successful extinguishments in smaller tanks.

CHAPTER 5. SPRAY FOAM SYSTEMS FOR EXTERIOR PROTECTION

500. General.

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

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

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

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

510. Foam Application.

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

520. Supply of Foam-Producing Materials.

521. GENERAL: Supplies to be maintained shall be the sum of the quantities defined in 522 and 523.

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 511, then the operating time may be reduced proportionately.

523. RESERVE SUPPLY: There shall be a reserve supply of foam-producing materials in accordance with 326.

530. Foam Discharge Outlets.

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

540. Operation.

541. AUTOMATIC OPERATION: Foam systems of this type should be automatic in operation. This may be accomplished by use of listed fire detectors installed in accordance with their accepted spacing rule for outdoor applications, and connected to a deluge valve and other equipment to make a complete system. The requirements of 2120 and 27 shall be complied with where applicable.

542. MANUAL OPERATION: Where manually operated systems are used, the controls shall be located in an accessible place, sufficiently removed from the hazard so that they may be safely operated in an emergency. The location and purpose of the control shall be plainly indicated.

550. Foam System Piping.

551. GENERAL REQUIREMENTS: a) Piping which will normally be filled with liquid shall be protected against freezing when necessary. b) The requirements of Section 26 shall be complied with where applicable.

552. Applicable parts of Chapter 3 of the NFPA Standard for the Installation of Sprinkler Systems (No.

13) shall be consulted for requirements applicable to piping, valves, pipe fittings, and hangers, including corrosion-protection coatings (galvanizing or other means). In these open-head systems, galvanized pipe and fittings should be used for normal occupancies. Corrosive atmospheres may require other coatings.

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

553. Piping carrying air-foam liquid concentrate shall be black steel or cast iron.

CHAPTER 6. MONITOR AND HOSE NOZZLES FOR EXTERIOR PROTECTION

600. General.

*601. SCOPE: This chapter relates to systems in which the foam is applied through fixed or portable monitor or hose nozzles. They are usually recommended as auxiliary protection in conjunction with fixed piping systems or portable towers as specified in Chapters 3 and 4. They are suitable when used alone for extinguishment of spill fires and fires in small fixed roof atmospheric storage tanks. Portable hose nozzles are also suitable for extinguishment of rim fires in floating roof tanks.

NOTE 1: Fires in tanks up to 130 feet in diameter have been extinguished when the entire liquid surface was involved by use of large capacity foam monitors. Depending on the fixed roof tank outage and fire intensity, the up draft due to chimney effect may prevent sufficient foam from reaching the burning liquid surface for formation of a blanket. Foam must be applied continuously and evenly. Preferably, it should be directed against the inner tank shell so that it flows gently onto the burning liquid surface without undue submergence. This can be difficult to accomplish as adverse winds, depending on velocity and direction, will reduce the effectiveness of the foam stream. Due to their limitations, monitors should not be depended upon as a primary means of extinguishment for fixed roof tanks over 50 feet in diameter. Monitors operated at grade usually are not recommended for floating roof rim fire extinguishment because of the difficulty of directing foam into the annular space.

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

602. DEFINITIONS:

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

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

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

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

610. Foam Application.

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

In determining total solution flow requirements, consideration should be given to potential foam losses from wind and other factors as noted in 601 — Note 1.

6110. FOR LIQUID HYDROCARBONS:

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

(2) For dry powder chemical foam generator systems, the water rate to the generators shall be at least 0.16 gpm/sq. ft. of liquid surface area to be protected.

(3) For chemical foam systems with stored solutions, the delivery rate shall be at least 0.08 gpm of solution "A" and 0.08 gpm of solution "B" for each sq. ft. of liquid surface area to be protected.

NOTE 1: Flammable liquids having a boiling point of less than 100° F may require higher rates of application. Suitable rates of application should be determined by test. Flammable liquids with a wide range of boiling points can develop a heat layer after prolonged burning and then may require application rates of 0.2 gpm per square foot or more.

NOTE 2: Care should be taken in applying portable foam streams to high viscosity materials heated above 200° F. Judgment must be used in applying foam to tanks containing hot oils, burning asphalts or burning liquids which are above the boiling point of water. Although the comparatively low water content of foams can beneficially cool such fuels at a slow rate, it can also cause violent frothing and "slop over" of the contents of the tank.

6111. FOR OTHER FLAMMABLE AND COMBUSTIBLE LIQUIDS REQUIRING SPECIAL FOAMS: Water soluble and certain flammable and combustible liquids and polar solvents which are destructive to regular foams require the use of alcohol type foams. In general, alcohol type foams can be effectively applied through foam monitor or foam hose streams to spill fires of these liquids when the liquid depth does not exceed 1 inch. For liquids in greater depth, monitor and foam hose streams should be limited for use with special alcohol type foams listed for Type II discharge. Systems using these foams require special engineering consideration. In all cases, the manufacturer of the foam concentrate and the foam-making equipment should be consulted as to limitations and for recommendations based on listings or specific fire tests. The following are minimum recommended application rates.

Type of Liquid	Solution Rate gpm/sq. ft.
Methyl and Ethyl Alcohol	0.16
Acrylonitrile	0.16
Ethyl Acetate	0.16
Methyl Ethyl Ketone	0.16
Acetone	0.24
Butyl Alcohol	0.24
Isopropyl Ether	0.24

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

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

Solution transit time, that is, the elapsed time between injection of the foam concentrate into water and the induction of air, may be limited, depending on the characteristics of the foam concentrate, the water temperature, and the nature of the hazard protected. The maximum solution transit time of each specific installation shall be within the limits established by the manufacturer.

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

620. Supply of Foam-Producing Materials.

621. GENERAL: The supplies to be maintained shall be the sum of the quantities defined in 623, 624, 625 and 626.

622. MINIMUM DISCHARGE TIMES: The equipment shall be capable of operation to provide primary protection at the delivery rates specified in 611 for the following minimum periods of time. If the apparatus available has a delivery rate higher than specified in 611, proportionate reduction in the time figures may be made.

FOR TANKS CONTAINING LIQUID HYDROCARBONS

Lubricating Oils; dry viscous residuum (more than 50 seconds Saybolt-Furol at 122°F); dry fuel oils, etc., with flash point above 200°F	35 min.
Kerosene; light furnace oils, diesel fuels, etc., with flash point 100°F to 200°F	50 min.
Gasoline; naphtha, benzol, and similar liquids with flash point below 100°F	65 min.
Crude petroleum	65 min.

FOR TANKS CONTAINING OTHER FLAMMABLE AND COMBUSTIBLE LIQUIDS REQUIRING SPECIAL FOAMS

"Alcohol" type foams require special application procedures as discussed in 6111. The operation time shall be 65 minutes at specified application rate, unless the manufacturer has established by fire test that a shorter time can be permitted.

6221. DRY POWDER CHEMICAL FOAM GENERATOR CONSUMPTION RATES: For the purpose of 611, it shall be assumed that dry powder generators (dual or single powder type) consume 1.25 lbs. of powder per gallon of water. Where "listings" of dry powder generators and powder by nationally recognized testing laboratories show powder consumption less than 1.25 lbs. per gallon of water, such lower figure may be used when the generator is used in the manner on which the listing was based.

623. REQUIREMENTS FOR TANKS: The quantity of foam-producing material shall be determined by multiplying the total flow in gallons per minute for each tank by the appropriate time in 622. The largest resulting value shall determine the quantity required.

624. SUPPLEMENTARY HOSE STREAM AND HYDRANT REQUIREMENTS: Additional foam hose streams and required equipment shall be provided as supplemental protection for ground fires at least as specified in 324 and 344.

625. REQUIREMENTS TO FILL PIPE LINES: These shall be the same as specified in 325.

626. RESERVE SUPPLY OF FOAM-PRODUCING MATERIALS: There shall be a reserve supply of foam-producing materials the same as specified in 326.

630. Hose Requirements.

631. UNLINED FABRIC HOSE: Unlined fabric hose shall not be used with foam equipment.

CHAPTER 7. TESTS FOR THE PHYSICAL PROPERTIES OF FOAM

*700. **General:** This chapter relates to the laboratory tests of foam concentrate or foam producing devices when it is desired to correlate physical characteristics with fire extinguishing properties.

*701. SCOPE: The appendix contains detailed laboratory procedures for the sampling and analysis of fire fighting foam.

APPENDIX

A-1141. Stored Solution Systems:

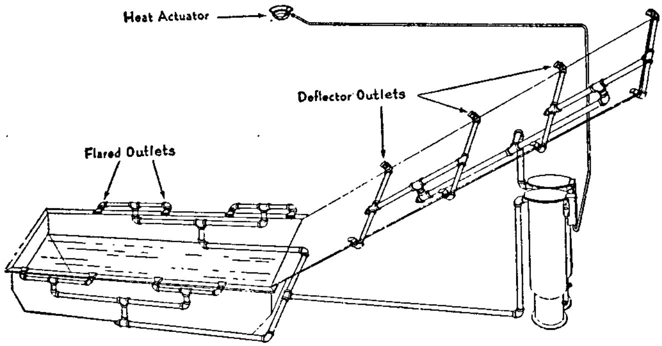


Fig. A-1141. An automatic chemical foam system of the stationary unit type protecting a dip tank and drain board.

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-1142. Continuous Foam Generators: Figures A-1142A and A-1142B 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-1144. 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.

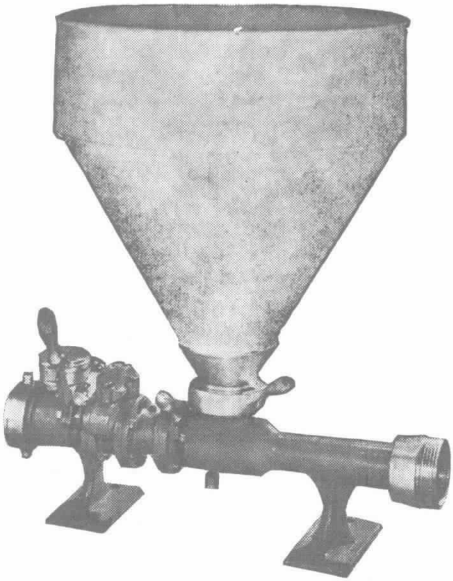


Fig. A-1142A. Single hopper chemical foam generator of the single powder type.

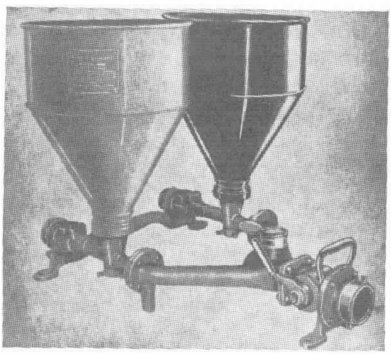


Fig. A-1142B. Dual hopper chemical foam generator of the two powder type.

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-1145. FOAM POWDER.

A-1145 (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. (See Notes 1 and 2, A-1145 (c).)

Dual foam powder is packed in pails containing approximately 50 lbs. The pails are distinctly marked with the letters "A" and "B."

Powder pails should be stored in a dry place and kept painted to prevent perforation of the container by corrosion with attendant deterioration of the contents. Powder should not be exposed to excessively high temperatures, preferably, not over 100°F., to prevent deterioration of the powder within the pail.

The entire stock of pails should be restacked every six months and the pails turned over (i.e., inverted with respect to their former position) to prevent compacting of the powder. This is particularly important where the stocks are subject to vibration.

A-1145 (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. (See Notes 1 and 2, A-1145 (c).)

Single powder is packed in 50-lb. pails which are distinctively marked. The precautions given in A-1145 (a) also apply to single powder chemicals.

A-1145 (c). 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. (See Note 2 under the following table.)

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

Alcohols
Methyl alcohol
Ethyl alcohol
Propyl alcohols
*Butyl alcohols
*Diacetone alcohol

Esters
Methyl acetate
Ethyl acetate

Ethers
Ethyl ether
Isopropyl ether
Amyl ether
Dioxane
Ethyl Cellosolve
Butyl Cellosolve
*Carbitol
*Butyl Carbitol

Ketones
Acetone
Methyl ethyl ketone

*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.

The precautions given in A-1145 (a) also apply to the "alcohol" type foam chemicals.

NOTE: 1. The foam produced by powders referred to in A-1145(a) and A-1145(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-1151. 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 stabilizer from which the stabilizer is drawn by the flowing water passing through the foam maker. Such devices may be automatically or manually operated by controlling a single valve.

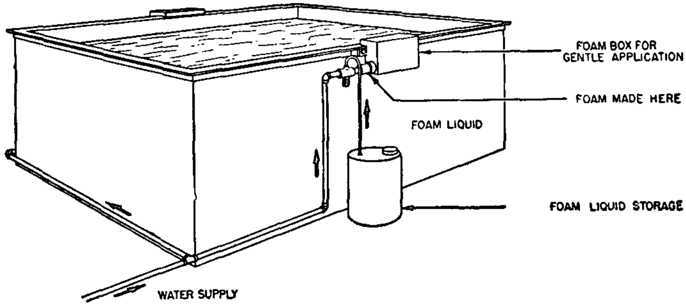


Fig. A-1151. Schematic diagram showing protection of dip tanks with air foam system. Foam liquid (stabilizer) storage in vessel beside dip tank.

A-1154. AIR FOAM PUMPS: Fig. A-1154 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 stabilizer is drawn through hose (9) by pump (2) and delivered to the discharge side of the water pump. The mixture of water and stabilizer 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 stabilizer 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

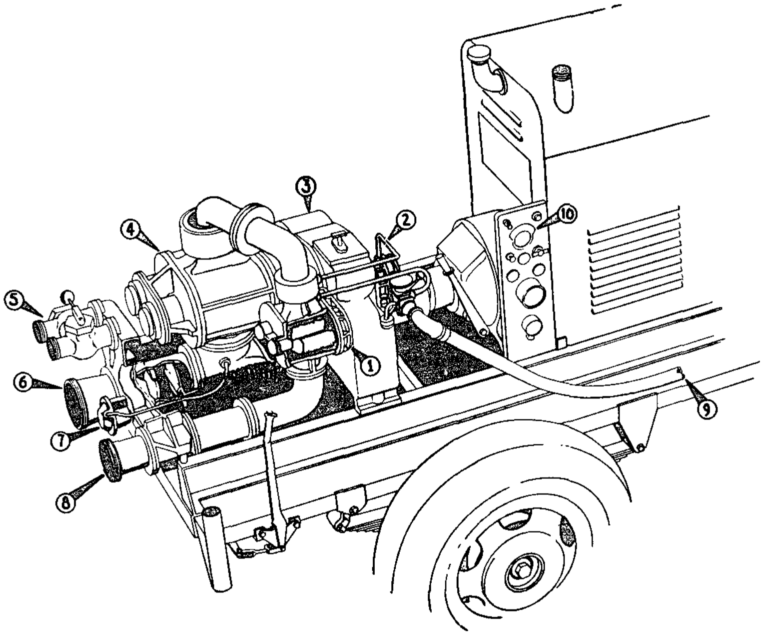


Fig. A-1154. Air Foam Pump.

(1) Water Pump, (2) Stabilizer Pump, (3) Gear Box, (4) Churn Pump, (5) two 2½-in. Hose Connections, (6) 6-in. Hose Connection, (7) Pressure Control, (8) 4½-in. Water Inlet, (9) Hose Connection to Stabilizer Container, (10) Tachometer on Control Panel.

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.

A-1155. AIR FOAM HOSE STREAM NOZZLES:

Fig. A-1155. Air Foam Playpipe.

A-1156. AIR FOAM STABILIZER: The "high expansion" type stabilizer produces about 350 gals. of air foam per gallon of stabilizer and 16 to 18 gals. of air foam per gallon of water. The "low expansion" type of stabilizer produces 120 to 200 gals. of air foam per gallon of stabilizer 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 1157 (a) (1). Premixed Air Foam Solutions: The manufacturer should be consulted regarding stabilizer to be used in the preparation of premixed solution.

A-1157 (b) (1). Pump Suction Method: This type of proportioner (Fig. A-1157 (b) (1)) 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.

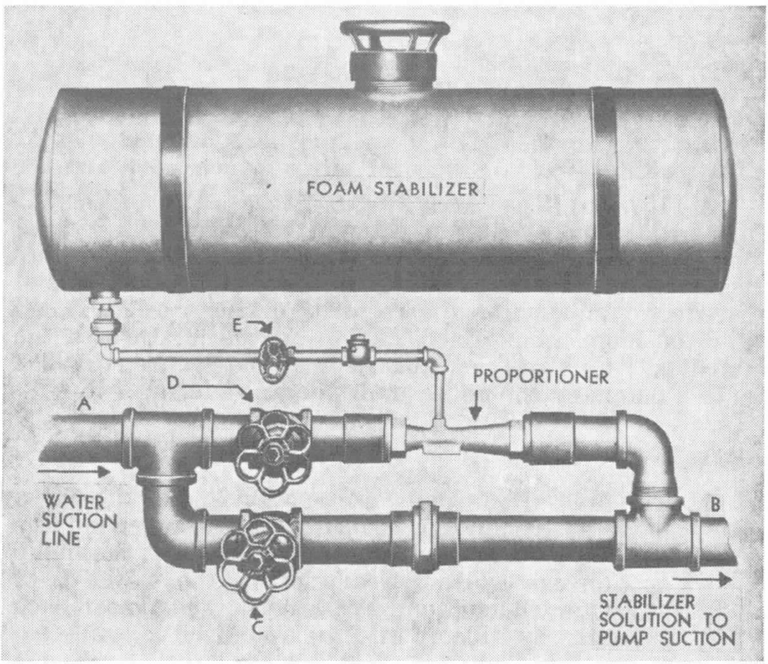


Fig. A-1157 (b) (1). Pump Suction Proportioner. To install: connect A to water suction line, connect B to suction side of pump. To operate foam system: close valve C, open valves D and E. To discharge plain water: close valves D and E, open valve C.

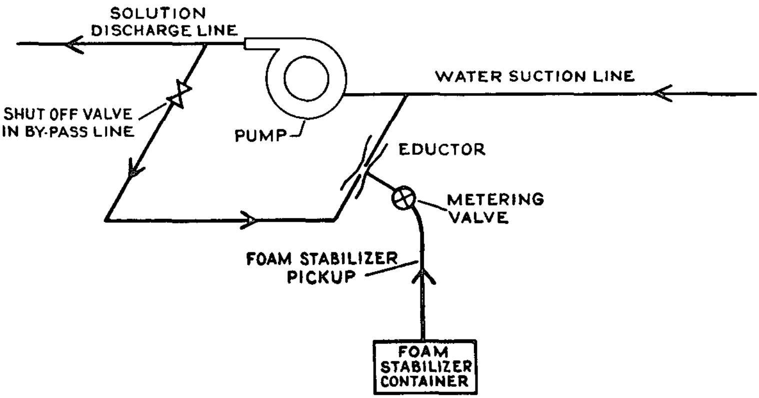


Fig. A-1157(b)(2). Around-the-Pump Proportioner.

A-1157 (b)(2). 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 stabilizer 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 stabilizer educted and even the flow of water back through the eductor into the stabilizer container.

2. The elevation of the bottom of the stabilizer 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.

A-1157 (c) (1). 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-1157 (c) (1) shows an arrangement of 2 tanks with a proportioner so installed that it can draw air foam stabilizer from either tank.

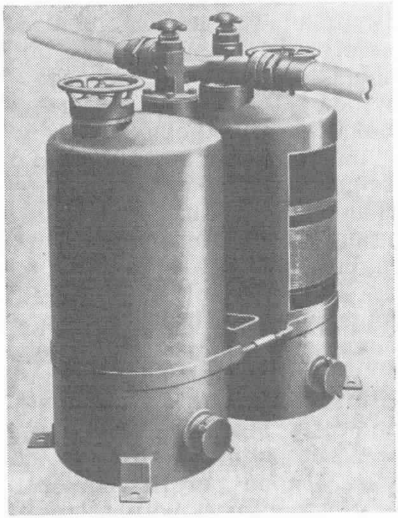
Each compartment has a screw cap on top for charging with stabilizer and a screw cap at the bottom for draining the water from the compartment upon exhaustion of the foam compound. Above each compartment is a valve which when opened permits the introduction of stabilizer from that tank into the water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

To operate, the valve on one tank is opened. When the supply of stabilizer 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.

Pressure Proportioner, Compartmented Single Tank.



Pressure Proportioner, Dual Tank.

Fig. A-1157(c)(1).

A-1157 (c)(2). 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 stabilizer 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 stabilizer container should not be more than 6 ft. below the inductor.

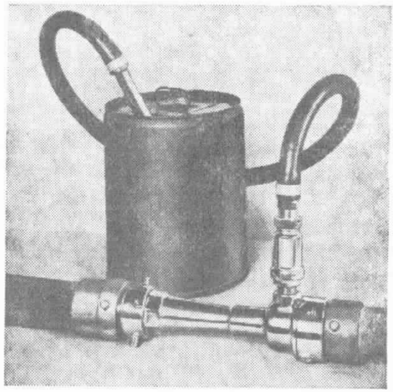


Fig. A-1157(c)(2). In-Line Inductor.

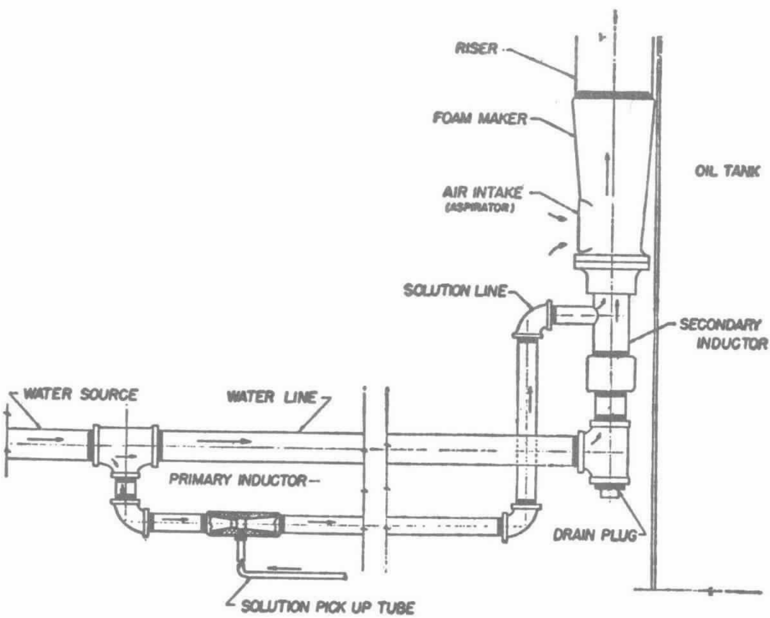


Fig. A-1157(c)(3). Air Foam Auto-induction System. Solution pick-up tube picks up stabilizer from its container.

A-1157 (c) (3). PRIMARY-SECONDARY INDUCTION METHOD: This method of introducing air foam stabilizer into the water stream en route to a fixed foam maker is illustrated in Fig. A-1157 (c) (3).

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 stabilizer 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 stabilizer 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 stabilizer container should not be more than 6 ft. below the primary inductor.

A-1157 (c) (4). PRESSURE SIDE PROPORTIONER: 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 stabilizer pump should be opened fully and the pump started. By slowly closing the bypass valve to increase the discharge pressure of the foam stabilizer, 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 stabilizer is being injected into the water stream.

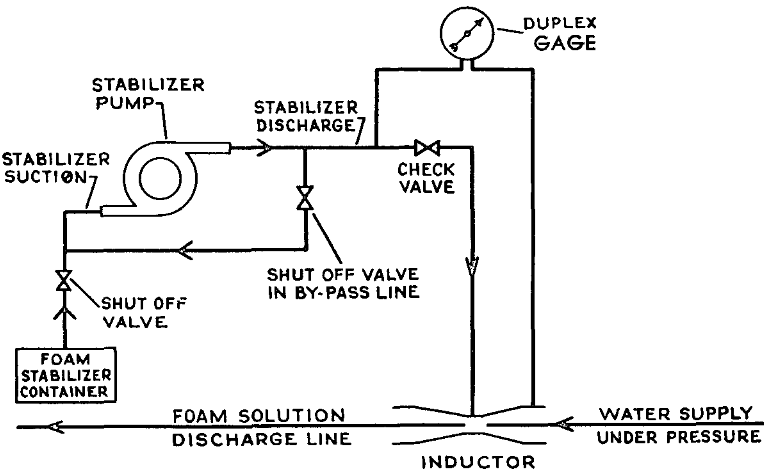


Fig. A-1157(c)(4). Pressure Side Proportioner.

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 stabilizer to the inductor.

A-1157 (c)(5). WATER MOTOR PROPORTIONER: 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 stabilizer 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 stabilizer 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 delivered 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 stabilizer concentrations between 6½ and 5½ per cent. It has no limitations in respect to pressure.

A-1157 (d) (1). BUILT-IN INDUCTOR IN FOAM MAKER: Figures A-1151 and A-1155 show this type of proportioner where one or more of the jets in the foam maker are utilized to draft the stabilizer.

LIMITATIONS: The bottom of the stabilizer 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 stabilizer container and the foam maker should conform to the recommendations of the manufacturer.

A-1213. 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.

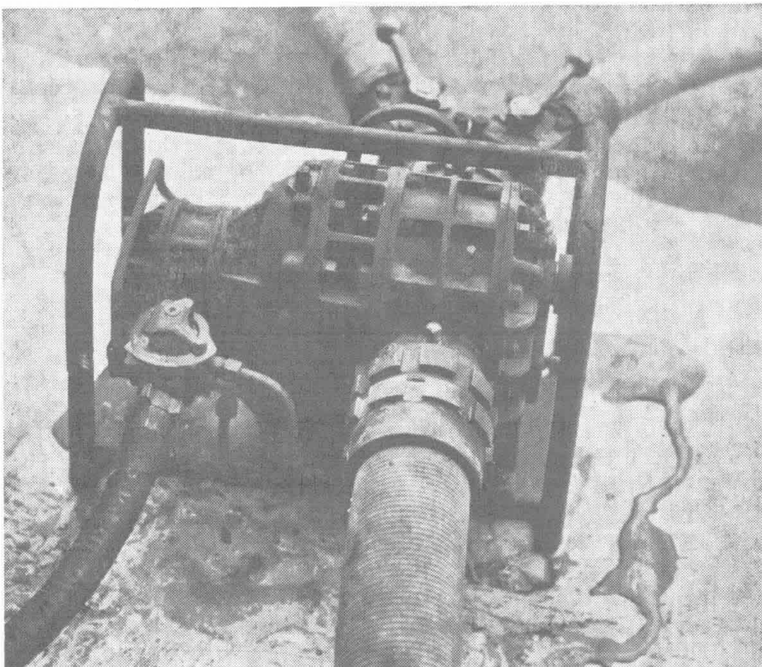


Fig. A-1157(c) (5). Water Motor Proportioner.

A-122. 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-132. FOAM MIXING CHAMBERS FOR CHEMICAL FOAM: The minimum volume of a mixing chamber (in gallons) should be approximately one-thirtieth of the water rate to the chamber in gallons per minute.

A-134. 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° 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° and 100°F.

A-1344. 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-144. WET STORAGE CHEMICAL FOAM SYSTEMS:

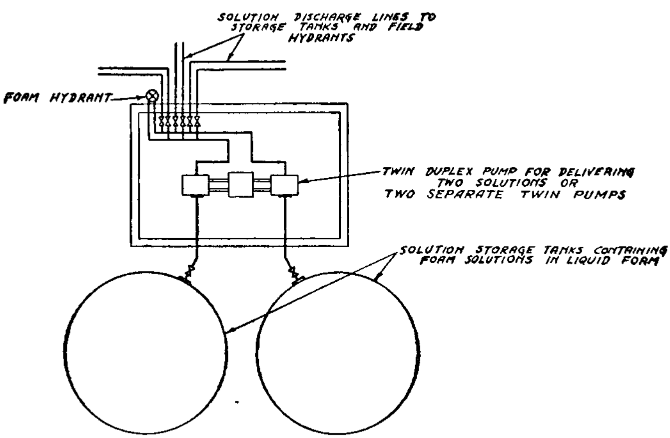


Fig. A-144. Typical two solution (acid and basic) chemical foam system layout. Discharge line layout similar to that for two powder type shown in A-1452B.

A-1442. 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-1445. This usually requires a twin duplex pump or two identical pumps operated from a common prime mover.

A-1452. CENTRALIZED FIXED PIPING SYSTEMS:

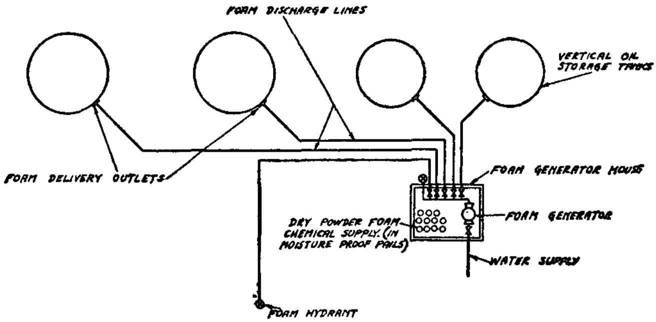


Fig. A-1452A. Typical chemical foam generator system layout of the single powder type.

Diagram not to scale. Foam generator houses should be located well away from tanks. Dikes not shown.

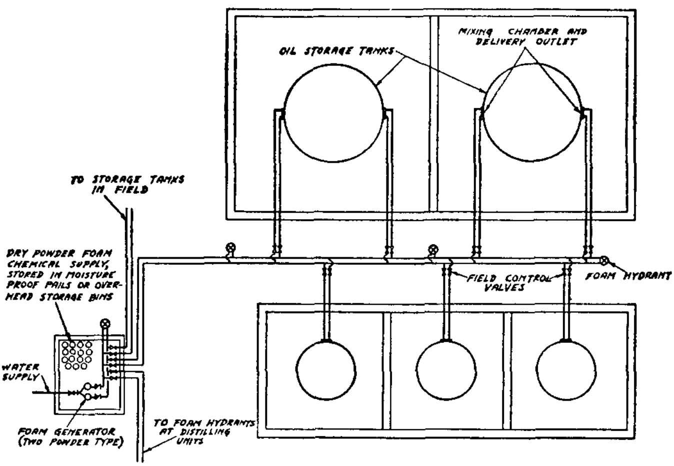


Fig. A-1452B. Typical chemical foam generator system layout of the two powder type.

A-1452 (a). Dual Powder Generator System With Powder in Bins:

A-1452 (b). 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-146. Air Foam Systems:

A-152. 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.

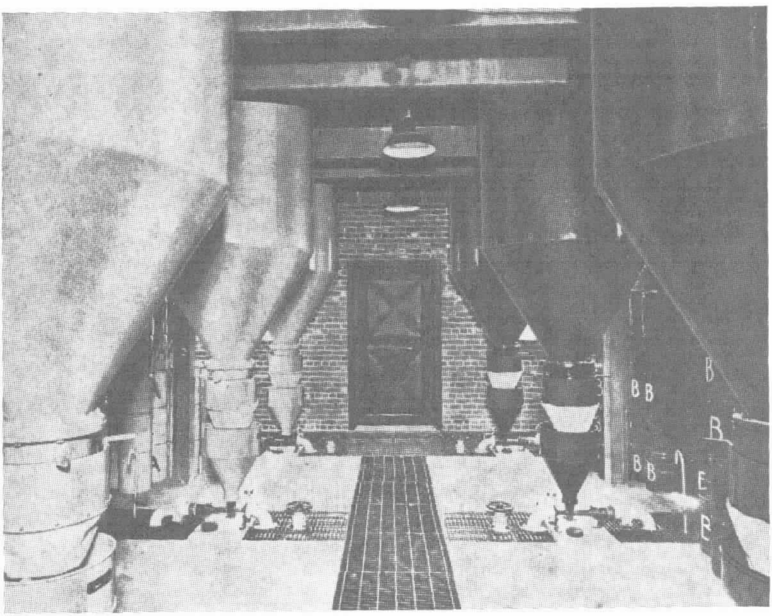


Fig. A-1452(a). Dual Powder Generator System with Powder in Bins.

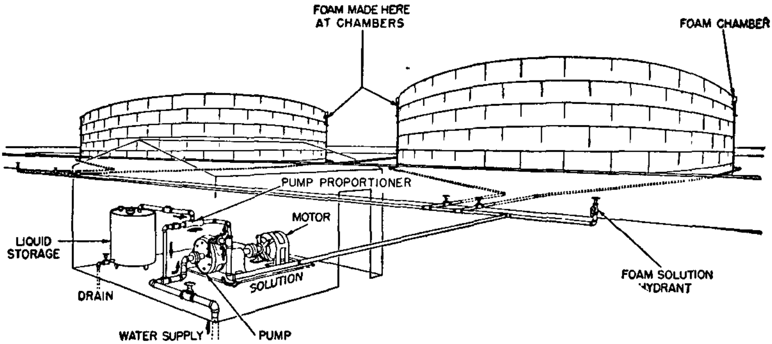


Fig. A-146. Schematic arrangement of air foam protection for storage tanks.

Liquid storage indicated lower left of illustration is stabilizer storage.

A-183. TESTS:

(1) A foam system will extinguish a flammable liquid fire if operated within the proper solution pressure range, at adequate foam liquid concentration and at sufficient discharge density per square foot of protected surface. The acceptance test of a foam system should ascertain:

(a) All foam producing devices are operating at "design" pressure and at "design" foam solution concentration.

(b) The laboratory tests have been conducted where necessary, to determine that water quality and foam liquid are compatible.

(2) The following data are considered essential to the evaluation of foam systems performance.

(a) Static water pressure.

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

(c) Rate of consumption of foam liquid concentrate.

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

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.

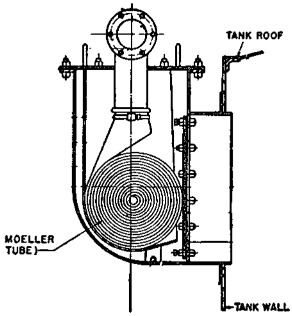


Fig. A-302A. Cross-section Moeller Tube Chamber.
Tube is designed to unroll and fall to oil level.
Foam flows through interstices in tube.

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).

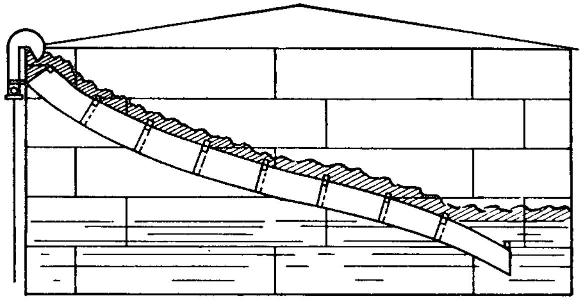


Fig. A-302B. Foam Trough.

(3.) Foam chute or ladder (see Fig. A-302 C).

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

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

FOAM TROUGH: The trough shown schematically in Fig. A-302 B consists of sections of steel sheet formed into a chute which is securely attached to the inside of the tank wall so that it forms a descending spiral from the top of the tank to within 4 ft. of the bottom.

FOAM CHUTE: The device illustrated in Fig. A-302 C consists of a foam mixing chamber (external to the tank) and an internal delivery conduit or chute. Staggered openings are provided at intervals in the conduit. The foam delivered piles up in the chute and emerges through the first opening immediately above the liquid surface. The discharge of foam through the higher openings is prevented by the use of baffles which shield the openings. The maximum distance that the foam must drop onto the liquid surface is regulated by the spacing of the overflow outlets.

A-302 C. TYPE II DISCHARGE OUTLETS.

See illustrations A-302 D and A-302 E.

Where Type II outlets are used with alcohol type hazards, the manufacturer should be consulted for adequacy of protection.

A-302 D. Fixed systems are preferred because there is a minimum of manpower required for their operation, and they can be put into action more quickly than portable means.

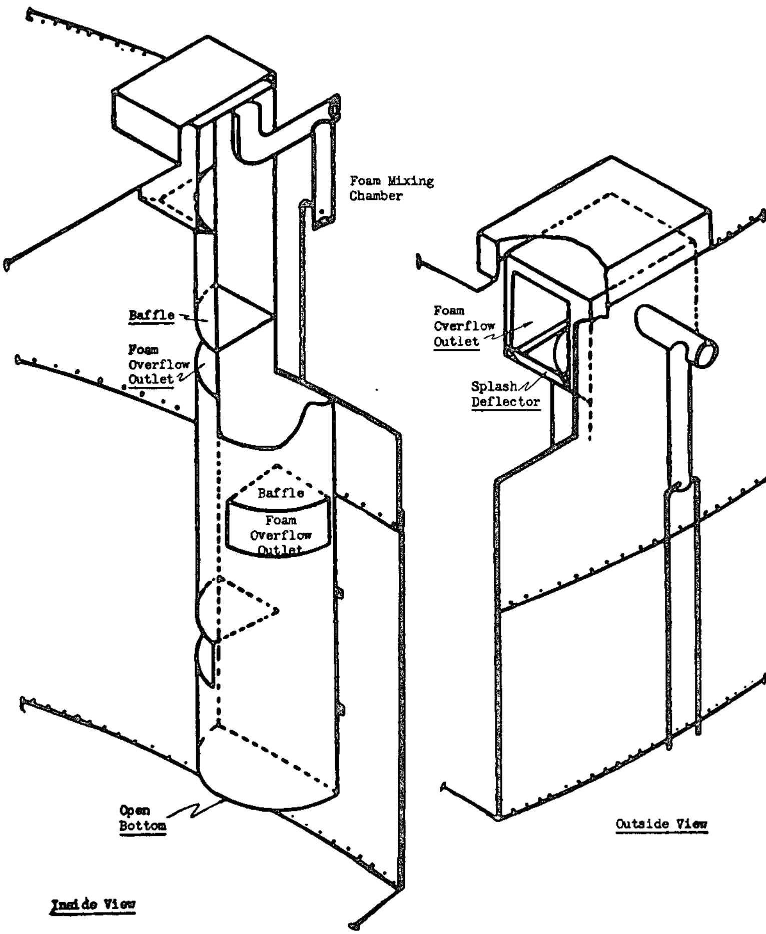


Fig. A-302C. Foam Chute.

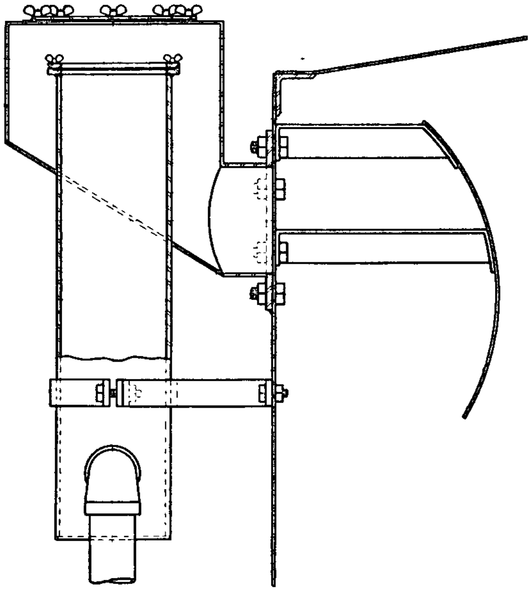


Fig. A-302D. Chemical Foam Chamber.

A-302 E. SEMI-PORTABLE INSTALLATIONS: These systems are less reliable than fixed systems, particularly where large tanks are involved. A relatively large crew, well trained in the use of the apparatus, is needed. Adequate facilities to transport the equipment and a good road system throughout the property are necessary.

A-311. GENERAL: These requirements of 0.1 gpm of water (or solutions) per sq. ft. of liquid surface are equivalent to the requirements of former editions of this standard which were expressed in terms of foam volumes. In the case of the liquid hydrocarbons, for example, a delivery rate of ¾ gal. of foam per sq. ft. of burning area was specified as minimum. This foam was produced either by (1) the reaction of one gallon of combined A and B (½ gal. of each) wet solutions or (2) the reaction of 1 lb. of combined A and B powders with 1 gal. of water. Either of these types of foam production resulted in 7.5 gals. (or 1 cu. ft.) of foam.

Obviously, if one-tenth of this volume of foam — or ¾ gal. — was specified for the protection of each sq. ft. of

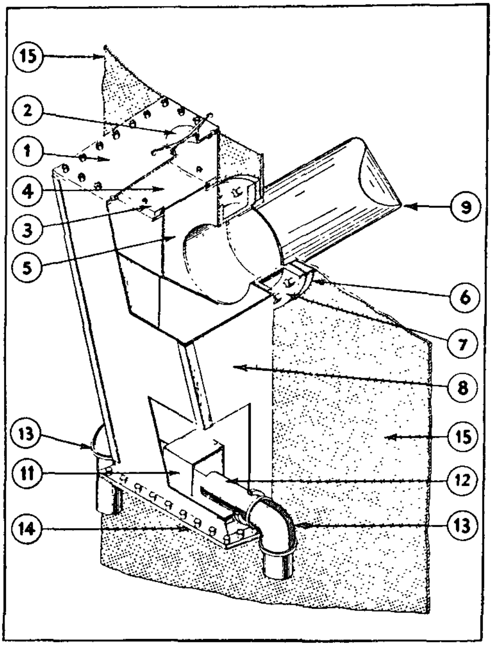


Fig. A-302E. Chemical foam chamber. (1) Top plate. (2) Inspection cap. (3) Diaphragm frame. (4) Diaphragm. (5) Inner chamber. (6) Adapter flange shaped to fit tank curvature. (7) Chamber throat and mounting flange. (8) Chamber body. (9) Deflector. (11) Baffle. (12) Inlet nipples. (13) Inlet solution elbows. (14) Bottom plate. (15) Tank shell.

burning surface, then one-tenth of its water volume is used, or 0.1 gpm for the application. This water rate is equivalent to 0.1 gpm per sq. ft. used throughout this standard.

A-312. Rate of Application: Water Soluble Solvents. The system shall be designed on the basis of fighting a fire in but one tank at a time. The rate of application for which the system is designed shall be the rate computed for the protected tank considering both the liquid surface area and the type of flammable liquid stored.

Example: The property contains 40 ft. diameter tank storing ethyl alcohol and 35 ft. diameter tanks storing isopropyl ether.

Liquid surface area, 40 ft. diameter tank	= 1257 sq. ft.
Solution rate for ethyl alcohol, 0.1 gpm/sq. ft. or 1257 x 0.1	= 126 gpm
Liquid surface area, 35 ft. diameter tank	= 962 sq. ft.
Solution rate for isopropyl ether, 0.15 gpm/sq. ft. or 962 x 0.15	= 144 gpm

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

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

A-321. In general the foam system may be designed on the basis that only a single tank is involved in any one fire. The quantity of foam producing materials required shall be based on the "worst risk" in the group of tanks to be protected; i.e., with due consideration to the factors of liquid surface area, rate of application, contents and type of foam discharge outlet used.

A-324. Auxiliary foam hose streams may be supplied directly from the main system protecting the tanks (e.g., in the case of centralized fixed pipe systems) or may be provided by additional equipment.

A-331. It may be deemed advisable to install a proper sized flanged connection on all atmospheric pressure storage tanks, regardless of present intended service, to facilitate the future installation of an approved discharge outlet if a change in service should require such installation.

A-3311. Open Top Floating Roof Tanks. Open Top Floating Roof Tanks within the scope of this standard are open tanks which have double deck or pontoon type roofs and are constructed in accordance with the requirements set forth in NFPA No. 30, Flammable and Combustible Liquids Code. Plastic blankets, floating diaphragms or closures which are easily submerged are not included.

Two techniques are available for application of foam through fixed outlets. One involves a discharge of foam on top of the seal. The other utilizes devices which apply foam below the seal, directly onto the flammable liquids surface.

Fixed foam fire-fighting systems may be either of the manually operated type or the automatically operated type, or may be the type capable of both automatic and manual operation.

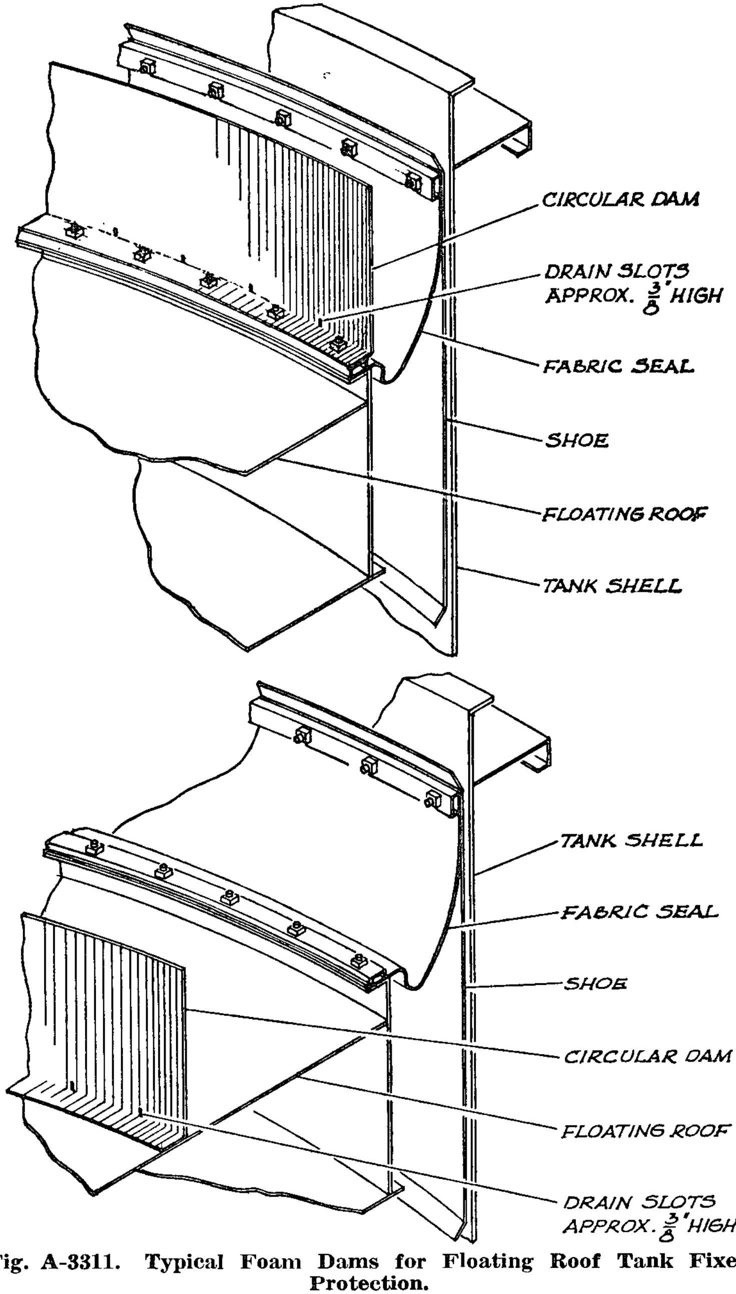


Fig. A-3311. Typical Foam Dams for Floating Roof Tank Fixed Protection.

(1) When it is desirable to provide fixed foam discharge devices above the seal, the following may be used as a design guide:

(a) A circular dam made of at least No. 10 US Standard Gage thickness steel plate shall be securely fastened to the floating roof. The purpose of the dam is to retain the foam at the seal area and to provide for sufficient depth (approximately 12 inches) to cause the foam to flow laterally to a point where the seal may have been ruptured. The dam shall be slotted at the bottom to provid for drainage of rain water. Total drain slot areas should be 0.04 square inch per square foot of diked area, and the slots should be approximately ⅜ inch high. See Figure A-3311 for an illustration of typical circular dam arrangement. The foam dam should be at least 1 foot and not more than 2 feet from the edge of the roof.

(b) Precaution should be taken to prevent mechanical interference of foam devices with the floating roof.

(c) The number of points of foam application are to be determined by the circumference of the tank. The maximum spacing between applicators shall be 40 ft. of tank circumference. The foam shall be a low expansion, fluid type of foam usually associated with drainage times near the "lower acceptable limit" (see Figure A-601G).

(d) Rate of application and supply of foam liquid shall be calculated using the area of the annular ring between the circular dam and the tank shell. The minimum solution rate shall be 0.5 gpm per square foot. The supply of foam liquid shall be adequate to operate the system for 10 minutes.

(2) When it is desirable to provide fixed foam devices below the seal, the following may be used as a design guide:

(a), (b), and (c) remain the same as in the 1970 edition.

(d) The rate of application and the supply of foam liquid shall be calculated using the area of the annular ring between the tank shell and the floating roof edge. The minimal rate should be 0.5 gpm per square foot of area. The supply shall be adequate to operate the system for 10 minutes.

A-3312. COVERED FLOATING ROOF TANKS: Covered Floating Roof Tanks within the scope of this standard are open-vented fixed roof tanks with a metal floating pan or cover on the liquid surface and with venting provided as set forth in Appendix H of API Bulletin 650. "Welded Steel Tanks for Oil Storage" (see Note Below). Venting should then be sufficient to maintain the vapor space below the lower flammable limit except during initial fill and for a short period thereafter, depending on the volatility of the product. When a Covered Floating Roof Tank is not designed according to API Bulletin 650, it shall be treated as a fixed roof tank.

NOTE: *Vents in Covered Floating Roof Tanks.*

Suitable vents shall be provided to prevent overstressing of the roof deck or seal membrane. These vents shall be adequate to evacuate air and gases from underneath the roof when the roof is on its supports during the filling operations. They shall also be adequate to relieve any vacuum generated underneath the roof after it still is on its supports during withdrawal operations. The purchaser shall specify filling and emptying rates so that the fabricator may size the vents properly.

Circulation vents or openings shall be located in the tank shell above the seal of the floating roof when the tank is full. The maximum spacing shall be 32 ft. but in no case shall there be less than four equally spaced vents. The total open area of these vents shall be equal to or greater than, 0.2 sq. ft. per ft. of tank diameter.

An open vent shall be provided at the center or at the highest elevation of the fixed roof. It shall have a weather cover and a minimum open area of 50 square inches.

When foam protection is desired for covered floating roof tanks, two approaches may be taken.

(a) When protection against seal fires is deemed sufficient, shell entry, fixed discharge outlets and a circular foam dam as described in Section A-3311 for above the seal protection should be used.

(b) When protection for the entire tank area is deemed necessary in the event that the floating cover sinks or is destroyed, the foam system should be designed in accordance with Chapter 3 for other than Floating Roof Tanks.

A-333. SEMISUBSURFACE INJECTION METHODS

The arrangement of these devices may take a variety

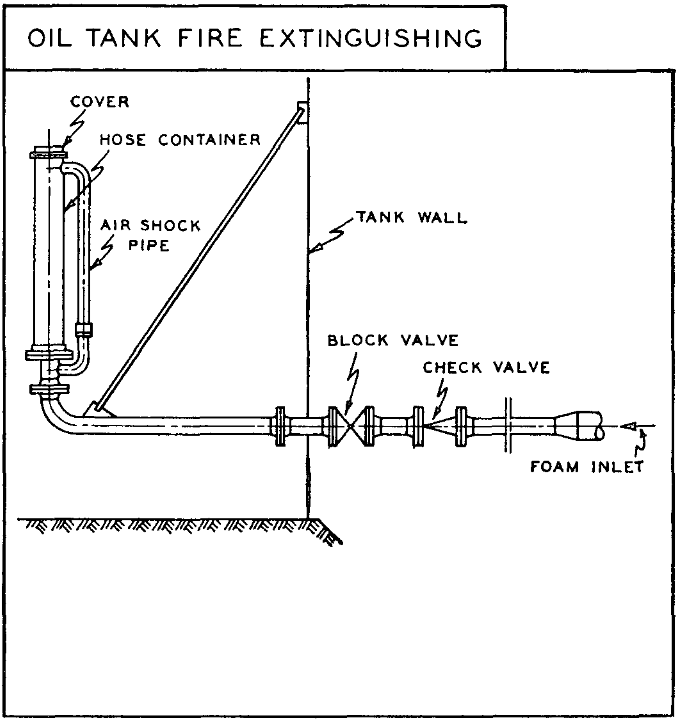


Fig. A-333A

of forms. Figures A-333A and A-333B show a typical device which has been developed and used primarily in Sweden.

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

When the foam is forced through the inlet pipe, the compressed air contained in the piping before the foam, passes outside the container through the shock pipe and in