Engineering Manual

NATIONAL FOAM

(Rev. 03/17/10)

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BASICS OF FOAM

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SECTION 1
BASICS OF FOAM

GENERAL OVERVIEW

WHY SHOULD YOU CONSIDER NF FOAM CONCENTRATES?

All foam systems, regardless of size, consist of a foam concentrate supply, proportioning device, water supply, and foam maker(s). While all the components must function properly to ensure system performance, the foam concentrate is the most vital component of the system.

Throughout the fire fighting industry, different terms express foam concentrates. In some cases, the terms "Foam", "Foam Liquid", "Foam Concentrate", "Liquid" and "Concentrate" all mean the same thing.

In this NF section, the following definitions clarify these differences:

Foam Concentrate -
Foam concentrate is concentrated liquid foaming agent as supplied from the manufacturer.

Foam Solution -
A homogenous mixture of water and foam concentrate in proper proportions.

Foam -
Fire fighting foam is a stable aggregation of small bubbles of lower density than oil or water that exhibit a tenacity for covering horizontal surfaces. It flows freely over a burning liquid surface and forms a tough, air-excluding, continuous blanket that seals volatile vapors from access to air. It resists disruption from wind and draft or heat and flame attack and is capable of resealing in case of mechanical rupture.

National Foam, Inc. (NF) has been a pioneer in the development of mechanical foam concentrates and a world leader in fire fighting foam technology for over 75 years. NF's foam products successfully fought flammable and combustible liquid fires, as well as hazardous fires such as storage tanks, process areas, marine tankers, loading facilities and spills that result from aircraft and automotive crashes.

Today, NF performance records continue to set the standard in the fire fighting industry. In every corner of the world, NF foam concentrates and equipment provide reliable, durable flammable liquid fire protection.

With over 1000 different flammable liquid materials being manufactured and consumed, and with many different fire fighting foam concentrates available for their protection, it may seem difficult at first to pick the most suitable concentrate for your hazard needs. However, it becomes much easier when dealing with a manufacturer who produces a wide variety of foam concentrates and related products.

NF manufactures the largest and most comprehensive line of fire fighting foams available to the industry. Whether the hazard is a small manufacturing installation or a sophisticated storage and process facility, NF's diverse product line simplifies selection of the best, most cost-effective foam concentrate.

PROPER STORAGE AND HANDLING OF FOAM CONCENTRATES

All NF foam concentrates are designed and tested to provide long shelf life stability. However, storage conditions will have a significant bearing on foam concentrate shelf life. Consult NF for specific recommendations regarding storage conditions and shelf life.

Storage in shipping containers is acceptable. Foam concentrates are typically shipped in approved plastic pails, drums or totes. Properly constructed large capacity tanks can offer near optimum conditions for prolonged storage.

Whether mounted on mobile equipment or part of an integral fixed system, foam concentrate storage tanks provide immediate access to large volumes of foam concentrate. A foam concentrate storage tank, whether fixed or mobile, should be constructed with an expansion dome capacity of at least 2% of the tank volume. The tank should be closed to the atmosphere except for a pressure-vacuum vent mounted on the expansion dome. The foam concentrate level in the tank should be kept at a point halfway within the expansion dome to reduce the mixing of air and foam.

Consult the relevant paragraphs within this section, individual product data sheets and NF Technical Bulletins for acceptable tank construction materials and recommended ambient storage temperatures. Section 3 provides details on foam concentrate storage tanks manufactured by NF. Consult the NF Engineering Department for specific details concerning internal tank coating applications.

Molded polyethylene storage tanks do not normally have expansion domes. In these cases NF recommends NF Foam Seal on the foam concentrate surface. NF Foam Seal is a highly refined grade of white mineral oil. It provides a sealing barrier between the foam and air and reduces the effects of evaporation and foam deterioration. Use a 1/2-in (13 mm) layer on top of protein, fluoroprotein, AFFF and AR-AFFF type foam concentrates. Foam Seal is only recommended for stationary polyethylene storage tanks. It should not be used in mobile truck or trailer foam tanks that slosh and agitate or in storage tanks made from materials other than polyethylene or fiberglass.

Note: Do not exceed maximum recommended storage temperatures. An excessive temperature may cause deterioration in any foam concentrate. The minimum usable temperature of a foam concentrate is not its freezing point. This minimum temperature is the point at which the concentrate will proportion properly through venturi-type pickup devices such as line proportioners and pickup type nozzles.

Quality foam concentrates are not adversely affected by excessively low temperatures, but they may become too viscous to proportion properly. (Freeze-thaw cycling is generally not detrimental to NF products. Of course, some products are more sensitive than others. Refer to specific product data sheets or consult with the NF Engineering Department).

The following summary provides recommendations for maintaining and monitoring foam concentrate integrity:

1. Keep the foam concentrate tank filled halfway within the expansion dome.
2. Provide a pressure-vacuum vent. A pressure-vacuum vent reduces condensation and evaporation that are harmful to the foam concentrate. This vent requires periodic inspection and cleaning.
3. Avoid storage above the maximum recommended temperatures.
4. Never mix different brands or types of foam concentrates for long-term storage.
5. Avoid the dilution of foam concentrate with water.
6. Avoid contamination with foreign ingredients, chemicals or oils. Agitation, intermixing and improper application of Foam Seal may contaminate the foam concentrate. Contact NF for specific recommendations.
7. Valves, couplings or piping in continual contact with the foam concentrate should not be constructed of dissimilar metals. Dissimilar metals may cause rust, or galvanic corrosion.
8. Contact NF's Technical Service Department for periodic analysis of your foam concentrate supplies.

FOAM CONCENTRATE INGREDIENTS

The many types of foam concentrates comprise a complex mixture of ingredients. Protein based foams are primarily a combination of hydrolyzed protein, freezing point depressants, organic and inorganic stabilizers. Synthetic foams are combinations of foamers, stabilizers, freezing point depressants and fluorinated surfactant.

ECOLOGICAL EFFECTS OF FOAM CONCENTRATES

NF concentrates are generally biodegradable. They possess a low order of toxicity and cause minimal environmental impact. Differing state and local regulations may govern disposal options; however, do not discharge foam concentrate or foam solution into biological sewer treatment systems without prior approval. Specific concerns are high Biological Oxygen Demand (BOD) overloading, or excessive foaming. Low dosage flow rate or antifoam agents acceptable to the treatment plant may be helpful. Do not flush to waterways.

As a service to our customers, National Foam has approvals in place with disposal facilities throughout the U.S. for waste water treatment and solidification and landfill of our foam liquid concentrates and foam solutions. If required, National Foam can also provide information on the disposal of drums used for shipping our concentrates. Please contact National Foam's Risk Management Administrator at (610) 363-1400 for additional information.

TOXICOLOGICAL EFFECTS OF FOAM CONCENTRATES

Based on testing done on our foam concentrates, there should be no negative effects when the foams are used in a diluted solution form.

However, prolonged skin contact with foam concentrate or solution may cause dryness. In case of contact with skin or eyes, flush thoroughly with water and consult a physician.

Note: See specific Material Safety Data Sheets for further information on a specific foam concentrate.

National Foam, Inc. also complies with OSHA Hazard

Communication Standard 29CFR 1910.1200.

TESTS AND APPROVALS

INTRODUCTION

All NF products undergo extensive testing from their conception in the research laboratory through rigid quality control standards prior to reaching the market. NF's foam concentrate products are approved and listed by independent testing agencies such as Underwriters Laboratories and Factory Mutual. Also, certain concentrates are approved by the US Coast Guard, U.S. Naval Research Laboratories, USDA and other agencies. These approvals are the customer's assurance that NF has demonstrated through extensive fire testing and evaluations that the product complies with the rigid requirements and specifications of the testing authority. Furthermore, any deviation from these standards can lead to revocation of these listings or approvals.

In special cases, fire tests are conducted to determine foam effectiveness on a particular flammable liquid and to determine the minimal application rates the hazard requires. NFPA Standards 11, 16 and 409 among others provide guidelines for application rates. Application rates for polar solvent or alcohol-type fuels are determined by the foam concentrate manufacturer through actual fire testing. The approvals for each particular foam concentrate are provided in their respective data sheets.

FOAM CONCENTRATE EVALUATION

Periodic testing of foam concentrate supplies through a good maintenance program can help sustain the integrity of the foam concentrate. NF's Technical Service Program offers analytical evaluations of foam concentrates to ensure the integrity of the foam concentrate. The Technical Service Report includes the results of at least four laboratory tests.

TECHNICAL SERVICE LABORATORY TESTS

1. pH - determine if a pH value of the foam concentrate lies within its original specified limits.
2. Specific Gravity - determines if the foam concentrate is diluted, or if it is concentrated due to evaporation.
3. Sediment - measures the undissolved solids or particles in a foam concentrate. Problems with dispersion occur with sediments in excess of 0.5% **Note:** Ensure that the foam sample represents the overall foam supply.
4. Foam Quality - the quality of a good foam is the sum total of its expansion, its 25% drainage time, and ultimately, its fire performance. Procedures for these tests are outlined in NFPA Standard 11.

Note: Synthetic foam concentrates may require additional tests to evaluate surface tension, viscosity and the effectiveness of the aqueous film or polymeric membrane.

If the Technical Service Report for your foam concentrate sample reveals results consistent with its original specifications, it is considered satisfactory and suitable for fire service. Significant deviation from the original specifications in any of the test results may indicate one of the following problems:

1. Contamination
2. Improper storage conditions
3. Chemical change
4. Any combination of the above

At this point, fire tests are recommended.

FIRE TESTS

Fire tests on foam samples are conducted within specially designed fire modeling equipment using a protocol developed to simulate full scale UL Standard (UL 162, 6th Edition) fires. Hydrocarbon and/or polar fuels are used as appropriate.

A satisfactory fire performance is achieved if a working strength solution of the sample extinguishes the fire within specified times. Then, after adding a flame source, the foam blanket must be able to prevent fuel reignition.

HOW TO COLLECT FOAM CONCENTRATE SAMPLES

THE IMPORTANCE OF COLLECTION FOAM CONCENTRATE SAMPLES

If samples of foam concentrate are sent to NF's Technical Service Department on a regular basis, problems involving storage conditions can usually be detected and corrective measures recommended before the foam concentrate is irreversibly damaged. Periodic sampling of foam concentrate ensures its ready status in a fire emergency. In general, collect foam concentrate samples at least once a year.

SAMPLE COLLECTION

Proper foam concentrate sampling is crucial. The foam concentrate sample submitted must represent the product in storage, whether in tanks or drums. Depending on your maintenance program, foam concentrate may consist of the following samples:

1. One sample - bottom only
2. Two samples - one top and one bottom
3. Three samples - one each from top, bottom and middle

4. One sample - composite after recirculating contents. This is the preferred method.

Submit all samples in a clean one-pint (500 ml) plastic bottle. If fire testing is recommended, a larger sample will be requested. "Request for Analysis" forms are available from your local representative, NF world headquarters in Exton, PA, or our website www.Kidde-Fire.com.

BOTTOM SAMPLING

Since the bottom of the tank may collect sediment such as rust, scale, or degradation products, it is important that these excessive contaminants be separated when drawing a sample.

A suggested procedure follows below:

1. Open the lowest drain valve and flush out one or two gallons of concentrate into a large clean bucket.
2. Fill at least one pint (500 ml) into a clean plastic bottle. Submit this sample for analysis.
3. Return the initial flushings to the top of the tank with the fill funnel. A strainer removes the excess sediment.

COMPOSITE SAMPLING

Composite sampling is a good technique if many samples are collected. However, the contents of a storage tank must not be recirculated where dilution is known or suspected. Many fire protection engineers use a periodic start-up of their pumps and recirculation of the foam concentrate as part of their required maintenance program. Treat contents collected from the drain valve as bottom samples.

HOW TO CHOOSE A FOAM CONCENTRATE

When selecting the proper foam concentrate, the flammable liquid or fuel will determine which one to use.

Basically, there are two general classes of flammable liquids; hydrocarbons and polar solvents. Hydrocarbons are non-water miscible products such as crude oil, gasoline, hexane, naphtha, diesel oil, etc. Polar solvents are generally water miscible products such as alcohols, esters, ketones, etc. Moreover, some industrial solvents are a mixture of both classes.

Consider the following information to properly choose the most suitable foam concentrate:

1. Principal flammable liquids requiring protection (actual chemical name).
2. Foam solution application rates (may vary depending on concentrate selected).
3. Type of application. **Note:** Subsurface applications are **not** to be used on polar solvent hazards.
4. Foam concentrate cost.
5. System components and field piping cost.
6. Projected cost of foam system maintenance.

Remember, a little money invested in NF foam concentrates can save more money in field piping and maintenance expenses. Conversely, protection systems normally designed around a costly foam concentrate can now use a less expensive foam that also provides complete protection.

PROTEIN FOAM CONCENTRATES

INTRODUCTION

Regular Protein foams are intended for use on hydrocarbon fuels only. They produce a homogeneous, stable foam blanket that has excellent heat resistance, burnback, and drainage characteristics. Regular Protein foams have slow knockdown characteristics; however, they provide superior post fire security at very economical cost. Regular protein foams may be used with fresh or seawater. They MUST be properly aspirated and should not be used with non-aspirating structural fog nozzles.

Proteins foams were the first types of mechanical foam to be marketed extensively and have been used since World War II. These foams are produced by the hydrolysis of granulized keratin protein (protein hydrolysate) such as hoof and horn meal, chicken feathers, etc. In addition, stabilizing additives and inhibitors are included to prevent corrosion, resist bacterial decomposition and to control viscosity.

Protein foam concentrates work with all types of proportioning equipment manufactures by NF. They include line proportioners, standard pressure proportioners, bladder tank proportioners, standard balanced pressure proportioners, and in-line balanced pressure proportioners. See Section III of the NF Engineers Manual for specific details.

These regular type foams are not suitable for subsurface injection or protection of polar solvents and are generally not compatible with dry chemicals. However, they are compatible with all of the generally recognized construction materials for storage tanks and distribution systems with the exception of welded stainless steel tanks or aluminum tanks. Do not use galvanized pipe & fittings in foam concentrate service.

FLUOROPROTEIN FOAM CONCENTRATES

Fluoroprotein foams have fluorochemical surfactants which greatly enhance performance with fast knockdown, improved resistance to fuel pick-up, and dry chemical compatibility. They are intended for use on Hydrocarbon fuels and select oxygenated fuel additives. As with Protein, they have excellent heat resistance, burnback, and post fire security. Fluoroprotein foams may be used with fresh or sear water. They MUST be properly aspirated and should not be used with non-aspirating structural fog nozzles.

Fluoroprotein foams are made by the addition of special fluorochemical surfactants to protein foam. This enhances the properties of protein foam by increasing foam fluidity and improves the properties of regular protein foam by providing faster knockdown and excellent fuel tolerance.

Fluoroprotein foams are designed for use on hydrocarbon-type flammable liquids fires through NFPA Type II devices and air-aspirating foam nozzles. However, these type concentrates are not used for non-aspirating equipment. Available in both 3% and 6% concentrations, XL Fluoroprotein Concentrates work with fresh or seawater. "Cold foams" are available for frigid climates or when heated storage is not available.

Fluoroprotein foam concentrates work with all of the proportioning equipment manufactures by NF. They include line proportioners, standard pressure proportioners, bladder tank proportioners, standard balanced pressure proportioners, and in-line balanced pressure proportioners. See Section III of the NF Engineering Manual for specific details.

They are compatible with all of the generally recognized construction materials for storage tanks and distribution systems with the exception of welded stainless steel tanks & aluminum storage tanks. Do not use galvanized pipe & fittings in pure concentrate service.

SYNTHETIC FOAM CONCENTRATES

INTRODUCTION

Synthetic concentrates date back to the first half of the century during the introduction of mechanical foams. The fluorine containing synthetic concentrates can generally be traced to development work carried out by the US Navy in the mid-1960's. These synthetic concentrates were called Aqueous Film Forming Foams (AFFF's). Synthetic foam concentrates were divided into two groups: Conventional AFFF's and Alcohol Resistant AFFF's (AR-AFFF). In the early 1970's, NF invented and patented the AR-AFFF technology by introducing Universal. AR-AFFF is a synthetic product that was developed for **both** hydrocarbon and polar-solvent materials. Since then, NF introduced a variety of the AR-AFFF type concentrates. Although high expansion concentrates fall into the synthetic type, they are treated as a separate, distinct class of concentrates.

CONVENTIONAL AFFF FOAM CONCENTRATES

AFFF's are designed to drain foam solution quickly from the foam bubble to produce optimum filming for rapid fire extinguishment.

These concentrates are a combination of fluorocarbon surfactants and synthetic foaming agents that add a new dimension to fire fighting - the aqueous film. This film is a thin layer of foam solution that spreads rapidly across the surface of most hydrocarbon fuels and causes dramatic fire "knockdown", an important factor in crash rescue fire fighting.

The aqueous film is produced by the action of the fluorocarbon surfactant reducing the surface tension of the foam solution to a point where the solution can actually be supported by the surface tension of the hydrocarbon fuel. Therefore, the effectiveness and durability of the aqueous film can be influenced by the surface tension of the hydrocarbon.

AFFF's are more effective on fuels with higher surface tension values such as kerosene, diesel oil, and jet fuels but less effective on fuels with low surface tension coefficients like hexane and high octane gasolines. However, long-term sealability and burnback resistance are sacrificed by this rapid drainage.

By design, AFFF's require a very low energy input to produce a good quality foam and a relatively long lasting blanket. AFFF's typically demonstrate sufficient foam-making ability that they will produce foam from non-aspirating equipment which has an impinging stream action to help draw in air. When used through air-aspirating discharge devices, the foam extinguishes faster and offers better burnback resistance.

Of even greater significance, Aer-O-Water and Aer-O-Lite produce foam from standard type water sprinkler heads. The foam produces a sufficient quality to meet the requirements of Underwriters Laboratories for AFFF. Aer-O-Water and Aer-O-Lite will also produce adequately expanded foam through many directional and spray nozzles used in special hazard systems. Existing water deluge systems are readily converted to foam systems merely by adding the appropriate proportioning equipment.

Use NF's conventional AFFF's with fresh or sea water. "Cold Foam" versions are available upon request. All NF conventional AFFF's may be sparingly used as excellent wetting agents. They are compatible with dry chemical agents.

Conventional AFFF concentrates work with all types of proportioning equipment manufactured by NF except standard pressure proportioners. The specific gravity of these agents is so near the specific gravity of water that an adequate separation cannot be achieved and maintained. See Section III of the NF Engineering Manual for specific details.

ALCOHOL RESISTANT-AFFF FOAM CONCENTRATES

INTRODUCTION

Certain flammable and combustible liquids known as polar solvents are destructive to conventional fire fighting foams. Polar solvents extract the water contained in the foam and rapidly destroy the foam blanket. Therefore, these fuels require alcohol or polar solvent resistant foam. Alcohol resistant concentrates include a polymer that protects the foam blanket from the water miscible fuel.

NF invented and patented present day AFFF based Alcohol Resistant (AR-AFFF) Foam technology. Today, NF's AR-AFFF concentrates are unquestionably the most effective and versatile foam concentrates available when a variety of fuels must be protected.

NF's AR-AFFF brand foam concentrates combine totally synthetic stabilizers, foamers, fluorocarbons and polymers. These polymers remain in the foam until it contacts the polar solvent. As the polar solvent extracts the water from the foam blanket, this tough polymeric membrane prevents further destruction of the foam blanket. AR-AFFF can be used through NFPA Type II application devices as well as portable and monitor mounted air-aspirating nozzles.

NF offers a family of AR-AFFF brand foam concentrates to use on polar solvent hazards. Recent advances now incorporate the best features of all previous foams of this type into AR-AFFF brand concentrates that are highly effective on nearly all flammable liquids.

The fluorosurfactants in AR-AFFF effectively combat hydrocarbon fires and give them true AFFF film-forming capabilities. AR-AFFF concentrates can be used in either fresh or sea water. Generally no special proportioning or foam making equipment is required; however, some standard proportioners reveal narrower proportioning ranges when using AR-AFFF type concentrates.

With the exception of standard pressure proportioners, all of the proportioners manufactured by NF work with AR-AFFF concentrates. See Section III of the NF Engineering Manual for specific details.

NF AR-AFFF concentrates are suitable for subsurface injection into hydrocarbon fuels; however, they are not suitable for subsurface injection into polar solvent fuels.

Consult individual Data Sheets or system design sections for recommended application rates and proportioning requirements.

HIGH EXPANSION FOAM CONCENTRATES

INTRODUCTION

NF's High Expansion, or Synthetic Detergent foam concentrate is designed for use through air-aspirating or forced air devices producing foam expansions from 100 to one up to 1000 to one. These very high expansion ratios produce large quantities of finished foam from relatively small amounts of water and foam concentrate. 1-2% proportioning is recommended for most medium to high expansion foam generators.

High expansion foam is primarily used on Class A fires in confined areas such as basements, mine shafts, attics and other places inaccessible to the fire fighter. By placing a high expansion foam generator at an opening into a confined space and providing proper ventilation at a point opposite the generator, a fire can be brought under control without personnel entering a potentially hazardous space. High expansion foam control fires by cooling, smothering and reducing oxygen content by steam dilution. Exercise care in positioning the foam generator so that combustible products are not drawn into the air inlet. Ventilation must be planned carefully to allow foam to reach all areas of the confined space.

CLASS A FOAM CONCENTRATES

INTRODUCTION

Class A foam concentrates are a mixture of foaming and wetting agents in a non-flammable solvent. These products are generally non-hazardous, non-corrosive and non-flammable.

Class A foam is typically used at very low concentrations. Proportioning percentages range from 0.1% to 1% by volume of water. In addition to the methods of proportioning discussed in this guide, premixing provides an inexpensive and uncomplicated method for use. Unlike Class B foams, proportioning accuracy and application rates are not as critical to the performance of the foam.

Class A foam is typically used at very low concentrations. Proportioning percentages range from 0.1% to 1% by volume of water. In addition to the methods of proportioning discussed in this guide, premixing provides an inexpensive and uncomplicated method for use. Unlike Class B foams, proportioning accuracy and application rates are not as critical to the performance of the foam.

Class A foam extinguishes by improving the the penetrating or wetting capability of water, reducing the fuel temperature and separating the supply of oxygen. It reduces the surface tension of plain water which allows it to penetrate surfaces, where water might normally run off, to reach deep seated fires. This helps reduce the amount of water required to extinguish the fire and provides quicker knockdown. Class A foam also increases the absorbing capabilities of water by allowing increased contact with the fuel and adherence to vertical surfaces. Class A foam may be used for exposure protection to prevent Class A fuels from igniting by raising their moisture content and providing a tough protective barrier to an oncoming flame front.

SECTION 2
FOAM CONCENTRATE PROPORTIONING

National Foam

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SECTION 2
FOAM CONCENTRATE PROPORTIONING

GENERAL OVERVIEW

Proportioning is the process of mixing or combining two or more ingredients into a common product at specific ratios. The various types of proportioning systems each have certain advantages or strengths as well as limitations. Therefore, care must be used in selecting the proper type of proportioning to fit the application. Selecting the wrong proportioning system for the application can result in serious consequences, which could be as simple as excessive system or maintenance costs to poor operation or failure of the system.

It is important that a proportioning system be able to consistently maintain the correct ratio of the foam concentrate injected into the water supply over the entire proportioning range required by the system. If proportioning is too “lean” (less than the design percentage of foam concentrate to water), the overall foam quality decreases. The drainage time decreases and the bubbles break faster resulting in less resistance to heat. Therefore, lean foam may or may not put out the fire. On the other hand, if proportioning is too “rich” (greater than the design percentage of foam concentrate to water), the foam shows stiffness and non-fluidity or reluctance to flow around obstructions. In addition, the foam concentrate supply is depleted more rapidly and hence may not adequately meet minimum operation time requirements.

PROPORTIONING DEFINITIONS

1. **Foam Concentrate:** Foam concentrate is concentrated liquid foaming agent as supplied from the manufacturer.

2. **Foam Solution:** A homogenous mixture of water and foam concentrate in proper proportions.

3. **Foam:** Fire fighting foam is a stable aggregation of small bubbles of lower density than oil or water that exhibits a tenacity for covering horizontal surfaces. It flows freely over a burning liquid surface and forms a tough, air-excluding, continuous blanket that seals volatile vapors from access to air. It resists disruption from wind and draft or heat and flame attack and is capable of resealing in case of mechanical rupture.

4. **Proportioner:** A device to properly mix foam concentrate and water at a desired percentage rate of foam concentrate injection.

PROPORTIONING METHODS

I. Premix Foam Solution
II. Venturi (Vacuum Inducing)
II. Pressure Proportioner
IV. Bladder Tank Proportioning
V. Balanced Pressure Proportioning
VI In-Line Balanced Pressure Proportioning
VII. Around the Pump Proportioning
VIII. Pick-Up Nozzles
IX. Jet Pump Proportioning.

I. Premix

The simplest method of proportioning foam concentrate is the premix method. This is accomplished by mixing pre-measured amounts of water and foam concentrate in a common container. Typically the storage container is a pressure rated tank using inert gas to pressurize the system. However, the premix can be stored in an atmospheric tank and a pump used to supply the premix solution under pressure to the discharge devices. Because the storage vessel must contain the water as well as the foam concentrate, this type of proportioning is usually limited to small systems. Although this is the simplest method, it has many drawbacks. Size of storage container limits the size of system, not all foam concentrates can be pre-mixed And storage life of premix solutions is unknown.

II. Venturi Type (Vacuum Inducing)

Line Proportioners are venturi devices that introduce Foam Concentrate into a flowing stream of water at a controlled proportioning rate. The line proportioner (also known as an inductor or eductor) is a simple, inexpensive method of proportioning when the water supply pressure is reasonably high. It has no moving parts and requires minimal maintenance.

The line proportioner is ideally suited to any proportioning application requiring a single fixed discharge flow and relatively high, consistent water pressure. They can operate with pressures as low as 75 PSI (5.2 Bar) or as high as 200 PSI (13.8 Bar), however, optimum performance is achieved with pressures above 125 PSI (8.6 Bar). They are not suitable for use in applications requiring operation over a range of flows or pressures. They are not recommended for applications using sprinklers or other multiple small orifice discharge devices, where blockage of a portion of the discharge devices could increase the allowable back pressure sufficiently to cause proportioning failure.

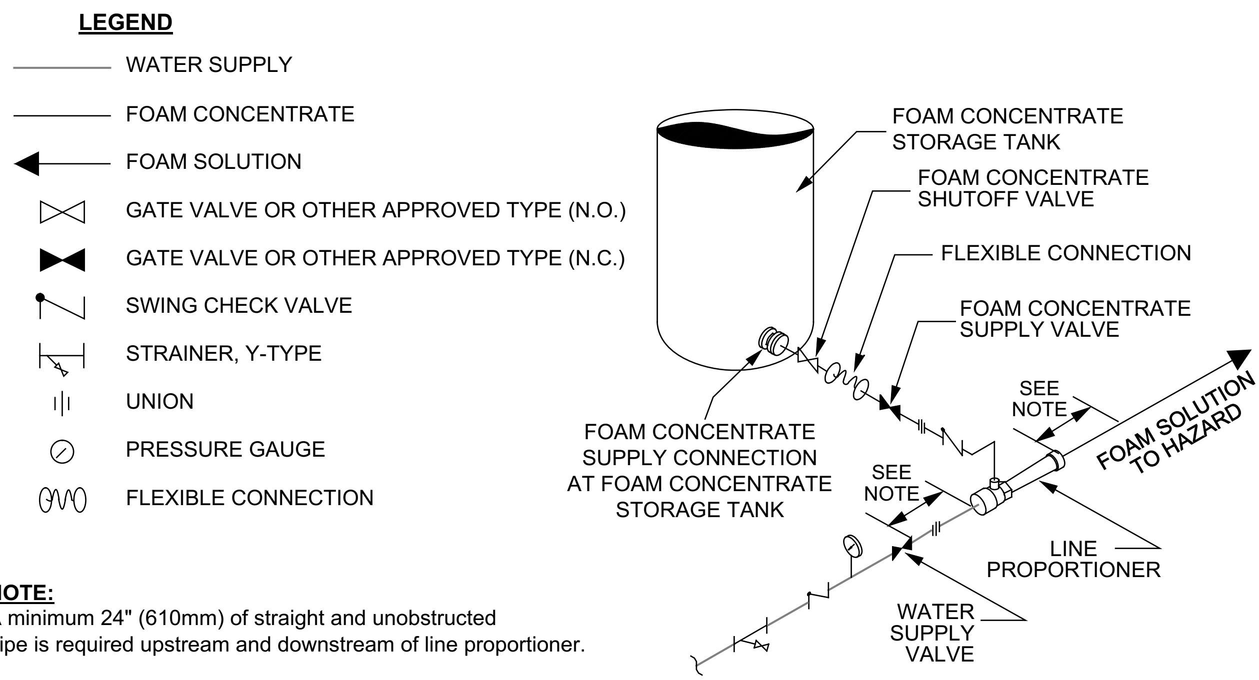
As water flows through the venturi (water orifice) at a high velocity, a negative pressure area develops at the discharge of the venturi. This negative pressure creates a pressure differential across the foam concentrate-metering orifice, thereby allowing atmospheric pressure to push foam concentrate in to the proportioner at the correct percentage. As the water pressure at the inlet to the proportioner increases or decreases the solution flow from the device will increase or decrease correspondingly. Because the amount of foam concentrate to be injected into the water stream is controlled by the relationship between the negative pressure area and atmospheric pressure the range over which proper injection occurs is limited. Therefore, each model of line proportioned has an operating pressure range and to achieve optimum performance, the water inlet pressure must be maintained within this range. Higher than design pressure will result in a leaner (lower percentage) mixture; lower than design pressure will result in a richer (higher percentage) mixture.

In addition to water pressure, LP's are sensitive to back pressure. Back pressure is the amount of pressure required down stream of the proportioner to discharge the total foam solution flow. This will include the pressure required at the inlet to the discharge device(s), elevation head and line losses. The total allowable back pressure on the discharge side of the LP can not exceed 65% of the water inlet pressure. If back pressure exceeds 65%, the LP may not pick-up foam concentrate or the solution may be lean.

The line proportioner can be designed for use in portable applications or installed in fixed piping systems. For portable applications the proportioner is equipped with hose connections to allow installation in a hose line. Foam concentrate is normally supplied from 5-gallon pails through a pickup tube. As noted above these proportioners are sensitive to the back pressure. Therefore, care must be used in matching the discharge nozzle to the proportioner as well as the amount of hose between the line proportioner and the nozzle. Line proportioners can be equipped with a metering valve to allow the desired percentage to be field set.

When line proportioners are used in a fixed piping systems, the foam concentrate is usually stored in a permanently installed storage tank with permanent piping between the tank and foam concentrate connection of the line proportioner. The line proportioner may be mounted up to a maximum height of 6-ft (1.8m) above the tank bottom. A minimum of 24 inches (610 mm) of straight unobstructed pipe should be installed upstream and downstream of the line proportioner. In fixed installations using Alcohol Resistant AFFF foam concentrates, the line proportioner should be installed at the bottom of the foam concentrate storage tank in order to provide a flooded suction at all times. A normally closed shutoff valve in the foam concentrate supply line will prevent possible siphoning of the foam concentrate.

See data sheets for physical dimensions of equipment and performance characteristics.



NOTE:
A minimum 24" (610mm) of straight and unobstructed pipe is required upstream and downstream of line proportioner.

FIGURE 2-1
Line Proportioning - Fixed Installation

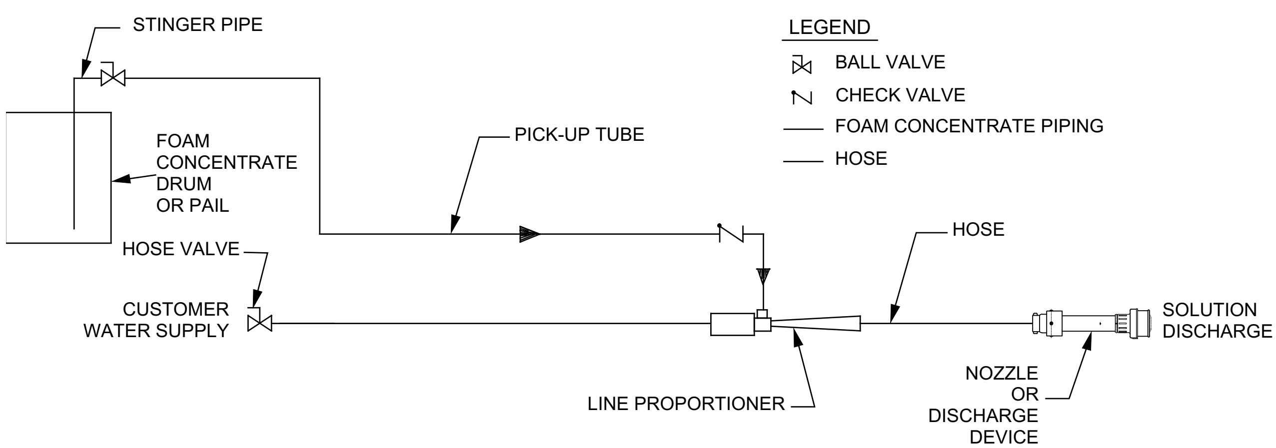


FIGURE 2-2
Portable Line Proportioning

III. Pressure Proportioner Type (Non-Bladder)

The pressure proportioning system is a complete self-contained proportioning system consisting of a foam concentrate storage tank and a pressure proportioning head. This system is designed to inject foam concentrate into a suitable water supply and automatically proportion foam concentrate over a wide range of flows and pressures.

During operation the foam concentrate is pressurized by diverting a small amount of water entering the proportioning head into the foam concentrate storage tank. As water passes through the water orifice it creates a low pressure area on the downstream side of the water orifice. This low pressure area is also common to the discharge of the foam concentrate metering orifice, thereby creating the pressure differential between the foam concentrate and the water supply, that allows injection of the foam concentrate into the water stream at the proper injection ratio.

As the system operates, water gradually displaces the foam concentrate inside the tank until the foam concentrate supply is exhausted. Because of the direct contact with water, only protein based foam concentrates with a specific gravity of 1.1 or higher can be used with this type of proportioning system. Since the pressure proportioning system is pressurized during operation the tank can not be refilled during operation. The system must be shutdown and the water drained from the tank prior to refilling with foam concentrate.

See data sheets for physical dimensions of equipment and performance characteristics.

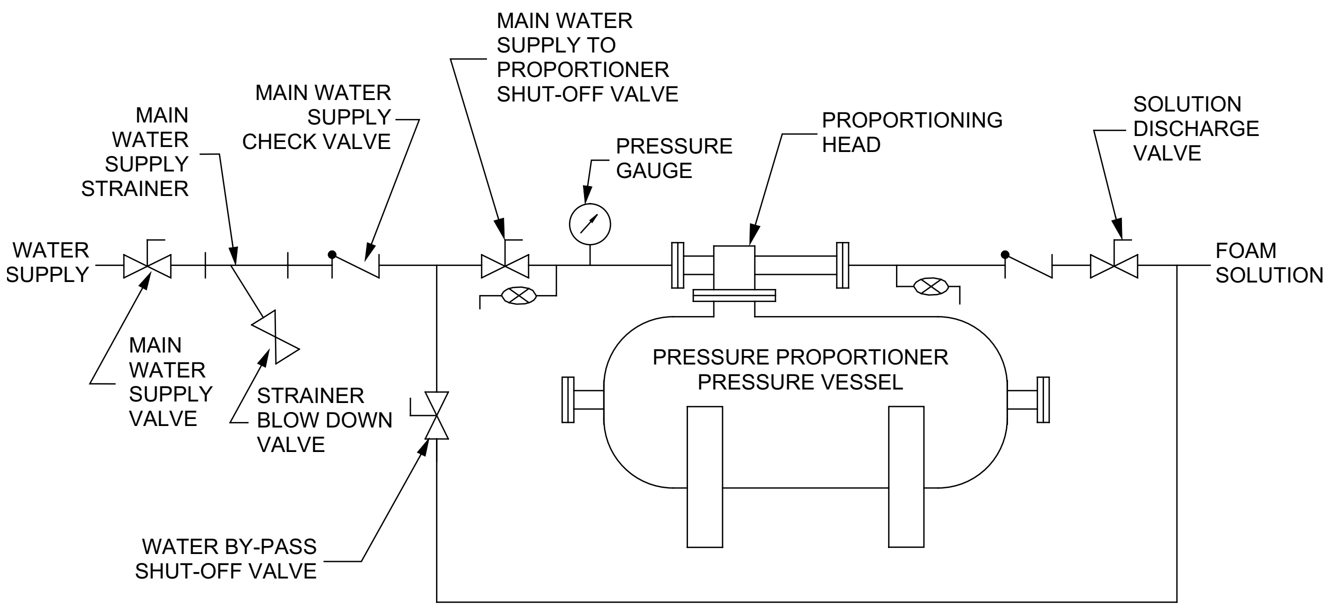


FIGURE 2-3
Pressure Proportioning

IV. Bladder Tank Proportioner Type

The bladder tank proportioning system is a balanced pressure proportioning system, requiring no external power other than an adequate water supply. A bladder tank, with an appropriate proportioner(s), injects foam concentrate into the water supply of a fire protection system and automatically proportions over a wide range of flows and pressures.

The foam concentrate storage tank is a steel pressure vessel fitted with an internal bladder that allows the stored foam concentrate to be physically separated from the water supply. During operation water diverted from the water main supplying the ratio controller is used to pressurize the tank, gradually displacing the foam concentrate by collapsing the bladder, forcing foam concentrate to the ratio controller at approximately the same pressure as the water main. Proper proportioning is achieved through the use of a modified venturi proportioner, commonly called a ratio controller. As water flows through the water jet, it creates a reduced pressure area between the jet and the receiver. This reduction in pressure creates a pressure differential across the foam concentrate metering orifice, causing the foam concentrate to flow into the low pressure area.

The foam concentrate is then drawn out of the low pressure area and mixed with the water supply as it enters the receiver. As the water flow through the ratio controller jet increases, the pressure reduction increases, thereby creating a corresponding higher pressure differential across the foam concentrate metering orifice. This increase in pressure differential results in an increase in the foam concentrate flow, which is proportionate to the water flow through the ratio controller. Proper proportioning is achieved simply by maintaining identical water and foam concentrate pressures at the respective inlets to the ratio controller.

This type of proportioning system is compatible with all types of foam fire protection systems, and proportions all types foam concentrates over the entire flow range of the ratio controller without manual adjustments, regardless of pressure. Since the bladder tank system is pressurized during operation, the bladder can be refilled with concentrate *only* when system is not in use. The bladder tank can also be isolated to allow the system to discharge water only.

See data sheets for physical dimensions of equipment and performance characteristics.

Caution:

1. Because the water pressure from the water main is being used to create the metering differential in the proportioner, some of the more viscous foam concentrates may have the lower proportioning range limits increased in order to develop sufficient pressure differential to move the foam concentrate.

2. It is important that adequate water pressure is available to create sufficient metering drop for correct proportioning.

3. When ratio controllers are being located remote from the bladder tank, piping between the tank and the controller must be reviewed to insure that adequate pressure is available at the inlet to the ratio controller to achieve proper proportioning.

4. Sight glass, when provided, can not be used during operation of the system to determine quantity of foam concentrate in the tank. To use sight glass, tank must be depressurized and water drained from the tank. Sight gauges, when provided on tanks using Alcohol Resistant AFFF type concentrates may show false readings.

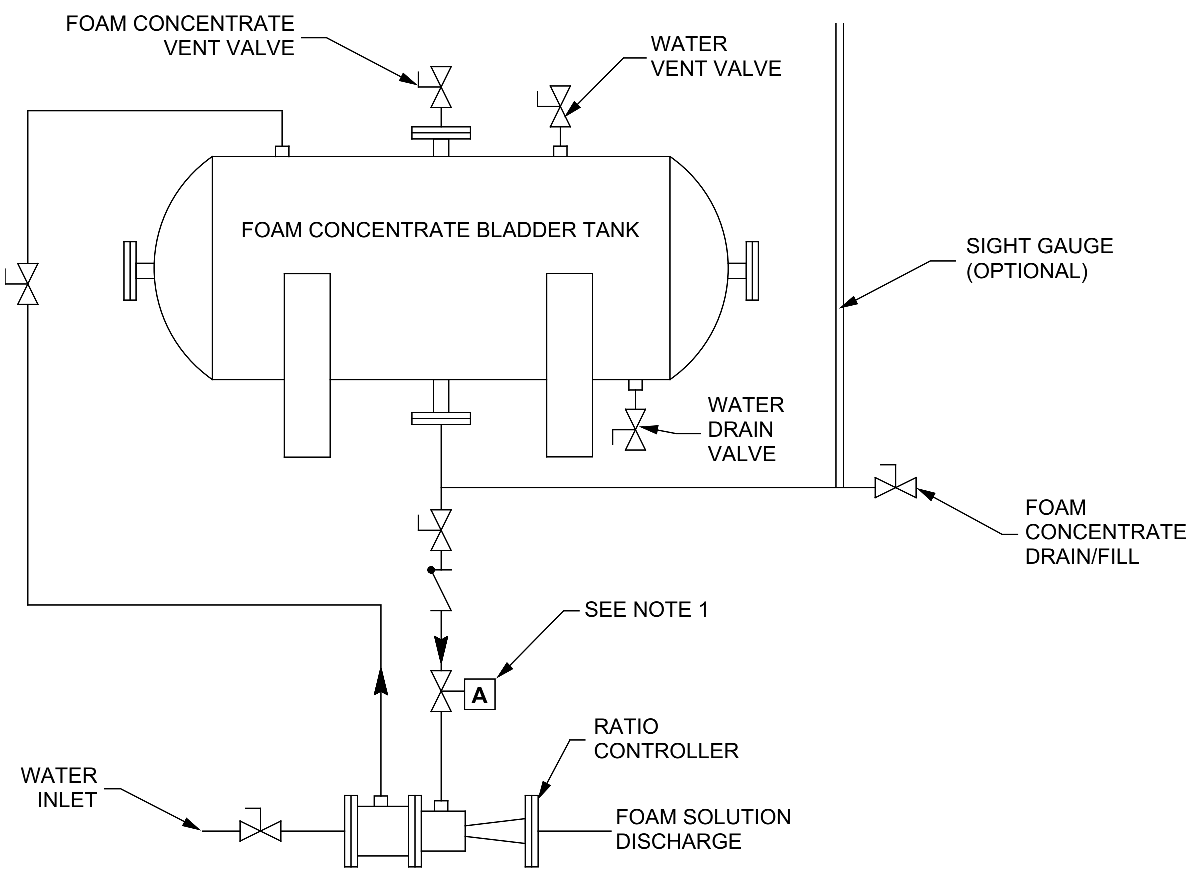


FIGURE 2-4
Bladder Tank Proportioning

V. Balanced Pressure Type (Back Pressure Balancing Method)

Balanced Pressure (BP) Proportioning Systems are the most common type of foam proportioning systems because of their versatility and accuracy. This type of proportioning system automatically and accurately proportions foam concentrate over the entire flow range of the ratio controller, regardless of pressure and without manual adjustments. This type of system can be used with fresh or salt water.

Proportioning is accomplished through the use of a ratio controller (modified venturi proportioner) installed in the water supply line. As water flows through the ratio controller it creates a reduced pressure area between the jet and the receiver. This reduction in pressure creates a pressure differential across the foam concentrate metering orifice, causing the foam concentrate to flow into the low pressure area. The foam concentrate is then drawn out of the low pressure area and mixed with the water supply as it enters the receiver. As the water flow through the ratio controller jet increases, the pressure reduction increases, thereby creating a corresponding higher pressure differential across the foam concentrate metering orifice. This increase in pressure differential results in an increase in the foam concentrate flow, which is proportionate to the water flow through the ratio controller. Proper proportioning is achieved simply by maintaining identical water and foam concentrate pressures at the respective inlets to the ratio controller. Foam concentrate, which is stored in an atmospheric type storage tank, is supplied to the ratio controller by a positive displacement type, foam concentrate pump. In order to control the excess flow of foam concentrate from the pump and maintain the correct pressure at the ratio controller, a back pressure control type, diaphragm valve is used. This valve automatically adjusts the foam concentrate pressure to correspond to the water pressure. Balancing is accomplished by sensing the water and foam concentrate pressures at the inlet to the ratio controller and adjusting the diaphragm valve opening to control the excess foam concentrate flow back to the concentrate storage tank. Pressure sensing lines from the water supply line and the foam concentrate sensing connection to the diaphragm valve sense both the water and the foam concentrate pressures. A duplex gauge is used to monitor both the water and foam concentrate pressures to insure proper balancing. The duplex gauge also allows the system to be manually balanced in the event of diaphragm valve failure by utilizing a manually operated valve in the foam concentrate by-pass piping. The diaphragm valve should be provided with a block valve and a bypass loop to allow manual adjustment the pressure in the event of diaphragm valve failure.

The positive displacement pump is normally driven by an electric motor. The pump driver should be installed with a listed pump controller in accordance with the requirements of NFPA 20. On installations were power is not dependable, other types of drivers such as diesel engines and water motors can be used to drive the primary pump or a standby pump.

See data sheets for physical dimensions of equipment and performance characteristics.

Caution:

1. The pump motor should be sized with sufficient horsepower to allow operation, with relief valve full open, without overloading the motor.

2. The suction piping shall contain a Y-type or basket strainer with stainless steel screen with 1/8” perforations.

3. A UL Listed or FM Approved, NFPA 20, pump controller, should be provided for each motor driven pump. National Foam does not recommend the use of pressure drop start to initiate operation of foam pumps.

4. All manual valves should have locking handles or other means of supervision in accordance with NFPA requirements for valve supervision.

5. A check valve should be installed in the foam concentrate discharge line to the ratio controller.

6. The ratio controllers have a minimum inlet pressure requirement of 30 psi (2.1 bar). However, depending on the total system flow and size of ratio controller selected, the minimum pressure requirement may exceed 30 psi (2.1 bar).

7. A minimum of 5 pipe diameters of straight and unobstructed pipe should be installed on the inlet and discharge side of the ratio controller.

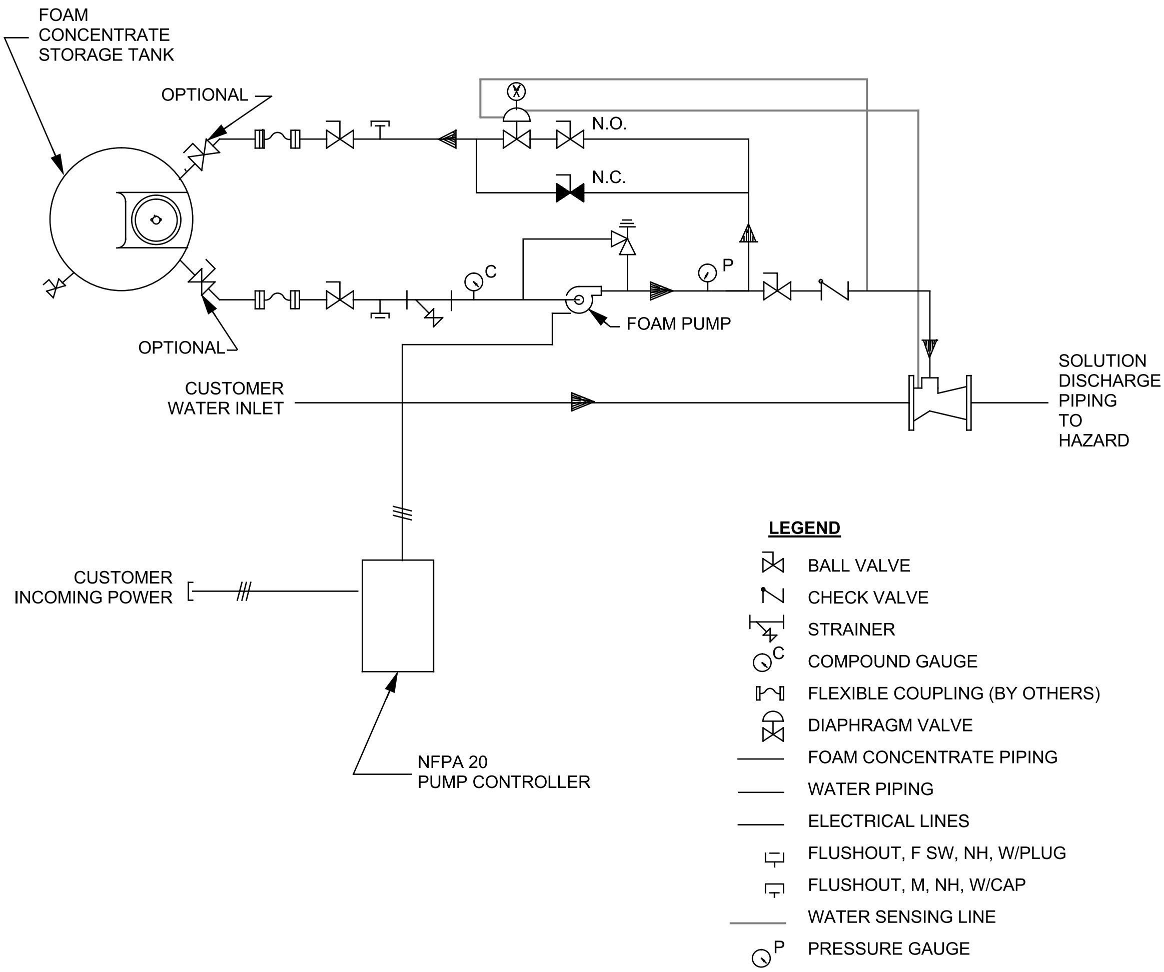


FIGURE 2-5
Balanced Pressure Proportioning

VI. In-Line Balanced Pressure Type

The In-Line Balanced Pressure Proportioning System is used to provide accurate proportioning at multiple locations, remote from the foam concentrate pump system and storage tank. The ILBP Proportioning System automatically and accurately proportions foam concentrate over the proportioner flow range, regardless of pressure, without manual adjustments. Proper proportioning is achieved simply by maintaining identical water and foam concentrate pressures at the respective inlets of the ratio controller. It is ideally suited to applications requiring operation under one or more of the following conditions.

1. Simultaneous operation of water or foam from some or all discharging systems.

2. Multiple foam maker operation with pressure differences between foam maker points.

3. Systems located in different areas, which are remote from the foam concentrate storage tank and proportioning system.

4. Capability of selectively operating with foam or water at each proportioning station.

5. Ability to choose the size proportioner best suited for the area to be protected and still use the same foam concentrate pump system and foam concentrate storage tank for other areas.

The ILBP proportioning system consists of two main groups of components. The first group is the proportioning modules, which controls the actual proportioning of the foam concentrate into the water line. The second group is the pump system, which supplies foam concentrate under pressure to the modules.

An ILBP proportioner module is used to provide accurate proportioning at multiple remote proportioning locations. The ILBP proportioning module typically consists of a ratio controller, pressure reducing diaphragm control valve (with or without manual override), duplex gauge, manual ball valve and foam concentrate inlet pressure gauge. The module is normally supplied, factory assembled, complete with all piping and sensing lines required. It may be supplied with or without a manual override feature, depending on system requirements. The duplex gauge is used to monitor both water and foam concentrate pressure and is required on all applications using a manual override. A check valve should be installed in the line feeding each module.

Each location requiring proportioning will require a ILBP module. Proportioning is accomplished through the use of a ratio controller (modified venturi proportioner) installed in the water supply line. As water flows through the ratio controller it creates a reduced pressure area between the jet and the receiver. This reduction in pressure creates a pressure differential across the foam concentrate metering orifice, causing the foam concentrate to flow into the low pressure area. The foam concentrate is then drawn out of the low pressure area and mixed with the water supply as it enters the receiver. As the water flow through the ratio controller jet increases, the pressure reduction increases, thereby creating a corresponding higher pressure differential across the foam concentrate metering orifice. This increase in pressure differential results in an increase in the foam concentrate flow, which is proportionate to the water flow through the ratio controller. Proper proportioning is achieved simply by maintaining identical water and foam concentrate pressures at the respective inlets to the ratio controller. Balancing the pressure at the inlets is achieved by regulating the volume of foam concentrate discharged to the ratio controller by the use of the pressure reducing diaphragm valve. Foam concentrate is normally supplied to the module from the pump system at a pressure approximately 25 – 30 PSI higher than the highest anticipated water pressure As an optional feature, the diaphragm valve can be supplied with manual override capability and a duplex gauge. The duplex gauge monitors balancing of the foam concentrate and water pressures at the ratio controller and also allows the system to be manually balanced in the event of diaphragm valve failure.

The ILBP pump system consists of a positive displacement type, foam concentrate pump with relief valve, an atmospheric type, foam concentrate storage tank and pressure sustaining valve. It supplies foam concentrate to the individual ILBP modules at a constant pressure regardless of the flow requirements to the proportioners. The pressure sustaining valve in the foam concentrate pump return line automatically maintains a constant preset pressure in the foam concentrate main at all design flow rates up to foam pump capacity. This pressure is maintained by adjusting the pressure sustaining valve opening to control the excess foam concentrate flow back to the concentrate storage tank. A bleed line should be provided on the pressure sustaining valve to prevent entrapment of air and prevent foam concentrate from drying in the valve resulting in improper operation. The pressure sustaining control valve should have a block valve and a bypass loop with manually operated valve, which can be used to manually adjust the pressure in the event of pressure sustaining valve failure. A check valve is normally installed in the discharge main to prevent the charged main from draining back to tank. A relief valve should be provided on the discharge line, downstream of the check valve, to prevent pressure buildup in the discharge line due to temperature fluctuations. A pressure gauge should be installed to verify proper foam concentrate discharge pressure and also to allow the system pressure to be manually adjusted. A compound gauge should be installed in the suction line downstream of the strainer, to monitor potential blockage during operation as well as pressure during flushing procedures.

The positive displacement pump is normally driven by an electric motor. The pump driver should be installed with a listed pump controller in accordance with the requirements of NFPA 20. On installations were power is not dependable, other types of drivers such as diesel engines and water motors can be used to drive the primary pump or a standby pump.

See data sheets for physical dimensions of equipment and performance characteristics.

<u>Caution:</u>

1. The pump motor should be sized with sufficient horsepower to allow operation, with relief valve full open, with out overloading the motor.

2. The suction piping shall contain a Y-type or basket strainer with stainless steel screen with 1/8” perforations.

3. A UL Listed or FM Approved, NFPA 20, pump controller, should be provided for each motor driven pump. National Foam does not recommend the use of pressure drop start to initiate operation of foam pumps.

4. All manual valves should have locking handles or other means of supervision in accordance with NFPA requirements for valve supervision.

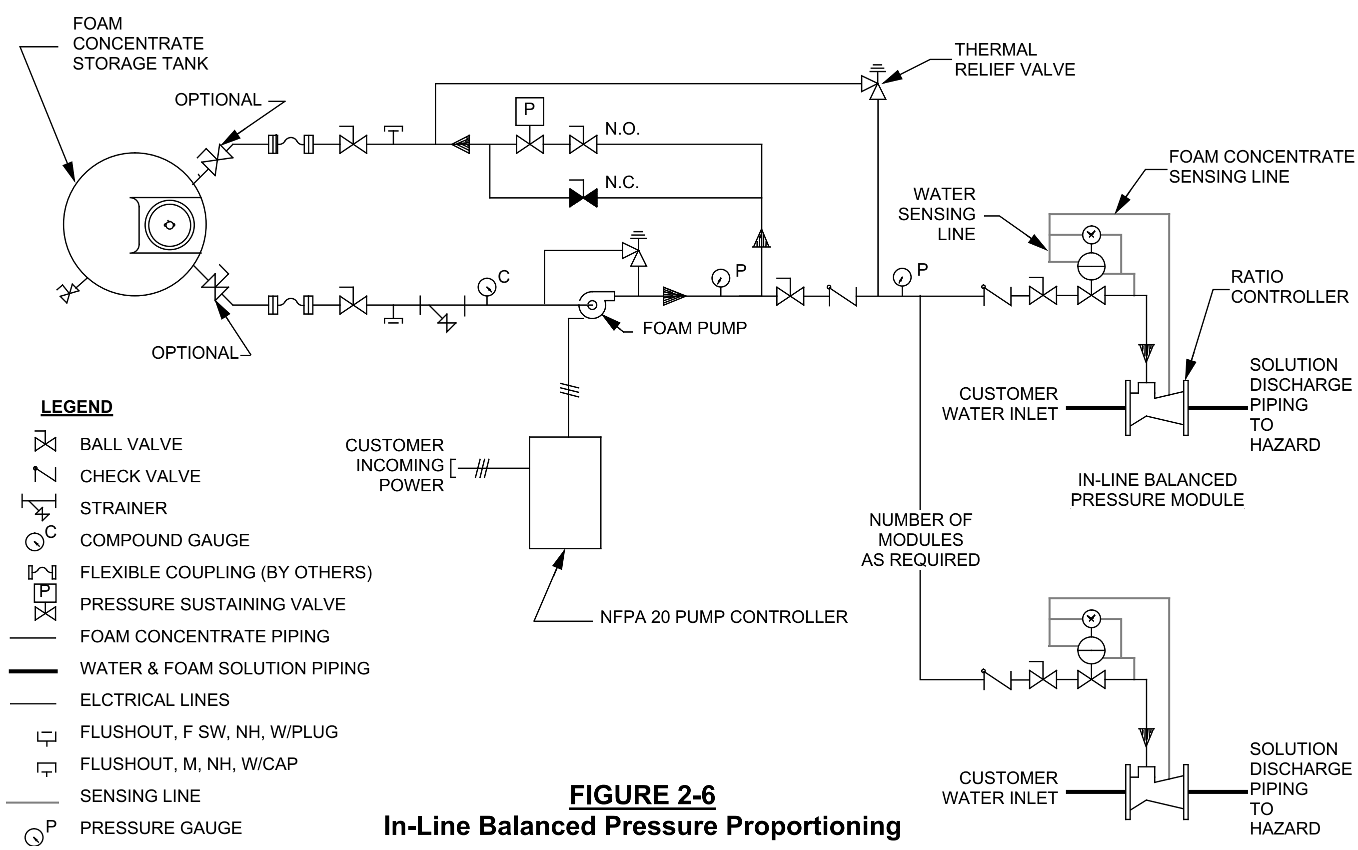
5. A check valve should be installed in the foam concentrate discharge line to the ratio controller.

6. These ratio controllers have a minimum inlet pressure requirement of 30 psi. However, depending on system total flow and size of ratio controller selected, this minimum pressure requirement may be increased.

7. A jockey pump will be required where concentrate pipe exceeds 50 ft. length. Jockey pumps must be installed where required by applicable NFPA codes, local codes or the authority having jurisdiction.

8. “Cold Foams” must be used in frigid climates when charged systems are installed.

9. A minimum of 5 pipe diameters of straight and unobstructed pipe should be installed on the inlet and discharge side of the ratio controller.



<u>FIGURE 2-6</u>
In-Line Balanced Pressure Proportioning

VII. Around The Pump Proportioner Type

Around the pump proportioning diverts a portion of the water pump discharge (typically 10 to 40 GPM) through an eductor. This proportioner produces a very rich foam solution mixture that is discharged back into the pump suction. When this rich foam solution is mixed back into the water, the pump discharges a foam solution at the desired 3% or 6%. Once the initial cycle is complete, the system will stabilize and produce a consistent foam solution at a specific flow rate. Around the pump proportioning is designed for operation at one rate of flow. It will not work over a range of flows. If more than one flow rate is required a metering valve will have to be installed on the eductor. Also the suction pressure on the water pump must be at "0" PSI or slight vacuum for the system to work.

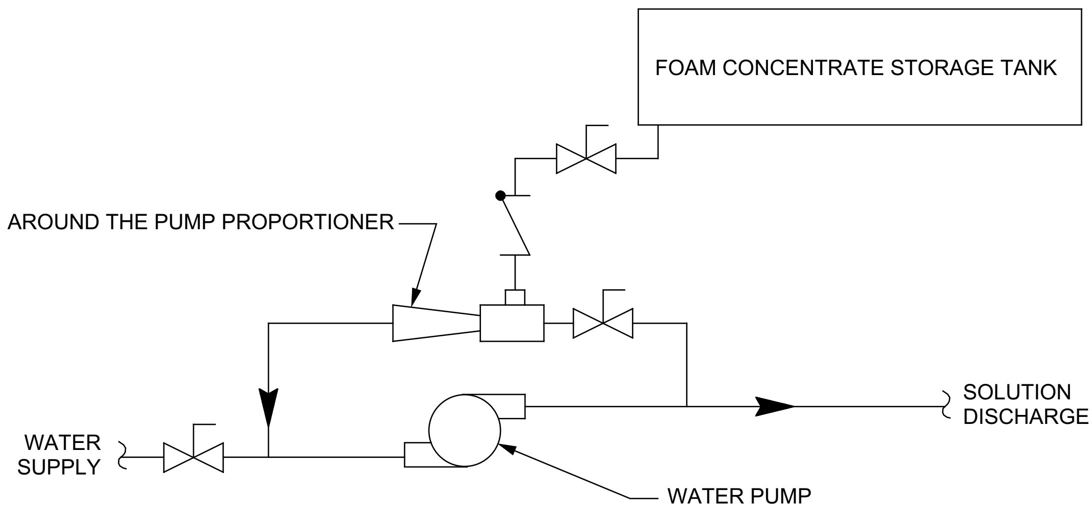


FIGURE 2-7
Around The Pump Proportioning

VIII. Pick-Up Nozzles

Pick-up nozzles are similar to line proportioners in operation except that the eductor is built into the nozzle body. They generally require higher water pressure for correct proportioning and are limited by the requirement that the foam concentrate supply must be at the nozzle location. Nozzles are available in both portable and monitor mounted versions.

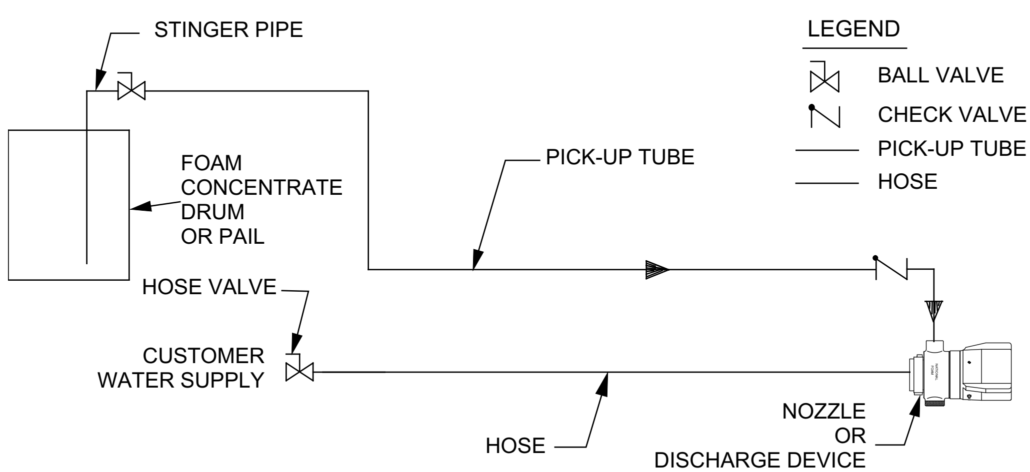


FIGURE 2-8
Portable Nozzle Proportioning

IX. Jet Pump Proportioning

Jet pumps are eductors that use water to perform the work of pumping foam concentrate from drums, tote tanks or bulk tankers. The jet pump principle involves taking a high pressure water stream, accelerating it through a tapered nozzle (jet) to increase its velocity thus creating a negative pressure area. Foam concentrate is drawn into this negative pressure zone through an inlet connection located on the side of the jet pump body. A flexible pickup hose is used for inducting foam concentrate from storage containers to the jet pump. The foam concentrate is mixed with the jet pump water stream at approximately a 60/40 ratio of foam to water. This 60% (rich) foam solution is then delivered to the discharge device, usually a nozzle, where it is thoroughly mixed and accurately proportioned into the water stream flowing through the device.

Caution:

There are several important factors involved in proper selection and application of National Foam jet pumps:

1. The jet pump foam induction rate must be compatible with the discharge device capacity.

2. The size and length of hose lay between the jet pump discharge and discharge device inlet is critical for proper jet pump operation. Jet pumps are sensitive to back pressure imposed on the discharge outlet. When maximum discharge pressure limits are exceeded the jet pump will cease to induct foam concentrate at the proper rate.

3. Pick up tube sizing must be correct for proper jet pump operation.

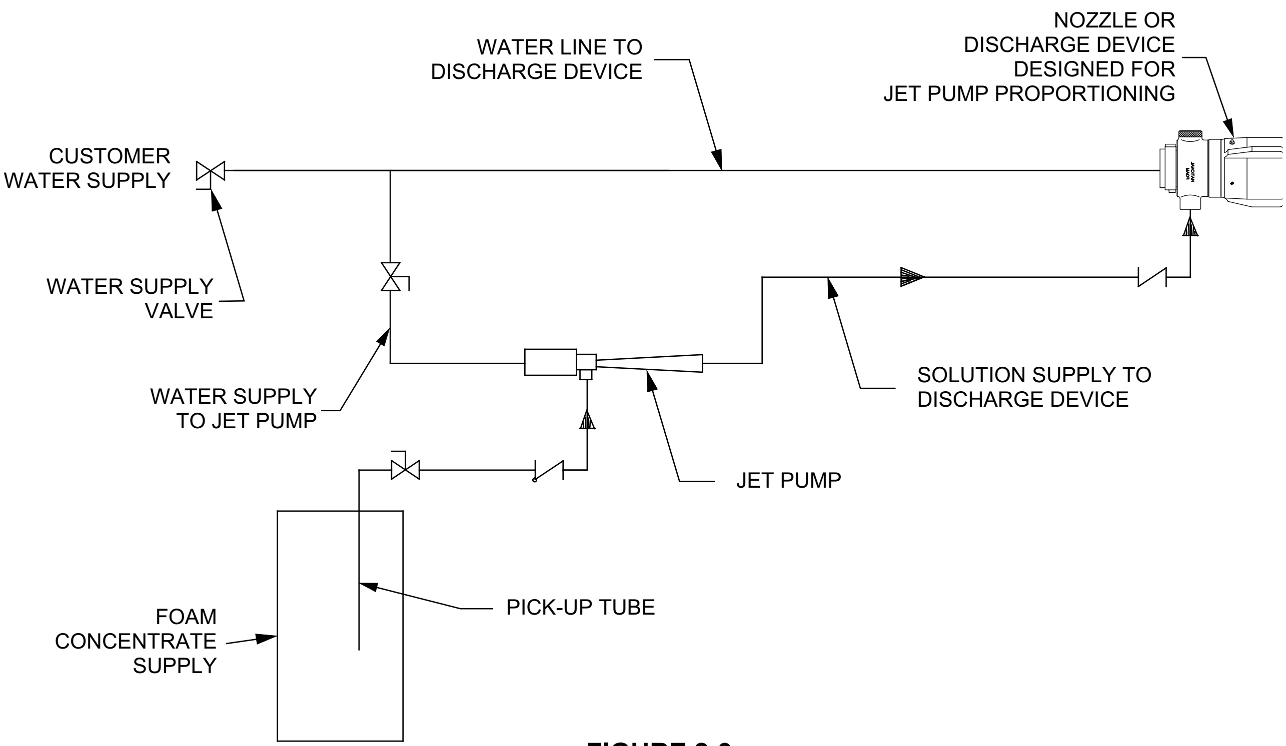


FIGURE 2-9
Jet Pump Proportioning

COMPARISON OF PROPORTIONING TYPES

Type	Advantages	Disadvantages
Premix	• Simplicity. • Independent of piped water supply. • Accuracy of proportioning.	• Limited foam generation capability. • Entire water supply becomes solution.Can not use with protein or fluoroprotein type foam concentrates. • Shelf life limited.
Venturi Type Proportioning	• Low Cost. • Simple operation. • Foam concentrate supply can be replenished during operation. • Can be used with all foam concentrates.	• Fixed flow rate. • High water pressure required. • Sensitive to back pressure limitations. • Discharge device(s) must be matched to flow of proportioner. • Not recommended for applications using sprinklers or other small orifice discharge devices where there is potential for blockage creating excessive back pressure.
Pressure Proportioning	• Simple operation . • Does not require external power other than water supply. • Proportions automatically over a wide flow range. • Proportioning is not sensitive to pressure variations.	• Can not use with AFFF or AR-AFFF type foam concentrates . • Foam concentrate can not be recharged without shutting down system and draining tank. • Water mixed directly with foam concentrate. May be some dilution of unused foam concentrate.
Bladder Tank Proportioning	• Proportions automatically over a wide flow range. • Proportioning is not sensitive to pressure variations. • Simple operation. • Low maintenance. • Does not require external power other than water supply.	• Foam concentrate can not be recharged without shutting down system and draining tank. • Specific fill procedure required to prevent damage to bladder. Time intensive. • AR-AFFF type foam concentrates may increase minimum proportioning range. • Limited capacities. • Piping limitations between tank and ratio controller.
Balanced Pressure Proportioning	• Proportions automatically over a wide flow range. • Proportioning is not sensitive to pressure variations. • Foam concentrate supply can be replenished during operation. • Can be used with all foam concentrates.	• Requires external power source. • Requires maintenance of pump(s) & electrical system. • May require alternate driver types in areas with undependable power. • More expensive than other types of proportioners, especially on small systems.

COMPARISON OF PROPORTIONING TYPES

Type	Advantages	Disadvantages
In-Line Balanced Pressure Proportioning	• Proportions automatically over a wide flow range • Proportioning is not sensitive to pressure variations. • Foam concentrate supply can be replenished during operation. • Can be used with all foam concentrates. • Allows proportioners to be mounted remote from pump system. Allows proportioners to be sized to individual hazards for optimum performanc • Allows selection of water of foam discharge to individual hazard	• Requires external power source. • Requires maintenance of pump(s) & electrical system. • May require alternate driver types in areas with undependable power. More expensive than other types of proportioners, especially on small systems.
Around The Pump Proportioning	• Simple operation. • Foam concentrate supply can be replenished during operation.	• Water pump supplies only foam solution. • Pump suction must be zero or slight vacuum. • Fixed discharge flow. If multiple discharge flows are required a metering valve is required to adjust proportioning. • Limited range limit. Typical applications are from 100 to 1000 GPM (379 to 3785 LPM).
Pick-Up Nozzles	• Inexpensive. • Simple operation. • Can be used with all foam concentrates.	• Limited capacities available. • Normally require high water pressures. • Limits movement of operator in portable application due to foam supply at nozzle.
Jet Pump Proportioning	• Low Cost. • Simple operation. • Foam concentrate supply can be replenished during operation. • Can be used with all foam concentrates.	• Fixed flow rate. • High water pressure required. • Sensitive to back pressure limitations. • Discharge device(s) must be matched to flow of proportioner.

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SECTION 3
STORAGE TANK PROTECTION

National Foam

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SECTION 3
STORAGE TANK PROTECTION

GENERAL OVERVIEW

In the early days of the industry, tank fires were a common occurrence. As the industry matured, there were improvements in codes regarding design and construction of product storage tanks. As a result we see fewer fires today. However, as the frequency of the fires decreased, the size of the tanks increased, resulting in an increase in the magnitude of the fire when it does occur. Because of the potential loss due to cost of product lost in a fire and damage to the tank as well as impact on the environment, we in the fire protection industry have had to develop ways of effectively extinguishing fires in large diameter storage tanks containing flammable liquids.

NFPA has established guidelines for protection of these types of hazards. The following is an explanation of the design requirements and guidelines for designing a fire protection system to protect flammable liquid storage tanks. Systems usually fall under one of two catagories: A fixed foam system which is a complete, installation including a central proportioning system, discharge devices at the hazard(s) being protected and all piping between the proportioning station and the hazards. All components of the system are permanently installed.

The other type is a semi fixed installation. In this application discharge devices are permanently installed on the hazard and piped to a termination point a safe distance from the hazard. The proportioning system is transported to the site after a fire has started and connected to the piping for discharge of foam through the permanently installed discharge device(s).

The following guidelines address the requirements for protection of the hazard and would be applicable to either type of system. See the proportioning section of the engineering manual for more detailed information on proportioning systems.

TYPES OF TANKS

There are four major types of tanks used to store flammable and combustible liquids.

Fixed (Cone) Roof Tank – Fixed roof tanks are defined as vertical cylindrical tanks with fixed roofs as a conical section and comply with the requirements set forth in NFPA 30. Typically, these tanks have a weak seam at the junction of the vertical side and the roof. In the event of an explosion, this seam parts allowing the roof to blow off, thereby leaving the shell intact to retain the contents of the tank. This type of fire involves the entire exposed surface area of the tank.

Open Top Floating Roof Tank – Open top roof tanks are defined as vertical cylindrical tanks without fixed roofs that have double deck or pontoon type floating roofs and comply with the requirements set forth in NFPA 30. The seal can be a mechanical shoe seal or tube seal. The tube seal can have a metal weather shield. Secondary seals of combustible or non-combustible materials may be installed. Tanks with the following types of roofs do not fall under the design standards for protection of open top floating roof tanks.

- Roofs made from floating diaphragms
- Roofs made from plastic blankets
- Roofs made from plastic or other flotation material, even if encapsulated in metal or fiberglass
- Roofs that rely on flotation device enclosures that can be easily submerged if damaged
- Pan roofs

Although these types of tanks can experience a full surface fire in the event that the roof sinks, experience shows that the most common type of fire in these tanks is a seal fire. The authority having jurisdiction will normally determine the protection requirements, however, the typical protection is for the seal area only.

Covered (Internal) Floating Roof Tank - Covered (internal) floating roof tanks are defined as vertical cylindrical tanks with fixed roofs (cone or geodesic dome) equipped with a ventilation system and containing a double deck or pontoon type floating roof or a metal floating roof cover supported by liquid tight metal flotation devices. Construction shall comply with the requirements set forth in NFPA 30.

Tanks with the following floating roof types do not fall under the design standards for protection of covered (internal) floating roof tanks.

- Roofs made from floating diaphragms
- Roofs made from plastic blankets
- Roofs made from plastic or other flotation material, even if encapsulated in metal or fiberglass

- Roofs that rely on flotation device enclosures that can be easily submerged if damaged
- Pan roofs

Tanks utilizing these types of roofs would fall under the requirements for fixed roof tanks.

Covered (internal) floating roof tanks can experience full surface fires as well as seal fires. The type of protection required is normally based on the construction of the floating roof. Tanks with the following types of roof construction are considered suitable for seal area protection:

- Steel double deck
- Steel Pontoon
- Full liquid surface contact, closed cell honeycomb, of metal construction conforming to API 650, Appendix H "Internal Floating Roof Requirements".

All other roof types will require full surface protection. The authority having jurisdiction should confirm the type of protection required for the specific hazard.

Horizontal Tanks – Horizontal Storage tanks are defined as horizontal cylindrical tanks with flanged and dished heads mounted on structural supports. Other than cooling sprays, fire protection is not normally applied to the tank, since a fire and explosion normally ruptures this type of tank dumping the contents into the diked area. If fire protection is required it is normally for protection of the diked area surrounding the tanks.

CLASSIFICATION OF FLAMMABLE AND COMBUSTIBLE LIQUIDS

The first step in designing a system is to determine the type of flammable or combustible liquid to be stored in the tank. Generally, these liquids can be divided into two basic categories: hydrocarbons and polar solvents. Hydrocarbons include non water-soluble petroleum liquids such as crude oil, gasoline, jet fuels, fuel oils, etc. Polar solvents include water soluble liquids such as alcohols, ketones, esters etc.

NFPA terminology and definitions that cover liquid products fall into the following categories:

Flammable Liquid means any liquid with a flash point below 100°F (38° C) and with a vapor pressure not exceeding 40 pounds per square inch (2.76 bar) absolute at 10°F (38°C). These liquids fall into the following divisions:

Class 1 includes liquids with flash points below 100° F (38°C). This class falls into these subdivisions:

- Class IA includes liquids with flash points below 73°F (23°C) and with a boiling point below 100°F (38°C). For foam application, they require special consideration.
- Class IB includes liquids with flash points below 73°F (23°C) and with a boiling point at or above 100°F (38°C).
- Class IC includes liquids with flash points at or above 73°F (23°C) and below 100°F (38°C).

Combustible Liquid means any liquid with a flash point at or above 100°F (38°C). These liquids fall into the following divisions:

- Class II includes liquids with flash points at or above 100°F (38°C) and below 140°F (60°C).
- Class IIIA includes liquids with flash points at or above 140°F (60°C) and below 200°F (93°C).

Note: Carefully apply foam to high viscosity materials heated above 200°F (93°C). Also, take care if applying foam to tanks that contain hot oils, burning asphalts or burning liquids that reach above the boiling point of water. Although the comparatively low water content of foam can cool such fuels favorably at a slow rate, it can also cause violent frothing, or "slop-over" of the contents of the tank.

The next step after finding out your liquid type involves considering the type of storage tank. Flammable liquids are stored in tanks of varying designs that depend on storage conditions, characteristics of the flammable liquid and other factors. Normally, those tanks include cone roof tanks, open top floating roof tanks, covered floating roof tanks and horizontal and multiple small tanks.

PROTECTION OF STORAGE TANKS

Fixed (Cone) Roof Tanks

In accordance with NFPA Standard No. 11, there are three accepted methods of protecting cone roof tanks:

- Surface (Foam Chamber) Method
- Subsurface Method
- Portable Foam Nozzle and Monitor Method

See the specific subsection and NFPA Standard No. 11 guidelines for limitations.

<u>Surface (Foam Chamber) Method:</u>
Foam chambers are generally considered Type II application devices which allow application of expanded

foam onto the product surface with minimal submergence of the foam and agitation of the product surface. See Figure 3-1. The foam chamber generally consists of a foam maker that is used to induce air into the foam solution and agitate the solution to create expanded foam and an expansion chamber that slows down the foam's velocity and allows it to expand before being discharged into the tank. The foam chamber is normally installed on the vertical shell of the tank approximately 8" (203 mm) to 12" (305 mm) below the roof line and shall be installed in such a manner that displacement of the roof is not likely to damage the foam chamber. The foam chamber shall be designed to prevent the tank contents from overflowing into the foam supply lines and shall contain an effective and durable seal, which ruptures under low pressure, preventing entrance of vapors into the foam outlets and pipelines. It shall also have a deflector to direct the foam discharge against the inside of the tank shell, resulting in a relatively gentle foam application on the fuel surface. Foam chambers can be used for protection of both hydrocarbon and polar solvent type products.

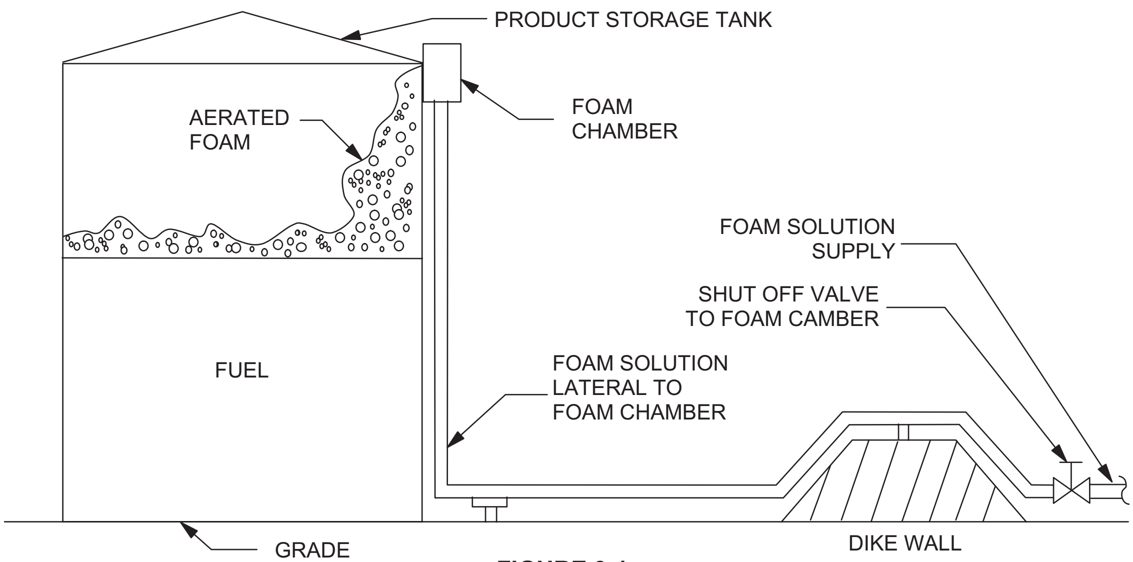


FIGURE 3-1
Surface Application Using Foam Chambers for Fixed Roof Tanks

When multiple foam chambers are required, they shall be equally spaced around the periphery of the tank as shown in Figure 3-2 and shall deliver approximately the same flow. Piping shall be installed in accordance with the requirements of NFPA Standard No. 11 and other applicable standards. Each foam chamber shall have a separately valved lateral terminating outside of the diked area and a minimum distance of 50' or one tank diameter (which ever is greater) from the tank.

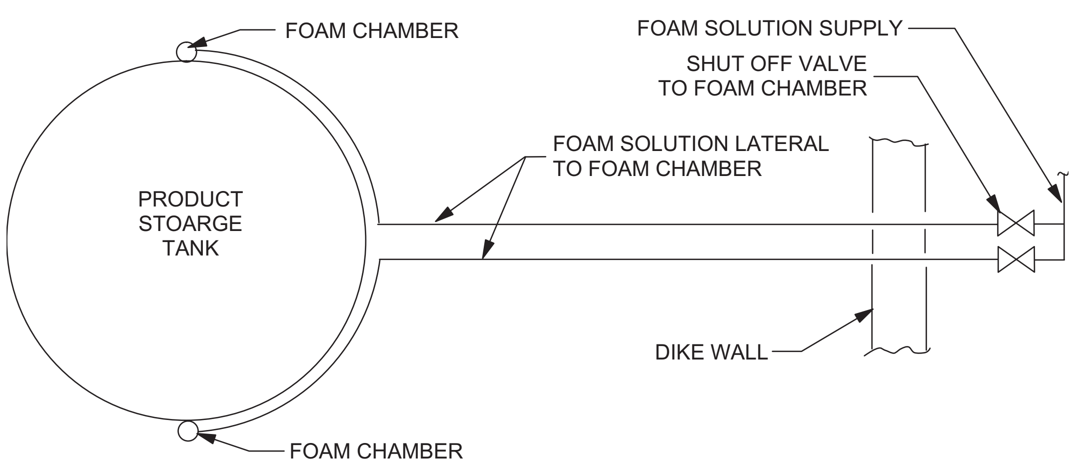


FIGURE 3-2
Surface Application Using Multiple Foam Chambers for Fixed Roof Tanks

Number and Size of Foam Chambers:
The number of foam chambers required is determined by the tank diameter. Where two or more chambers are required, they shall be equally spaced around the tank circumference. Each chamber shall be designed to deliver foam at approximately the same rate. The following table shows the number of chambers required for various diameter fixed (cone) roof tanks.

Chart 3-1
Number of Fixed Discharge Outlets Required Tanks Containing Hydrocarbons and Polar Solvents:

Tank Diameter (ft)	Tank Diameter (m)	Minimum Number Discharge Outlets
Up to 80	UP to 24	1
Over 80 to 120	Over 24 to 36	2
Over 120 to 140	Over 36 to 42	3
Over 140 to 160	Over 42 to 48	4
Over 160 to 180	Over 48 to 54	5
Over 180 to 200	Over 54 to 60	6

For tanks over 200" (60 m) in diameter, one additional outlet should be installed for each additional 5000 ft^2 (465 m^2) of product surface area or fractional part thereof.

Chamber size depends on the capacity required and the pressure available at the foam maker. To properly size the foam chambers and estimate the pressure required at the device inlet, see National Foam data sheets for sizing and performance data. Generally the higher the inlet pressure at the foam maker inlet, the better the foam quality.

Application Rate and Discharge Time:
The application rate and discharge time varies for the type of product being protected. The following chart covers the guidelines established by NFPA for both hydrocarbon and polar solvent type products. These are the minimum guidelines, however, National Foam engineering department should be consulted to confirm proper application rate.

Chart 3-2
Minimum Discharge Time and Application Rate Type II Discharge Devices on Fixed Roof Tanks:

Product	Flash Point	Minimum* Application Rate gpm/ft^2	Minimum* Application Rate lpm/m^2	Minimum Discharge Time
Hydrocarbon	100°F (37.8°C) to 140°F (93.3°C)	0.10	4.1	30
Hydrocarbon	Below100°F (37.8°C) or liquids heated above flash point	0.10	4.1	55
Crude Oil	Not Applicable	0.10	4.1	55
Polar Solvents	Not Applicable	See Mfg.	4.1	55

* Although most hydrocarbon products meet the minimum application rate of 0.10 gpm/ft^2 (4.1 lpm/m^2), there are some hydrocarbons that require higher application rates. For polar solvents, NFPA does not establish a minimum application rate. Although some polar solvents have a minimum application of 0.10 gpm/ft^2 (4.1 lpm/m^2), the minimum rate can vary drastically for polar solvents. Consult National Foam Engineering group for recommendations

Supplemental Protection:
In addition to the primary protection, supplemental hose streams are required for protection of fixed roof tanks. They are intended for protection of small spill fires. The minimum number of 50 gpm (189 lpm) hose streams required is shown on the following chart. The number of hose streams required is based on the largest single tank supplied by the foam fire protection system. The proportioning system shall be capable of flowing the required number of hose streams simultaneously with the main protection system, as well as being able to operate the supplemental hose streams without operation to the tank.

Chart 3-3
Supplemental Hose Streams Required

Diameter of Tank	# of Hose Streams
Up to 65 ft (19.5 m)	1
65 ft (19.5 m) to 120 ft (36 m)	2
Over 120 ft (36 m)	3

The following chart shows the minimum operating time for the supplemental hose streams. The foam concentrate supply shall be adequate to operate the required number of supplementary hose streams simultaneously for the period of time indicated.

Chart 3-4
Operating Times for Supplemental Hose Streams

Diameter of Tank	Minimum Operating Time
Up to 35 ft (10.5 m)	10 min
35 ft (10.5 m) to 95 ft (28.5 m)	20 min
Over 95 ft (28.5 m)	30 min

Design of System

The system design shall be based on the largest single hazard, when more than one tank is protected by the same system. It is not necessary to total all the individual requirements, since NFPA standards only require that the system be designed for protection of the greatest single hazard.

Criteria for designing a fire protection system for protection of fixed (cone) roof tank is as follows:

1. Identify the product stored in the tank.
2. Determine the best type of foam concentrate to use.
3. Determine the application rate required. This is based on the product stored and the type of foam concentrate.
4. Determine the product surface area to be protected. This is determined for the diameter of the tank.
5. Determine the solution requirement for protection of the tank. This is derived at by multiplying the product surface area by the application rate.
6. Determine the quantity and size of the foam chambers required. The number required is determined by the size of the tank. The discharge requirement is determined by dividing the total solution flow required by the number of discharge devices. See National Foam data sheets for performance data required for selection the proper size discharge device.
7. Determine required discharge time for operation to tank.
8. Determine the number of supplementary hose streams required and minimum operating time.
9. Determine the quantity of foam concentrate required for operation of the tank and hose streams.
10. Select the proper type of proportioning equipment to meet the needs of the system.

Design Example

Hazard Information:

Tank Type	Cone Roof
Tank Diameter	100' (30.4 m)
Tank Height	40' (12 m)
Product	Crude Oil
Proportioning System	To be determined
Available Water	1500 gpm (5678 lpm) @ 100 psi (6.9 bar)

1. Identify the product stored in the tank.

   Based on the information provided the contents of the tank being protected is crude oil.

2. Determine the best type of foam concentrate to use.

   When protecting a cone roof tank containing a hydrocarbon, the depth of the stored product and the potential of the fire burning for a long period of time, prior to application of foam, can result in a hot fuel layer at the top and a hot shell. This increases the difficulty for the foam to maintain a blanket and seal against the tank shell. Therefore, the agent of choice would be a fluoroprotein type foam concentrate.

3. Determine the application rate required. See Chart 3-2.

   The application rate for crude oil is 0.1 gpm/ft^2 (4.1 lpm/m^2).

4. Determine the product surface area to be protected. This is determined by the diameter of the tank.

   The tank diameter is 100' (30.4 m) which = 7854 ft^2 (729 m^2).

5. Determine the solution requirement for protection of the tank.

   7854 ft^2 (729 m^2) of surface area X 0.1 gpm/ft^2 (4.1 lpm/m^2) = 785 gpm (2971 lpm) of solution required.

6. Determine the quantity and size of the foam chambers required.

   Based on Chart 3-1, the 100 ft (30.4 m) diameter tank requires 2 foam chambers. The total solution flow required for this tank is 785 gpm (2971 lpm). To determine the size of the foam chamber divide the total flow by the number of foam chambers.

   785 gpm (2971 lpm) Solution flow divided by 2 (# of foam chambers) = 393 gpm (1487 lpm) per foam chamber.

   Select a foam chamber that will provide that flow at the available pressure. See National Foam data sheets for performance data required for selection the proper size discharge device.

7. Determine required discharge time for operation to tank.

   Based on Chart 3-2, Crude Oil requires 55 minutes operation.

8. Determine the number of supplementary hose streams required and minimum operating time.

Based on the supplementary hose stream Charts 3-3 & 3-4, the 100 ft (30.4 m) diameter tank requires 2 hose streams each flowing 50 gpm (189 lpm). The hose streams have to operate for a minimum of 30 minutes

9. Determine the quantity of foam concentrate required for operation of the tank and hose streams.

   Total quantity of foam concentrate required is as follows:

Solution rate for tank X % of injection X time	=	foam concentrate required for tank
Solution rate for H.S. X % of injection X time	=	foam concentrate required for H.S.
		Foam concentrate required total

Tank	785 gpm (2971 lpm) X .03 X 55 minutes	=	1295 Gal (4902 L)
H.S.	100 gpm (378 lpm) X .03 X 30 minutes	=	90 Gal (340 L)
Total		=	1385 gallons (5424 L)

   If actual application rate is higher than the design rate, a proportionate reduction can be taken but no less than 70% of the required operating time.

10. Select the proper type of proportioning equipment to meet the needs of the system.

Correct proportioning of the foam concentrate is essential to provide the foam solution flow required to protect the tank. While any of the proportioning methods described in the proportioning section of National Foam's Engineering Manual may be used, balanced pressure and in line balanced pressure proportioning systems are recommended for this type of application. These types of proportioning systems allow the foam storage tank to be filled during operation or immediately after and do not require an extensive refilling procedure as with bladder tanks. This is especially important if there are multiple tanks protected by the same system and the possibility exists that more than one tank in a group may be on fire.

The proportioning system shall be sized for operation to the largest tank in the system, plus simultaneous operation to the supplementary hose streams, but should also be capable of operating to the hose streams without discharging the tank system. The proportioning system shall have sufficient pressure to operate against the highest expected residual water pressure as determined by hydraulic calculation of the system piping arrangement. Detailed layout drawings, performance data of the various proportioning methods, and the requirements for the proportioning equipment are provided in the proportioning section of the National Foam Engineering Manual and data sheets.

Special Design Considerations:

- Storage of Monomers

Storage of monomers in fixed (cone) roof tanks presents a special problem when foam chambers are installed. Many common monomers react with water vapor resulting in polymerization of the product which forms solid deposits. Over a period of time the polymerization can build up, eventually blocking the foam chamber discharge. Tanks containing these types of products should have a discharge closure installed between the discharge outlet of the chamber and the tank. See Figure 3-3 The closure prevents product vapors from reaching the foam chamber body where moisture from condensation may exist, thereby inhibiting the formation of solid deposits that could prevent foam discharge into the tank. The Foam Chamber closure is designed to burst at a low pressure upon foam discharge, allowing foam flow into the tank. A regular maintenance program is recommended for inspection of the foam chamber discharge area and deflector for possible deposits.

Although the following list does not include all products which could have this effect, the following are examples of the Common Monomers Requiring Chamber Closures:

Acrolein
Acrylamide
Acrylic Acid
Acrylonitrile
Alkyl Acrylates (Alkyl=methyl, ethyl, etc.)
Alkyl Methacrylates (Alkyl=methyl, ethyl, etc.)
Chloroprene
Divinyl Benzene
Isoprene
Methacrolein
Methacrylamide
Methacrylonitrile
Methyl Styrene
Styrene (Vinyl Benzene)
Vinyl Acetate
Vinyl Butyrate
Vinyl Propionate
Vinyl Pyridine
Vinyl Toluene

- Gas Blankets

With today's concern for protection of our environment, many tanks have blankets of inert gas to reduce emission of vapors and reduce the risk of an explosion and fire. Special consideration must be given to these tanks to prevent premature rupture of the vapor seal. Special vapor seal or discharge closures may be required in these applications. Contact National Foam's engineering department for recommendations.

- Products Not Compatible with Foam Chamber Seals

With today's exotic chemicals and blends of chemicals, it is necessary to insure that the chemicals stored are compatible with the seal materials used in the manufacture of the foam chamber. National Foam uses an engineered vapor seal fabricated of graphite suspended in a phenolic resin binder, with viton seals.

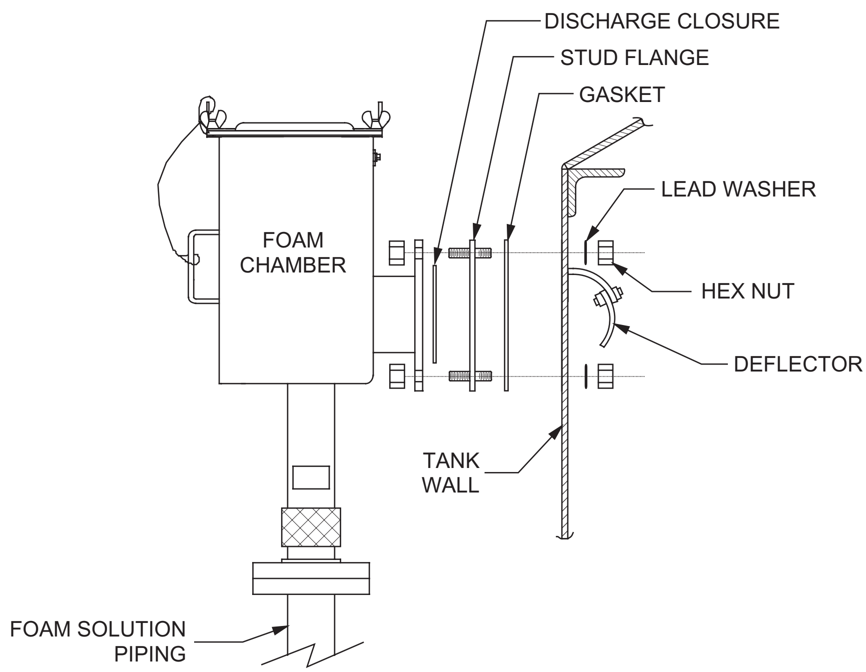


FIGURE 3-3
Typical Installation for Fixed Roof Tank Using Foam Chamber with Discharge Closure

SUBSURFACE INJECTION METHOD

(Base Injection)

Subsurface foam injection systems can be used for protection of vertical fixed roof tanks containing hydrocarbons, however, it is not recommended for use on Class 1A liquids or for tanks containing polar solvents. It is not recommended for use on tanks with floating roofs or pans since the roof offers potential blockage to the flow of foam especially, if the floor sinks. This type of application is less susceptible to damage from an explosion than other methods. Also, the rising foam tends to circulate the product assisting in cooling of the fuel at the surface. See Figure 3-4. The high back pressure foam makers used for subsurface injection require high operating pressures. In addition, the design of the downstream piping is critical to prevent excessive back pressure on the discharge line and excessive fuel pick-up if the maximum discharge velocity is exceeded.

NOTE: Subsurface foam systems are not recommended for use with hydrocarbon products having viscosities above 2000 SSU at 60°F (15°C). See NFPA standard No. 11 Note.

The type of foam concentrates suitable for use with this type of application method are limited. The expanded foam should be fairly fluid with an expansion between 2 to 4, have the ability to shed fuel pick-up, produce good sealability and burn back resistance of the foam blanket. Fluoroprotein type foam concentrates were designed for this type of application and are the best choice. Although conventional AFFF type foam concentrates have been used for this application, National Foam does not recommend their use. They tend to have higher fuel pick-up and less sealability. Standard protein based foams can not be used, as they tend to become saturated with fuel and burn along with the product. Some AR-AFFF's may be used but the fluoroprotein type foam concentrates provide the best performance.

Unlike the foam chambers, which include a foam maker mounted to the discharge device, subsurface injection uses high back pressure foam makers, located remote from the discharge outlet, to produce the expanded foam. When designing the system, consideration must be given to the pressure loss down stream of the foam maker. This type of foam maker will only tolerate a specific amount of back pressure, which is a percentage of the inlet pressure, before it will fail to produce foam. Back pressure includes head loss at the tank, plus friction loss through the piping down stream of the foam maker. National Foam manufactures a range of high back pressure foam makers to meet most flow and pressure requirements. National Foam high back foam makers will normally tolerate a maximum back pressure of 40% of the inlet pressure and operate with inlet pressures of 100 psi (6.89 bar) to 300 psi (20.68 bar). See National Foam data sheets for the specific flows and performance data for our high back pressure foam makers.

When designing the piping arrangement, it is recommended that a rupture disc be installed in the piping prior to each shell connection as shown in Figure 3-5. This will provide a positive shut-off to prevent any leakage of product into foam lines. Also, a test connection should be installed in each foam line, prior to the rupture disc, to allow testing of the system without discharging foam into the product.

As with fixed foam chambers, subsurface type protection also requires supplementary foam hose streams. See Charts 3-3 & 3-4 to determine the requirements.

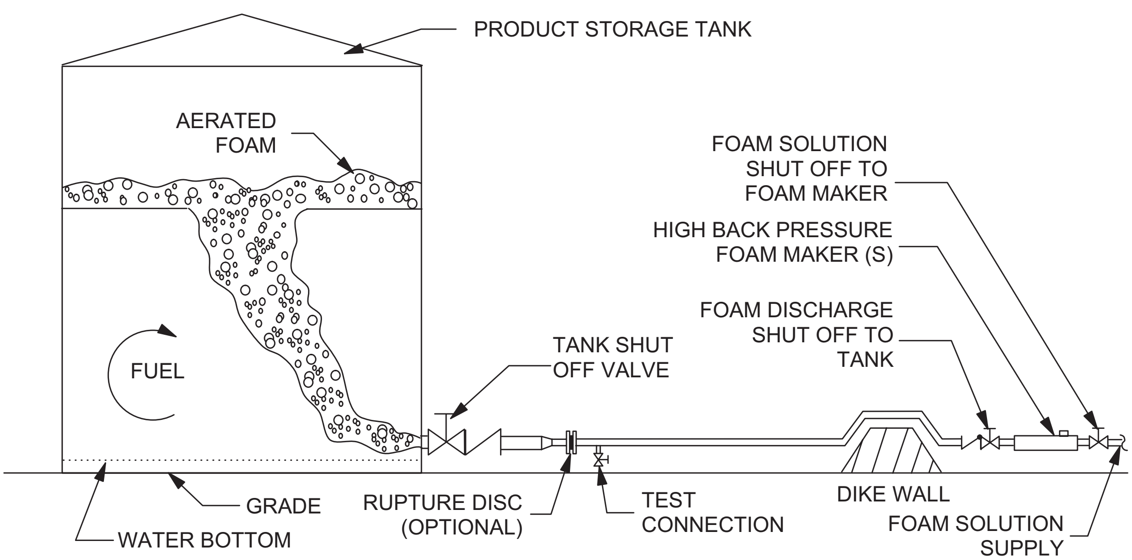
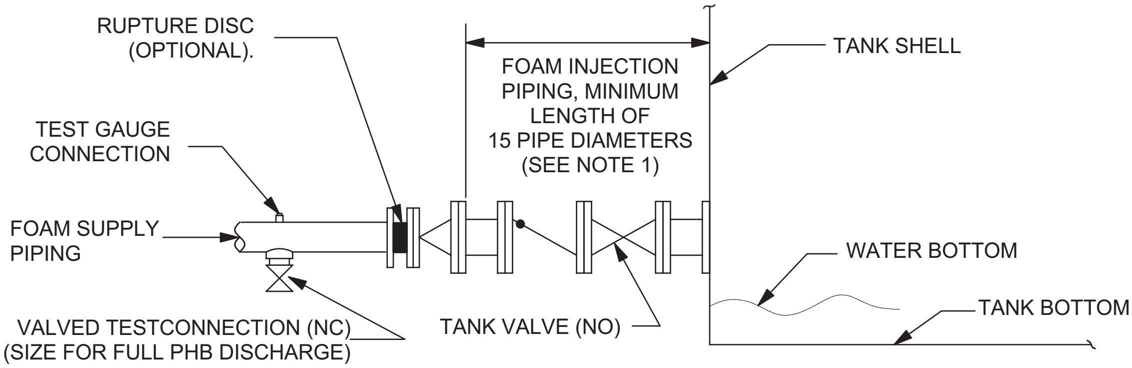


FIGURE 3-4
Sub-Surface Injection Application for Fixed Roof Tanks



NOTES:

1. Hydrocarbon entrapment in the foam is affected by the velocity of the foam as it enters the product. This veocity cannot exceed 10 ft/sec (3 m/sec) for Class 1B products or 20 ft/sec (6 m/sec) for all other classes. The length of the foam injection line must be a minimum of 15 pipe diameters of the foam discharge pipe size. This will assure that the foam has sufficient time to slow to the desired velocity.
2. Foam injection point(s) to be located a minimum of 1 ft (0.3 m) above tank water bottom or other product waste level.
3. Multiple foam injection points, when required, should be equally spaced around the tank circumference.
4. Test connection valve size is determined by each subsurface foam application requirement and is to be normally closed.
5. Special rupture disc assembly furnished by NF on request. Contact National Foam Engineering Dept. for specifications & recommendations.
6. Customer should specify most suitable piping layout for each product storage tank requiring subsurface application.
7. Rupture disc is to be removed and blanked off for testing foam system through valved test connection.

FIGURE 3-5
Typical Sub-Surface Injection Tank Connection

Foam Discharge Outlets:

The number of discharge outlets required is determined by the tank diameter. Where two or more discharges are required, they shall be equally spaced around the tank circumference. Each discharge shall be designed to deliver foam at approximately the same rate. Chart 3-5 shows the number of discharge outlets required for various diameter fixed (cone) roof tanks.

Discharge outlets can be the open end of the foam delivery line or product line, but shall be sized to limit the velocity of expanded foam at the point of discharge. The maximum velocity shall not exceed 10 ft/sec (3 m/sec) for Class IB products and Crude Oil and 20 ft/sec (6 m/sec) for all others. When multiple outlets are required they shall be sized to deliver approximately the same rate in order to provide uniform distribution of the foam. Outlets may be shell connections as shown in Figure 3-5 or a pipe manifold fed through a single shell connection as shown in Figure 3-6, located so that the maximum foam travel, on the product surface, does not exceed 100' (30.4 m). The elevation of the discharge outlet shall be a minimum of 1' (0.3 m) above the highest expected water level (water bottom) of the tank as shown in Figure 3-5.

Chart 3-5
Number of Fixed Discharge Outlets Required
For Subsurface Application to Tanks Containing Hydrocarbons

Tank Diameter		Minimum Number of Discharge Outlets	
(ft)	(m)	FP < 100°F (37.8°C)	FP 100°F (37.8°C) or <
Up to 80	UP to 24	1	1
Over 80 to 120	Over 24 to 36	2	1
Over 120 to 140	Over 36 to 42	3	2
Over 140 to 160	Over 42 to 48	4	2
Over 160 to 180	Over 48 to 54	5	2
Over 180 to 200	Over 54 to 60	6	3
Over 200	Over 60	6	3
		Plus1 outlet for each Additional 5000 ft^2 (465 m^2)	Plus1 outlet for each Additional 7500 ft^2 (697 m^2)

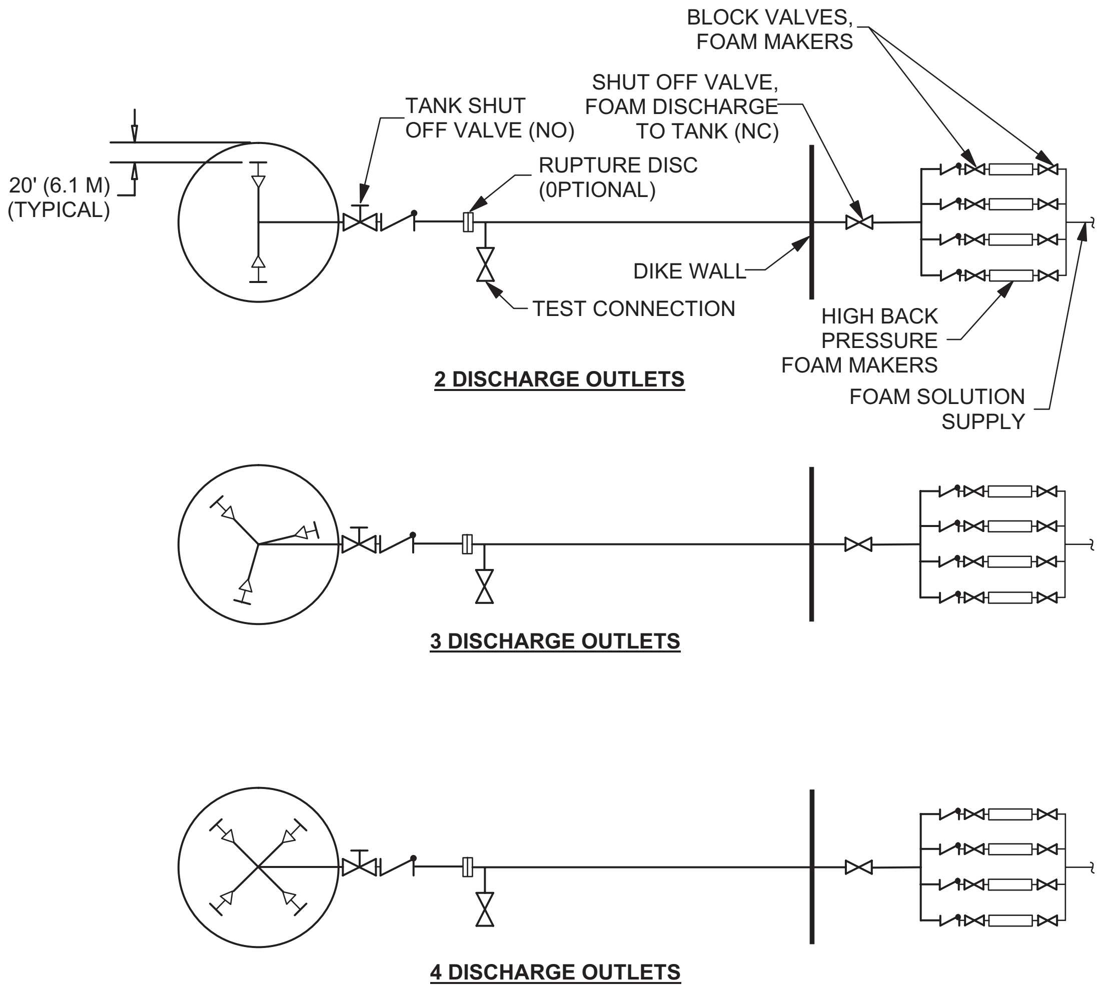


FIGURE 3-6
Typical Arrangement for Miltiple Discharges Using Internal Spider Arrangement

Application Rate and Discharge Time:
The application rate and discharge time varies for the type of product being protected. Chart 3-6 covers the guidelines established by NFPA for hydrocarbon type products. These are the minimum guidelines, however, National Foam Engineering Department should be consulted to confirm proper application rate.

Chart 3-6
Minimum Discharge Time and Application Rate
Subsurface Application on Fixed Roof Tanks

Product	Flash Point	Minimum* Application Rate gpm/ft²	Minimum* Application Rate lpm/m²	Minimum Discharge Time
Hydrocarbon	100°F (37.8°C) to 140°F (93.3°C)	0.10	4.1	30
Hydrocarbon	Below100°F (37.8°C) or liquids heated above flash point	0.10	4.1	55
Crude Oil	Not Applicable	0.10	4.1	55

* Although most hydrocarbon products meet the minimum application rate of 0.10 gpm/ft^2 (4.1 lpm/m^2), there are some hydrocarbons that require higher application rates. Consult National Foam Engineering group for recommendations. Also the maximum application rate shall not exceed 0.2 gpm/ft^2 (8.1 lpm/m^2).

Design of System

The system design shall be based on the largest single hazard, when more than one tank is protected by the same system. It is not necessary to total all the individual requirements, since NFPA standards only require that the system be designed for protection of the greatest single hazard.

Criteria for designing a fire protection system for protection for a fixed (cone) roof tank is as follows:

1. Identify the product stored in the tank.
2. Determine the best type of foam concentrate to use.
3. Determine the application rate required. This is based on the product stored and the type of foam concentrate.
4. Determine the product surface area to be protected. This is determined for the diameter of the tank.
5. Determine the solution requirement for protection of the tank. This is derived at by multiplying the product surface area by the application rate. After establishing the solution requirement, select the foam maker(s) required to meet the flow requirement.
6. Determine the quantity and size of the foam discharge outlets required. The number required is determined by the size of the tank. The size of discharge is determined by dividing the total solution flow required by the number of discharge outlets to determine the solution flow per outlet. Then the amount of expanded foam is determined by multiplying the solution rate per outlet X the expansion (4) to determine the flow of expanded foam per outlet. Determine the maximum allowable velocity. Then select a pipe size which will provide a velocity for the required flow of expanded foam, at or below the maximum velocity.
7. Confirm that back pressure down stream of the foam maker is with in the allowable limits
8. Determine required discharge time for operation to tank.
9. Determine the number of supplementary hose streams required and minimum operating time.
10. Determine the quantity of foam concentrate required for operation of the tank and hose streams.
11. Selection the proper type of proportioning equipment to meet the needs of the system.

Design Example

Hazard Information:

Tank Type	Cone Roof
Tank Diameter	100’ (30.4 m)
Tank Height	40’ (12 m)
Product	Crude Oil
Proportioning system	To be determined
Available water	1500 gpm (5678 lpm) @ 100 psi (6.9 bar)

1. Identify the product stored in the tank.

   Based on the information provided, the contents of the tank being protected is crude oil

2. Determine the best type of foam concentrate to use.

   Since we are protecting a cone roof tank containing a hydrocarbon, using subsurface injection, the agent of choice would be a fluoroprotein type foam concentrate.

3. Determine the application rate required. See Chart 3-6

   The application rate for crude oil is 0.1 gpm/ft^2 (4.1 lpm/m^2).

4. Determine the product surface area to be protected. This is determined by the diameter of the tank.

   The tank diameter is 100’ (30.4 m) which = 7854 ft^2 (729 m^2).

5. Determine the solution requirement for protection of the tank and select foam makers.

   7854 ft^2 (729 m^2) of surface area X 0.1 gpm/ft^2 (4.1 lpm/m^2) = 785 gpm (2971 lpm) of solution required.

   Based on this requirement we will select foammaker(s) with a capacity of 900 gpm (3406 lpm) @ 150 PSI (10.3 bar) which will provide a flow of 785 gpm (2971 lpm) @ 114 PSI (7.8 bar).

6. Determine the quantity and size of the foam discharge outlets required.

   Based on chart 3-5, the 100 ft (30.4 m) diameter tank containing crude oil requires 2 foam discharge outlets.

   The total solution flow required for this tank is 785 gpm (2971 lpm). To determine the solution flow per discharge outlet, divide the total flow by the number of discharge outlets.

785 gpm (2971 lpm) Solution flow / 2 (# of discharge outlets) = 393 gpm (1487 lpm) per discharge outlet.

Multiply the solution flow per outlet X the expansion to determine the amount of expanded foam discharged per outlet.

393 gpm (1487 lpm) solution X 4 (expansion) = 1572 gpm (5950lpm) expanded foam per discharge.

Determine maximum velocity allowed.

Based on the product classification, the maximum velocity for crude oil is 10 ft/sec (3.1 m/sec).

Determine pipe size that will not exceed this velocity.

Velocity Formula

English $V(ft/sec) = \frac{gpmfoam}{d^2} \times 0.4085$ [d = pipe ID (in)]

Metric $V(m/sec) = \frac{lpmfoam}{d^2} \times 21.22$ [d = pipe ID (mm)]

Based on the above calculation, 8" pipe has a velocity of 8.6 ft/sec (2.6 m/sec). This is the smallest pipe size which can be used for each discharge outlet without exceeding the 10 ft/sec maximum velocity. Therefore this tank requires two 8" discharge outlets.

Note: Although smaller piping would exceed the velocity limitations, the friction loss may not require the 8" pipe be run the entire distance from the foam maker to the tank. In cases where smaller pipe is used for most of the piping run, the pipe would have to be increased to the required size approximately 15 pipe diameters prior to the outlet. In this case, the last 10' (3.1 m) [8" X 15 = 120" divided by 12" = 10'] before it discharges into the product would have to be 8" pipe.

7. Confirm that back pressure down stream of the foam maker is with in the allowable limits

   In this example, the foam makers will flow of 785 gpm (2971 lpm) with an inlet pressure of 114 PSI (7.8 bar). The foam maker selected has an allowable back pressure (per NF data sheets) of 40% of the inlet pressure. With an inlet pressure of 114 PSI (7.8 bar) the allowable back pressure would be 45.6 PSI (3.1 bar) [114 psi inlet pressure X 0.40 (40%) = 45.6 psi ABP]. When sizing the piping between the tank and the foam maker, the calculated piping loss plus the head loss at the tank can not exceed the ABP.

8. Determine required discharge time for operation to tank.

   Based Chart 3-6, Crude Oil requires 55 minutes operation.

9. Determine the number of supplementary hose streams required and minimum operating time.

   Based on the supplementary hose stream Charts 3-3 & 3-4. The 100 ft (30.4 m) diameter tank requires 2 hose streams each flowing 50 gpm (189 lpm). The hose streams have to operate for a minimum of 30 minutes.

10. Determine the quantity of foam concentrate required for operation of the tank and hose streams.

   Total quantity of foam concentrate required is as follows:

Solution rate for tank X % of injection X time	=	foam concentrate required for tank
Solution rate for H.S. X % of injection X time	=	foam concentrate required for H.S.
		Foam concentrate required total

Tank	785 gpm (2971 lpm) X .03 X 55 minutes	=	1295 Gal (4902 L)
H.S.	100 gpm (378 lpm) X .03 X 30 minutes	=	90 Gal (340 L)
Total		=	1385 gallons (5424 L)

   If actual application rate is higher than the design rate, a proportionate reduction can be taken but no less than 70% of the required operating time

11. Select the proper type of proportioning equipment to meet the needs of the system.

Correct proportioning of the foam concentrate is essential to provide the foam solution flow required to protect the tank. While any of the proportioning methods described in the proportioning section of National Foam's Engineering Manual may be used, balanced pressure and in line balanced pressure proportioning systems are recommended for this type of application. These types of proportioning systems allow the foam storage tank to be filled during operation or immediately after and do not require an extensive refilling procedure as with bladder tanks. This is especially important if there are multiple tanks protected by the same system and the possibility exists that more than one tank in a group may be on fire.

The proportioning system shall be sized for operation to the largest tank in the system, plus simultaneous operation to the supplementary hose streams, but should also be capable of operating to the hose streams without discharging the tank system. The proportioning system shall have sufficient pressure to operate against the highest expected residual water pressure as determined by hydraulic calculation of the system piping arrangement. Detailed layout drawings, performance data of the various proportioning methods, and the requirements for the proportioning equipment are provided in the proportioning section of the National Foam Engineering Manual and data sheets.

PORTABLE FOAM NOZZLE AND MONITOR METHOD

Portable foam nozzles are generally used as auxiliary protection in conjunction with a fixed piping system. They are suitable, under limited conditions, for primary protection of small fixed roof storage tanks. Where acceptable to the authority having jurisdiction, portable foam nozzles may be used for protection of fixed roof tanks containing hydrocarbons, not over 30 ft (9m) in diameter nor over 20 ft (6m) in height. Monitor-mounted foam nozzles may be used for protection of fixed roof tanks up to 60 ft (18m) in diameter. Neither portable or monitor mounted nozzles are considered acceptable for protection of tanks containing polar solvents regardless of size.

Application Rate and Discharge Time:
The application rate and discharge time varies for the type of product being protected. Chart 3-7 covers the guidelines established by NFPA for hydrocarbon type products. These are the minimum guidelines, however National Foam engineering department should be consulted to confirm proper application rate.

The number of nozzles required for primary protection of tanks has not been defined by NFPA. However, in determining the location and number of nozzles required, factors such as the wind (speed & direction), nozzle range, and thermal updraft shall be considered. Because of the many variables involved, it may be advisable to locate additional nozzles on different sides of the tank, even though it may exceed the flow requirements or required number of nozzles, especially with fixed monitor locations. Although only the required flow needs to be discharged, it would allow attack of the fire from the most advantageous location. See National Foam data sheets for specific monitor and nozzle performance data.

Design Example

Hazard Information:

Tank Type	Cone Roof
Tank Diameter	60’ (18 m)
Tank Height	30’ (9 m)
Product	Crude Oil
Proportioning system	To be determined
Available water	1500 gpm (5678 lpm) @ 150 psi (6.9 bar)

A 60 ft (18m) diameter tank containing crude oil requires an application rate of 453 gpm (1715 lpm) of solution 0.16 gpm/ft^2 (6.5 lpm/m^2). One 500 gpm monitor-mounted nozzle with an inlet pressure of 150 psi (10.34 bar) would be adequate to meet the flow requirement for the tank. On the basis of the above table, the quantity of foam concentrate required would be calculated as:

2827 ft^2 x 0.16 gpm/ft x 3% x 65 minutes = 882 gallons of foam concentrate

(263 m^2 x 6.5 lpm/m x 3% x 65 minutes = 3334 liters

Chart 3-7
Minimum Discharge Time and Application Rate
Portable Nozzle & Monitor Protection for Fixed Roof Tanks Containing Hydrocarbons

		Minimum* Application Rate		Minimum Discharge
Product	Flash Point	gpm/ft^2	lpm/m^2	Time
Hydrocarbon	100°F (37.8°C) to 140°F (93.3°C)	0.16	6.5	50
Hydrocarbon	Below100°F (37.8°C) or liquids heated above flash point	0.16	6.5	65
Crude Oil	Not Applicable	0.16	6.5	65

Proportioning

Correct proportioning of the foam concentrate is essential to provide the foam solution flow required to protect the tank. While any of the proportioning methods described in the proportioning section of National Foam's Engineering Manual may be used, balanced pressure and in line balanced pressure proportioning systems are recommended for this type of application. These types of proportioning systems allow the foam storage tank to be filled during operation or immediately after and do not require an extensive refilling procedure as with bladder tanks. This is especially important if there are multiple tanks protected by the same system and the possibility exists that more than one tank in a group may be on fire.

If an eductor type proportioning system is used, the flow from the eductor(s) must be matched with an appropriate nozzle(s). In addition, piping losses, head loss & nozzle pressure must be maintained within the ABP of the eductor to insure proper system operation. Because of the potential for problems that effect back pressure and possible system operation, we do not normally recommend the use of eductors with a nozzle type system.

The proportioning system shall be sized for operation to the largest tank in the system, plus simultaneous operation to the supplementary hose streams, but should also be capable of operating to the hose streams without discharging the tank system. The proportioning system shall have sufficient pressure to operate against the highest expected residual water pressure as determined by hydraulic calculation of the system piping arrangement. Detailed layout drawings, performance data of the various proportioning methods, and the requirements for the proportioning equipment are provided in the proportioning section of the National Foam Engineering Manual and data sheets.

OPEN TOP FLOATING ROOF TANKS

Open top roof tanks are defined as vertical cylindrical tanks without fixed roofs that have double deck or pontoon type floating roofs and comply with the requirements set forth in NFPA 30. With this type of tank, the roof floats on the product surface allowing the product to be exposed only at the area between the roof and the tank shell. This exposed area is normally sealed using a mechanical type shoe (panograph) seal (Figure 3-7) or a tube seal (Figure 3-8). As shown in Figure 3-9, a metal weather shield may be installed over the tube seal. In order to reduce product emissions released into the atmosphere, many tanks today have secondary seals installed. Secondary seals may be manufactured from combustible or non-combustible materials (Figure 3-10).

Tanks with floating roofs as described above are not likely to experience the roof sinking and full involvement of the entire product surface area. As a result, most fires occur in the seal area of these tanks. Based on experience, these tanks do not justify the installation of a fixed system to protect the entire surface area. Therefore, when a system is installed it is normally designed to protect the seal area of the tank.

Seal protection is intended for tanks with very stable roofs that will not easily sink or become damaged in a fire. Tanks with the following types of roofs do not fall under the design standards for protection of open top floating roof tanks.

- Roofs made from floating diaphragms
- Roofs made from plastic blankets
- Roofs made from plastic or other flotation material, even if encapsulated in metal or fiberglass
- Roofs that rely on flotation device enclosures that can be easily submerged if damaged
- Pan roofs

The roof styles described above are considered to have a high possibility of the roof sinking or becoming damaged, exposing a part of or the entire product surface area, resulting in a full surface fire. Therefore, tanks with these types of roofs shall have the fire protection system designed to protect the entire surface area. The following design standards apply to tanks containing hydrocarbons or polar solvents. The authority having jurisdiction should be consulted to determine the acceptable level of fire protection required for the specific hazard.

Three techniques are available for application of foam to open top floating roof tanks.

- The first application utilizes a permanent fixed piping network to discharge foam above the mechanical seal, weather shield or secondary seal.

- The second application utilizes a permanent fixed piping network to discharge foam below the mechanical seal directly onto the flammable liquid, behind the weather shield directly onto the tube seal or beneath the secondary seal directly on the primary seal.

- Portable Handline Method uses a fixed piping system on the outside of the tank shell to which portable nozzles are attached during a fire.

Supplementary foam hose streams should be provided for spill fire protection, regardless of application method. The requirements are the same as for fixed roof tanks. See tables in under fixed roof requirements for number required and discharge times. Additional foam concentrate supplies should be provided to allow simultaneous operation with the tank system.

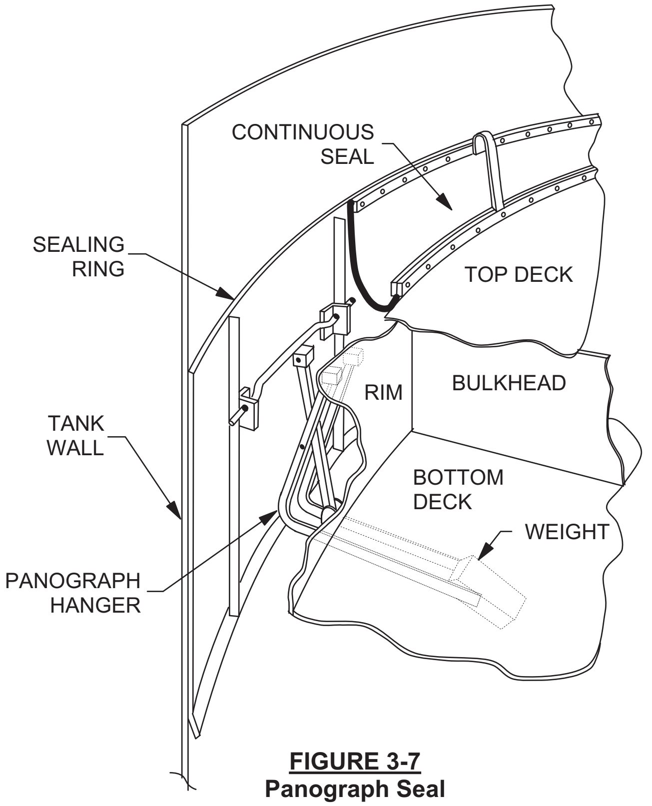


FIGURE 3-7
Panograph Seal

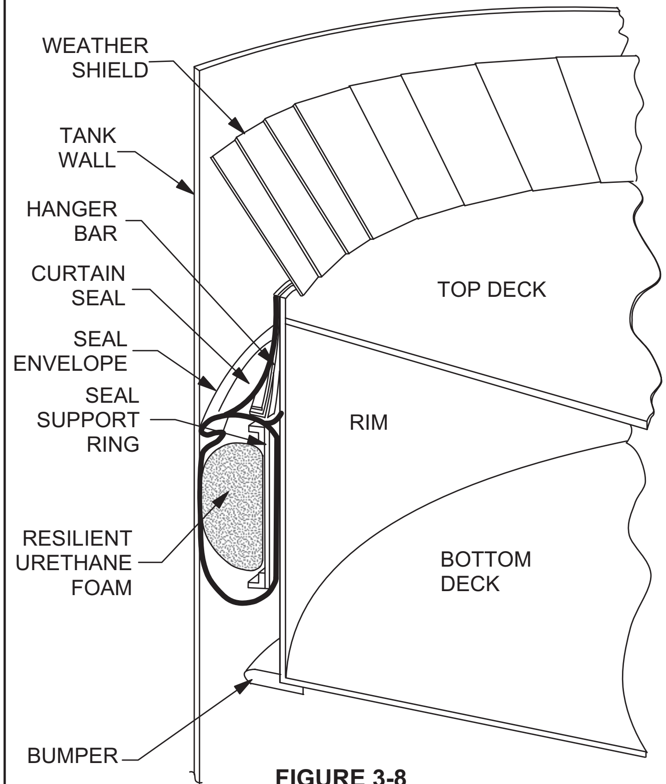


FIGURE 3-8
Tube Seal

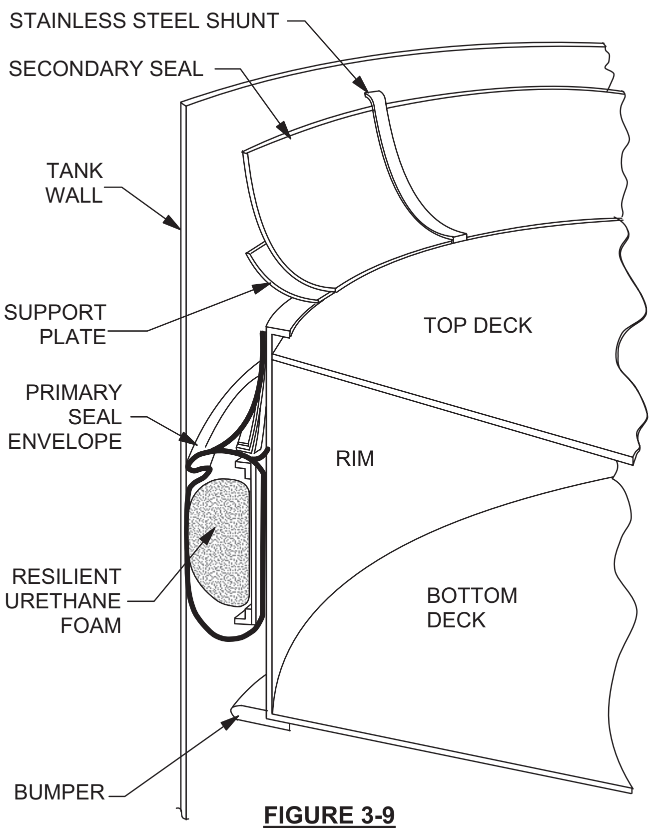


FIGURE 3-9
Double Seal System

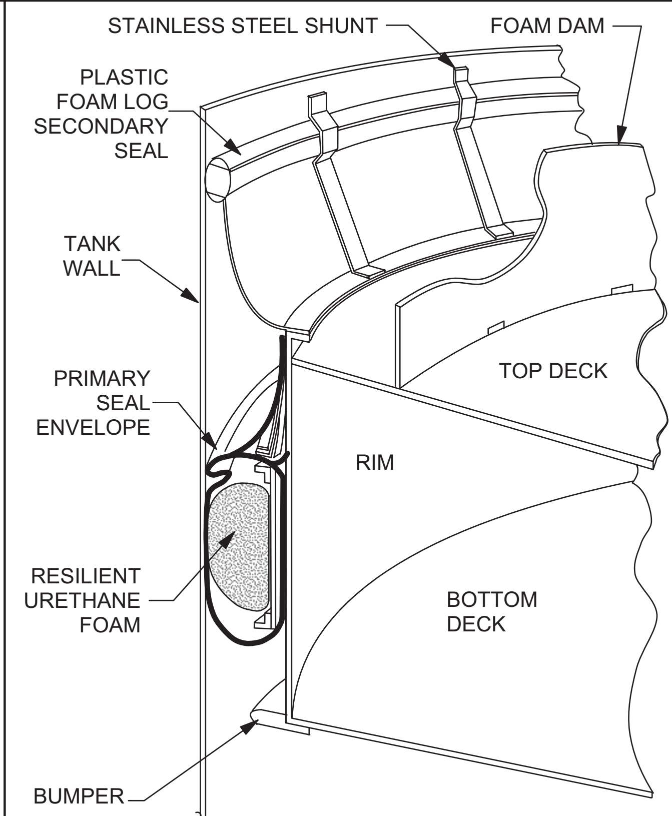


FIGURE 3-10
Double Seal System
Using A Plastic Foam Log (Secondary Seal)

Over the Seal Method:
This method requires a foam dam designed to retain the foam over the seal or weather shield while allowing it to flow laterally to the fire area. The foam dam shall be a minimum of 12“ (305mm) in height and extend a minimum of 2” (51mm) above the secondary seal or 2” (51mm) above any burnout panels in the secondary seal. To allow for extended spacing of the discharge devices, most tanks fabricated today have a foam dam with a minimum height of 24” (610mm). The foam dam shall be located a minimum of 12” (305mm) but not more than 24” (610mm) from the tank shell. Complete construction details of the foam dam may be found in the Appendix of NFPA Standard No 11.

There are two methods of applying foam to the seal area of the roof. The first uses fixed discharge devices mounted around the circumference of the tank. See Figure 3-11. In this application the discharge devices are typically connected to a ring main installed around the circumference of the tank which is supplied by a single lateral. The discharge devices may have an integral deflector designed to direct the foam down the inside of the tank shell to the seal area of the roof. See Figure 3-12. Other devices may be required to be installed on a wind shield. A deflector installed on the roof side of the wind shield directs the foam against the wind shield and down the inside of the tank shell to the seal area of the roof. Deflectors shall be designed to allow the roof to pass over the deflector without damaging it. See Figure 3-13.

The second application method uses discharge devices mounted on the floating roof. The discharge devices are typically connected to a ring main installed near the edge of the roof. The ring main is supplied from a catenary system that consists of a flexible hose that attaches to ring main and rides up and down with the stairway. The top end of this hose terminates at the upper platform where it connects to a pipe running vertically down the shell and outside the dike. See Figure 3-14 & 3-15. Some tanks may have the discharge devices feed from a manifold at the center of the tank which is connected to a hose running from for the tank roof to the base of the tank. See Figure 3-16 & 3-17. Regardless of the application system selected, the design requirements are the same.

Note: National Foam does not recommend the installation of vapor seals for the discharge outlets, because the discharges are fed from a common ring main, allowing inconsistent pressures to occur at each discharge, which may result in failure of all vapor seals to rupture.

The number of foam discharge devices required is based on the circumference of the tank and the height of the foam dam. If a foam dam with a minimum height of 24” (610mm) is installed, the maximum spacing between discharges increases. See Chart 3-8 for maximum spacing for each type of seal.

The rate of application and supply of foam concentrate shall be calculated using the area of the annular ring between the circular dam and the tank shell. See Chart 3-8 for application rates and discharge times.

Chart 3-8

Top of Seal Fixed Foam Discharge Protection for Open Top Floating Roof Tanks

Seal Type	Illustration	Minimum Application Rate gpm/ft^2	Minimum Application Rate lpm/m^2	Minimum Disch. time (min)	Maximum Spacing Between Discharge Outlets 12” (305 mm) Foam Dam ft (m)	Maximum Spacing Between Discharge Outlets 24” (610 mm) Foam Dam ft (m)
Mechanical Shoe Seal	A	0.3	12.2	20	40 (12.2)	80 (24.4)
Tube Seal w/ Metal Weather Shield	B	0.3	12.2	20	40 (12.2)	80 (24.4)
Full or Partly Combustible Secondary Seal	C	0.3	12.2	20	40 (12.2)	80 (24.4)
All Metal Secondary Seal	D	0.3	12.2	20	40 (12.2)	80 (24.4)

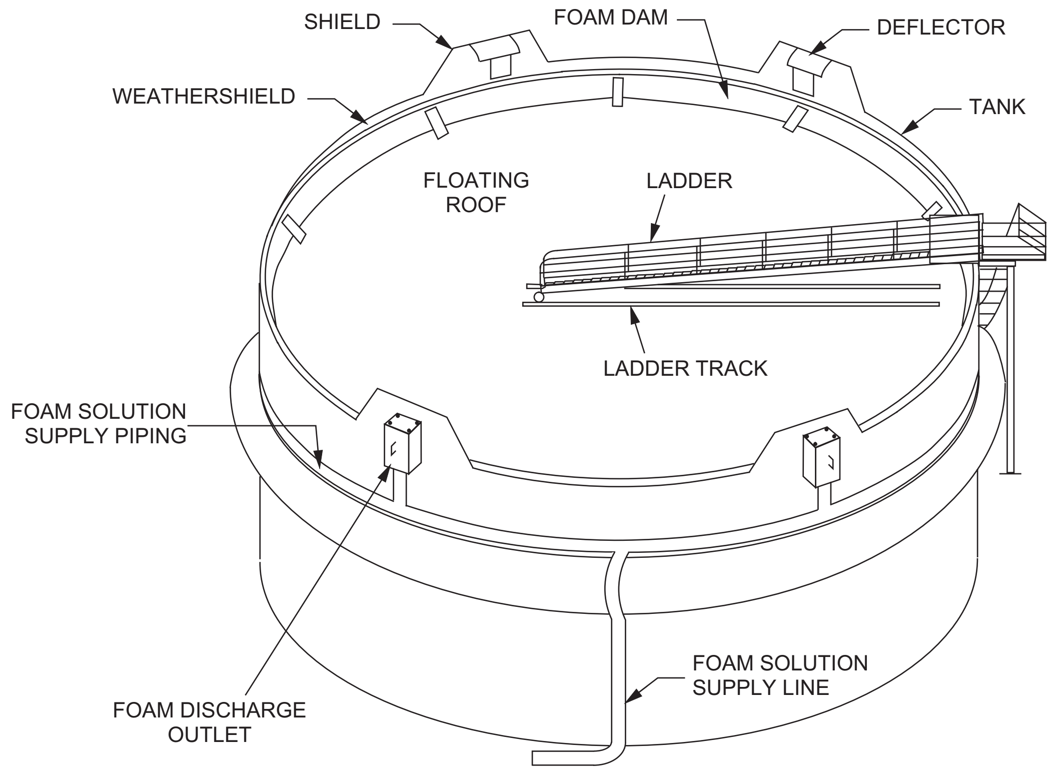
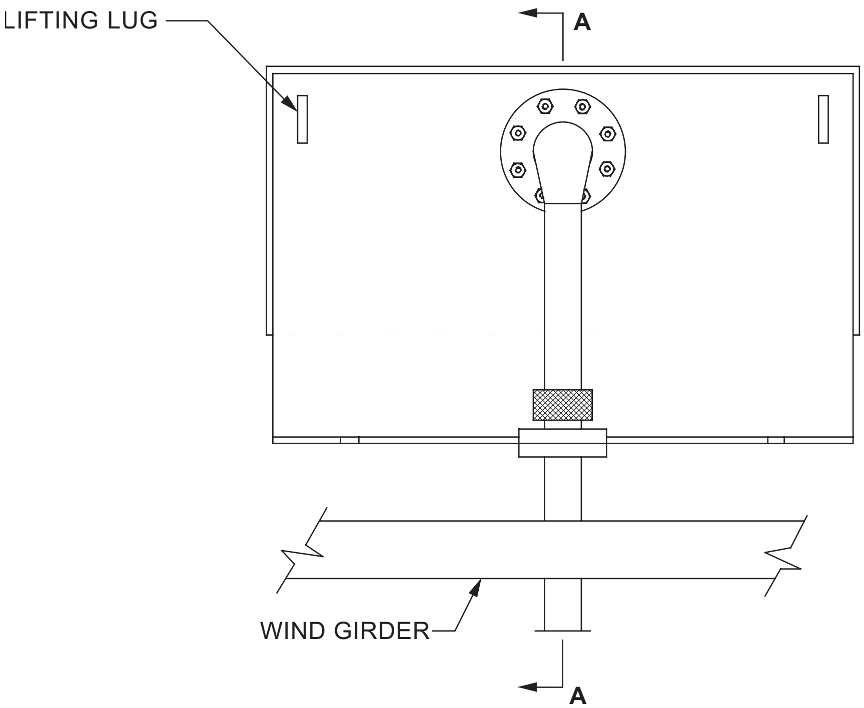
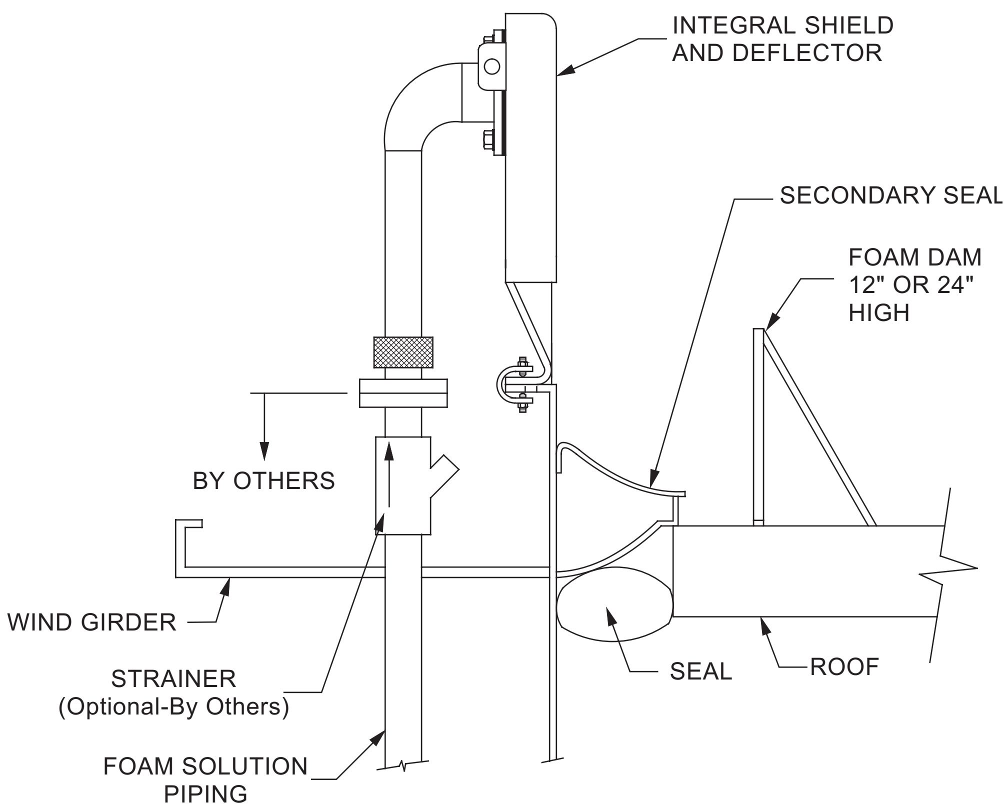


FIGURE 3-11
Typical Installation for Floating Roof Tank Seal Protection
Using Fixed Discharge Outlets Mounted Around Circumference Of Tank Shell





VIEWA-A

FIGURE 3-12

Typical Installation for Floating Roof Tank Over Seal Protection Using Discharge Outlets Around Circumference Of Tank Shell Foam Maker with Integral Shield & Deflector

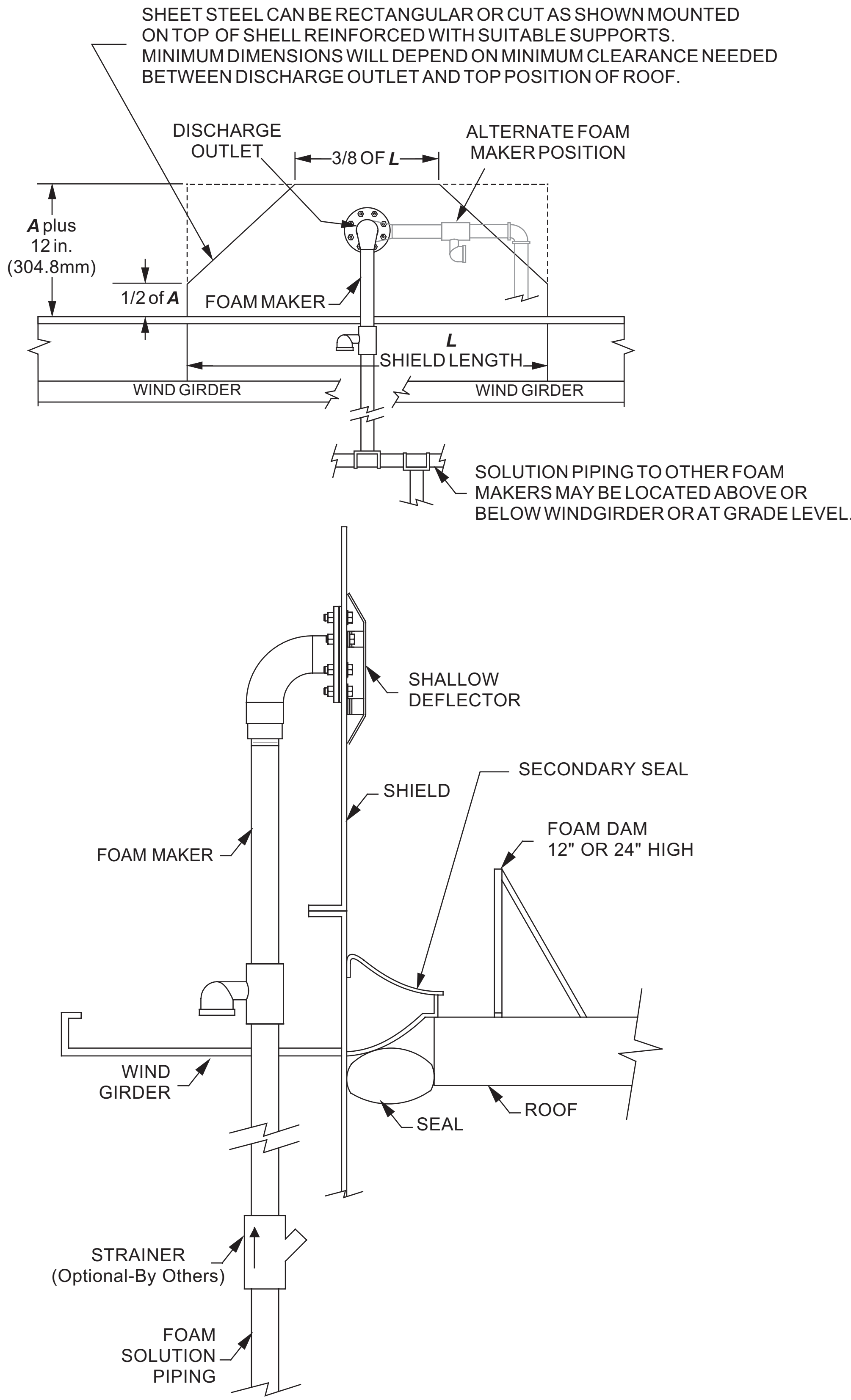


FIGURE 3-13

Typical Installation For Floating Roof Tank Over Seal Protection Using Discharge Outlets Around Circumference of Tank Shell

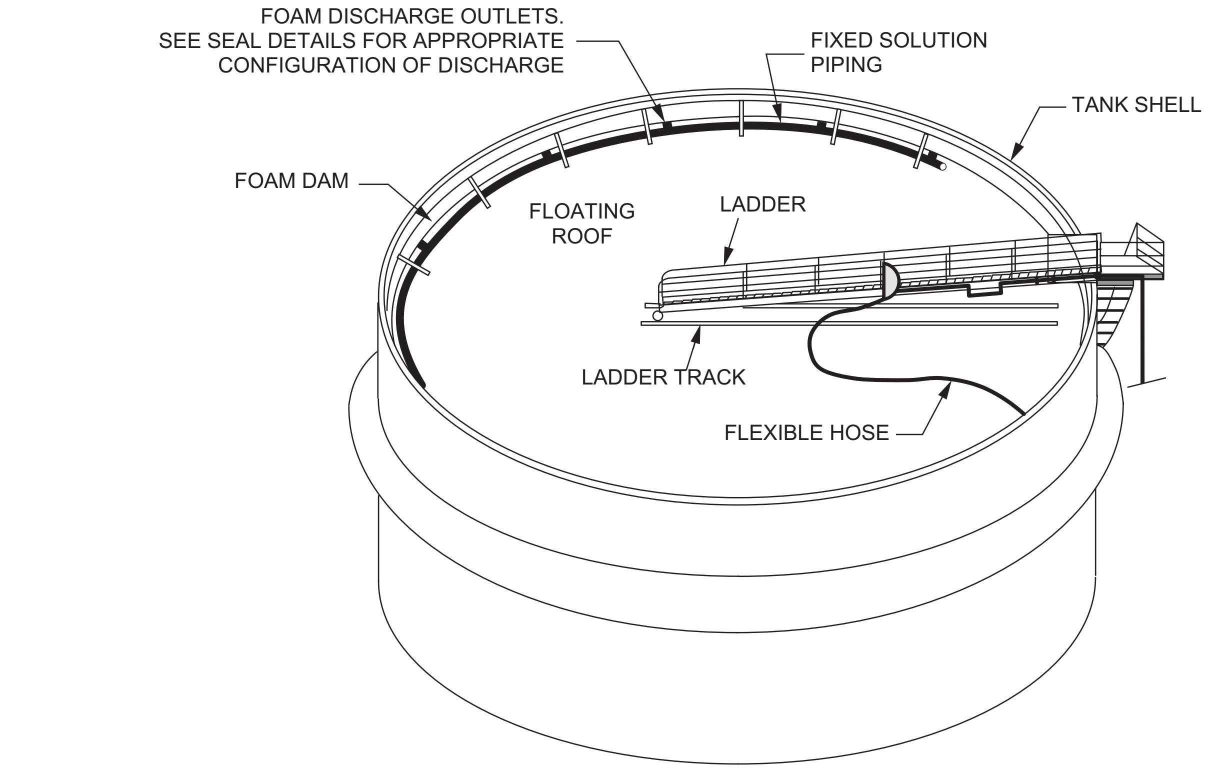


FIGURE 3-14
Typical Installation for Floating Roof Tank Seal Protection
Using Roof Mounted Discharge Outlets & Catenary System

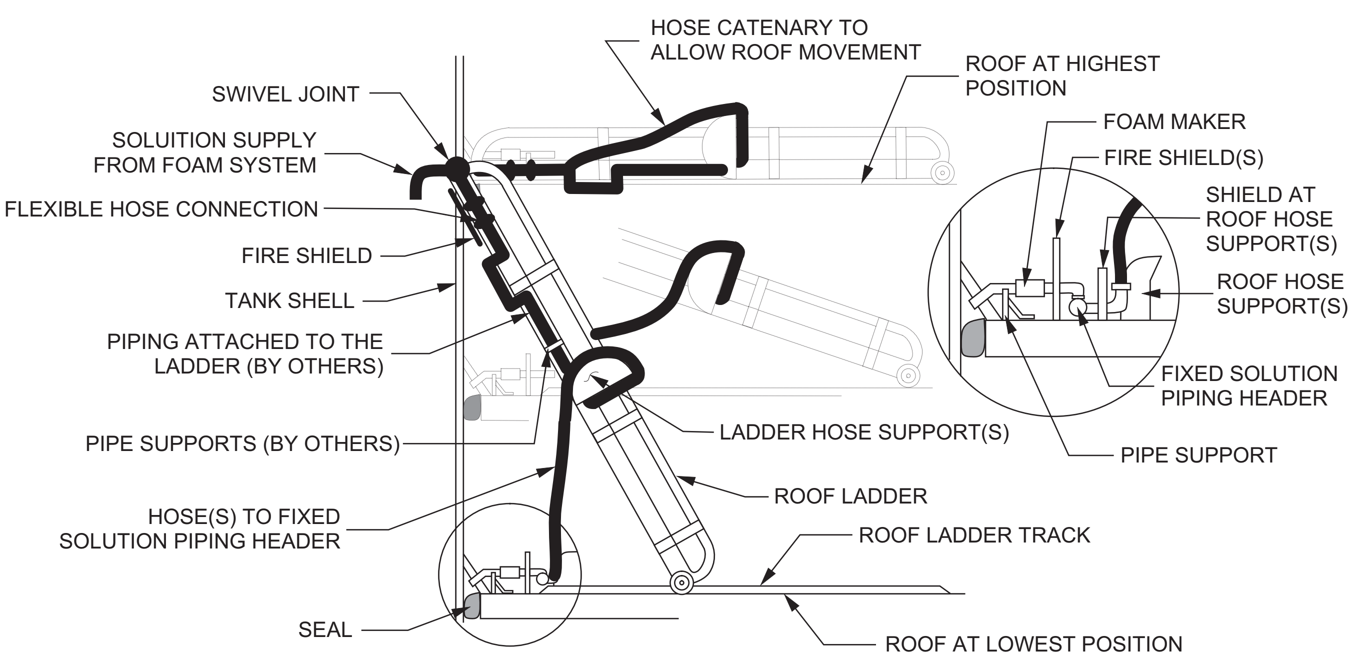


FIGURE 3-15
Typical Catenary System Arrangement for Floating Roof Tanks

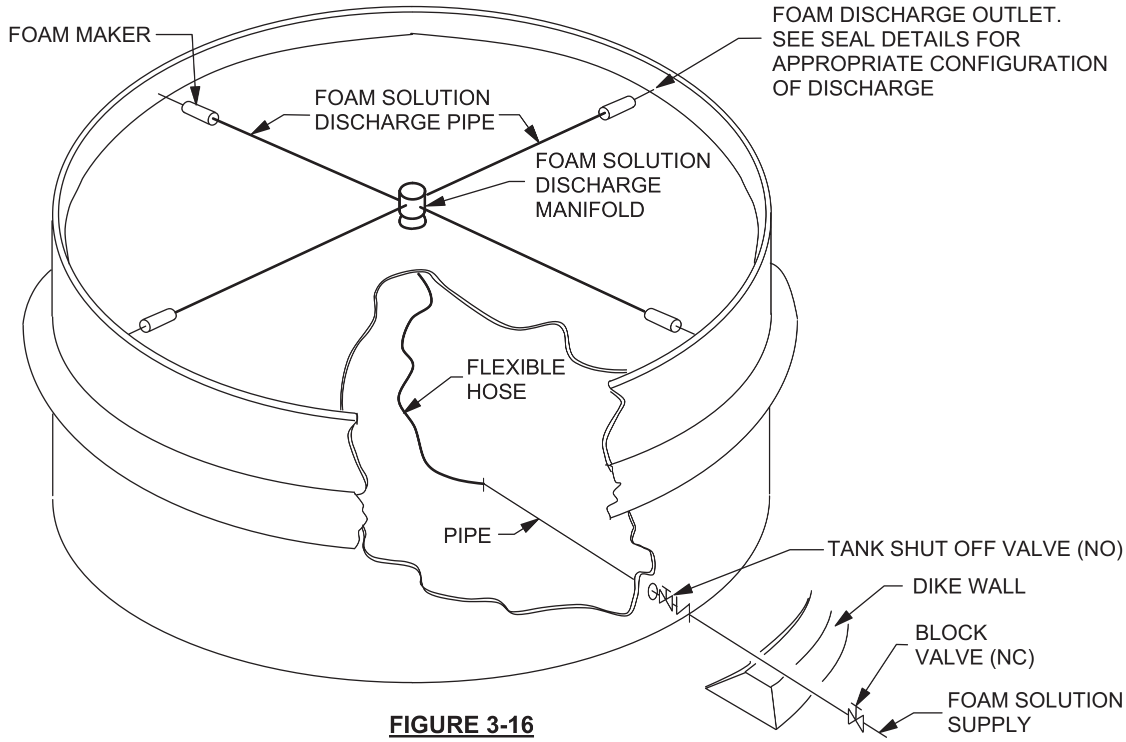


FIGURE 3-16

Typical Installation for Floating Roof Tank Seal Protection Using Flexible Hose Through Bottom of Roof and Roof Mounted Foam Makers

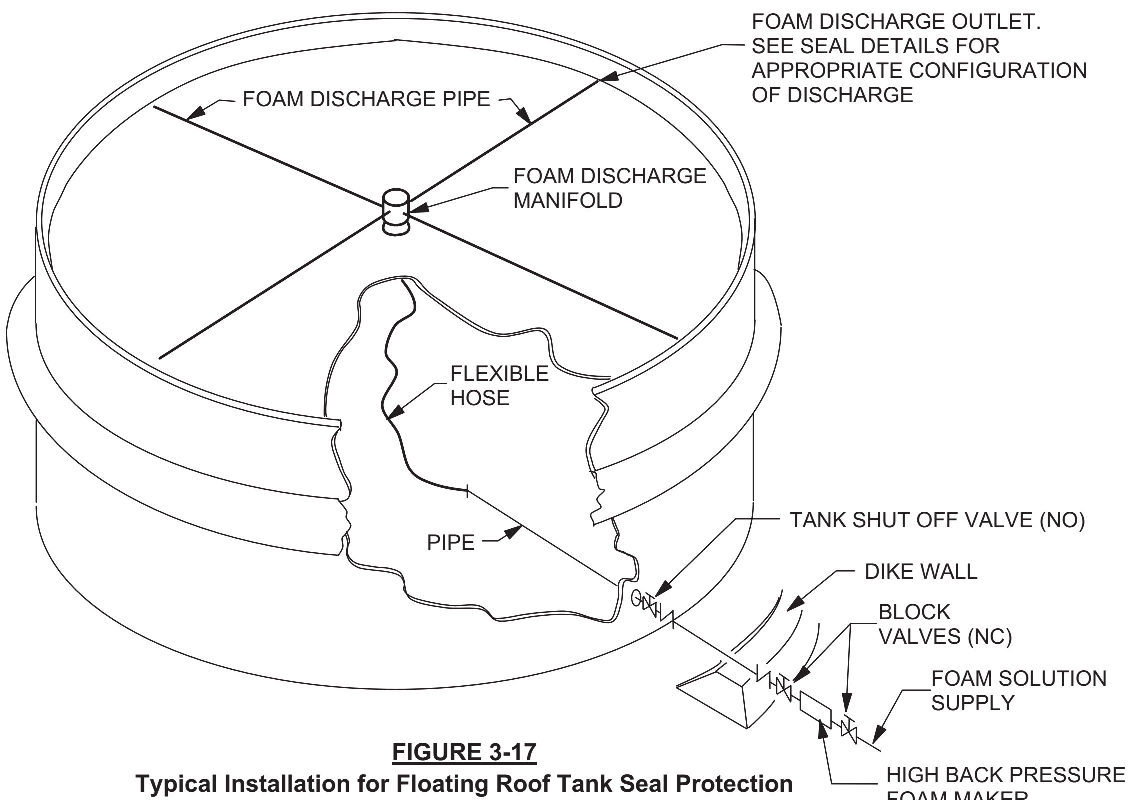
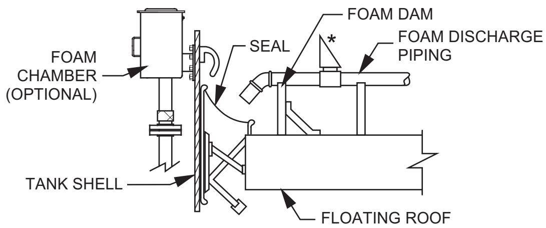
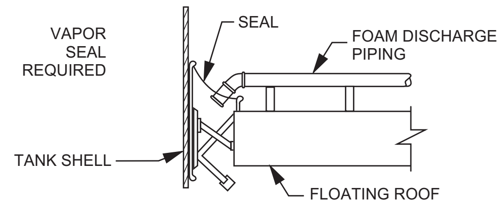


FIGURE 3-17

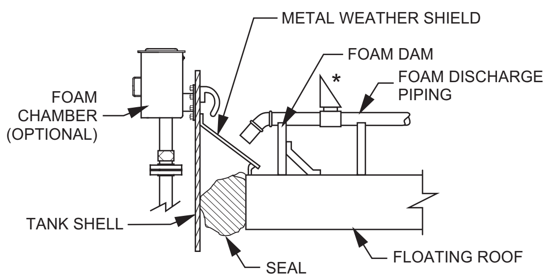
Typical Installation for Floating Roof Tank Seal Protection Using Foam Supplied From High Back Pressure Foam Maker Flexible Hose Through Bottom of Roof and Manifold



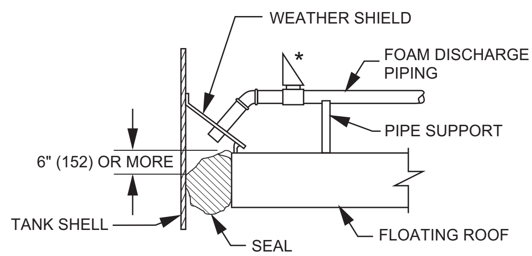
Detail - A: Top of Seal Application
Foam Discharge Above Mechanical Shoe Seal



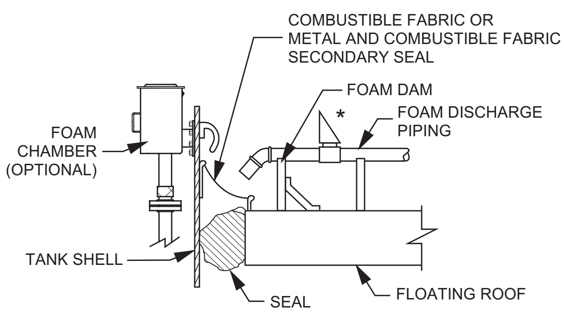
Detail - B: Below Seal Application
Foam Discharge Below Mechanical Shoe Seal - No Foam Dam



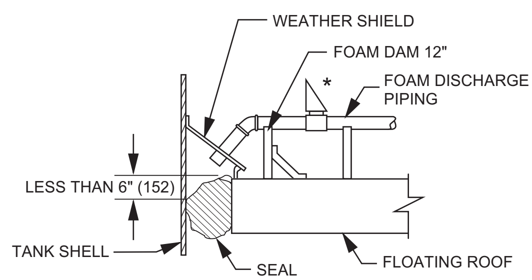
Detail - A1: Top of Seal Application
Foam Discharge Above Metal Weather Shield



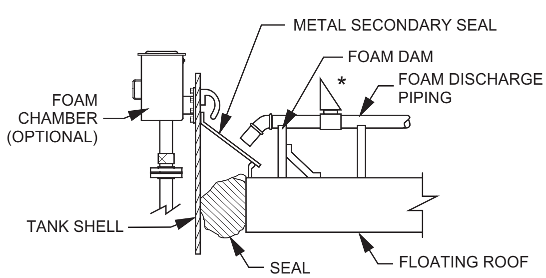
Detail - C: Below Shield Application
Foam Discharge Below Metal Weather Shield
Top of Seal 6" (152) or More Below Top of Floating Roof



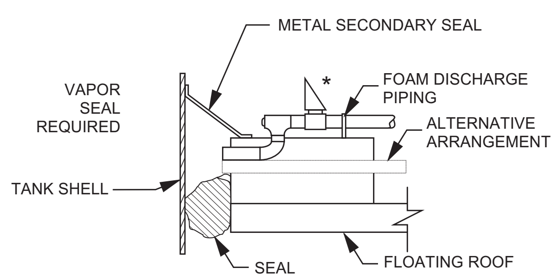
Detail - A2: Top of Seal Application
Foam Discharge Above Secondary Combustible Fabric Seal,
Or Metal with Combustible Fabric Sections



Detail - C1: Below Shield Application
Foam Discharge Below Metal Weather Shield
Top of Seal Less Than 6" (152) Below Top of Floating Roof



Detail - A3: Top of Seal Application
Foam Discharge Above Metal Secondary Seal



Detail - D: Below Seal Application
Foam Discharge Below Metal Secondary Seal

Foam Application Below Seal Not Suitable If Secondary Seal is Constructed of Any Combustible Fabric Sections. (Refer to Application Above Seal, Details A2 and A3)

*Foam maker for use when foam solution is supplied.

FIGURE 3-18

Foam System Arrangements for Catenary and Multiple Chamber Systems

Design of System

The system design shall be based on the largest single hazard, when more than one tank is protected by the same system. It is not necessary to total all the individual requirements, since NFPA standards only require that the system be designed for protection of the greatest single hazard.

Criteria for designing a fire protection system for protection for an open top floating roof tank is as follows:

1. Identify the product stored in the tank.
2. Determine the best type of foam concentrate to use.
3. Determine the application rate required. This is based on the type of seal and the method of applying foam to the annular area.
4. Determine the annular area to be protected. This is determined by subtracting the diameter of the foam dam from the diameter of the tank.
5. Determine the solution requirement for protection of the tank. This is derived by multiplying the annular area by the application rate.
6. Determine the quantity and size of the foam discharge devices required. The quantity of discharges is determined by the circumference of the tank and the maximum spacing allowed based on the height of the foam dam. The solution requirement for each discharge device is derived by dividing the total solution flow required by the number of discharge devices. See National Foam data sheets for performance data required to select the proper size discharge device.
7. Determine required discharge time for operation to tank.
8. Determine the number of supplementary hose streams required and minimum operating time.
9. Determine the quantity of foam concentrate required for operation of the tank and hose streams.
10. Selection the proper type of proportioning equipment to meet the needs of the system.

Design Example

Hazard Information:

Tank Type	Open Top Floating Roof
Tank Diameter	100' (30.4 m)
Tank Height	40' (12 m)
Product	Crude Oil
Height of Foam Dam	24" (610mm)
Width of Annular area	24" (610mm)
Type of seal	Tube Seal with Weather Shield
Proportioning system	To be determined
Available water	1500 gpm (5678 lpm) @ 100 psi (6.9 bar)

1. Identify the product stored in the tank.

   Based on the information provided the contents of the tank being protected is crude oil.

2. Determine the best type of foam concentrate to use.

   When protecting a floating roof tank containing a hydrocarbon, the depth of the stored product and the potential of the fire burning for a long period of time, prior to application of foam, can result in a hot fuel layer at the top and a hot shell. This increases the difficulty for the foam to maintain a blanket and seal against the tank shell. Therefore, the agent of choice would be a fluoroprotein type foam concentrate.

3. Determine the application rate required. See Chart 3-8

   The application rate for crude oil is 0.3 gpm/ft^2 (12.2 lpm/m^2).

4. Determine the annular area to be protected. This is determined by taking the diameter of the tank less the diameter of the foam dam.

   Area of 100' (30.4 m) diameter tank = 7854 ft^2 (729 m^2)

   Area of 96' (29 m) diameter foam dam = 7238 ft^2 (672 m^2)

   Annular area = 616 ft^2 (57 m^2)

5. Determine the solution requirement for protection of the tank.

   616 ft^2 (57 m^2) of surface area X 0.3 gpm/ft^2 (12.21 lpm/m^2) = 185 gpm (700 lpm) of solution required.

6. Determine the quantity and size of the discharge devices required.

   Based on Chart 3-8, the tank can use 80 ft (24.4 m) spacing between discharge devices based on a 24" (610mm) high foam dam.

   The 100 ft (30.4 m) diameter tank has a circumference of 314 ft (96 m).

   Circumference = Π X *Diameter* (ft).

   Number of discharge devices is determined by dividing the circumference by the maximum spacing.

314 ft. (96m) divided by 80 ft. (24m) = 3.9 or 4 discharge devices required.

To determine the size of the discharge device, divide the total flow by the number of discharge devices.

185 gpm (700 lpm) solution flow divided by 4 (# of discharge devices) = 47 gpm (178 lpm) per discharge device.

Select a discharge device that will provide that flow at the available pressure. See National Foam data sheets for performance data required for selection the proper size discharge device.

7. Determine required discharge time for operation to tank.

   Based on Chart 3-8, the tube seal with weather shield requires 20 minutes operation.

8. Determine the number of supplementary hose streams required and minimum operating time.

   Based on the supplementary hose stream Charts 3-3 & 3-4. The 100 ft (30.4 m) diameter tank requires 2 hose streams each flowing 50 gpm (189 lpm). The hose streams have to operate for a minimum of 30 minutes.

9. Determine the quantity of foam concentrate required for operation of the tank and hose streams.

   Total quantity of foam concentrate required is as follows:

Solution rate for tank X % of injection X time	=	foam concentrate required for tank
Solution rate for H.S. X % of injection X time	=	foam concentrate required for H.S.
		Foam concentrate required total

Tank	185 gpm (700 lpm) X .03 X 20 minutes	=	111 Gal (420 L)
H.S.	100 gpm (378 lpm) X .03 X 30 minutes	=	90 Gal (340 L)
Total		=	191 gallons (723 L)

   If actual application rate is higher than the design rate, a proportionate reduction can be taken but no less than 70% of the required operating time.

10. Selection the proper type of proportioning equipment to meet the needs of the system.

    Correct proportioning of the foam concentrate is essential to provide the foam solution flow required to protect the tank. While any of the proportioning methods described in the proportioning section of National Foam's Engineering Manual may be used, balanced pressure and in line balanced pressure proportioning systems are recommended for this type of application. These types of proportioning systems allow the foam storage tank to be filled during operation or immediately after and do not require an extensive refilling procedure as with bladder tanks. This is especially important if there are multiple tanks protected by the same system and the possibility exists that more than one tank in a group may be on fire.

    The proportioning system shall be sized for operation to the largest tank in the system, plus simultaneous operation to the supplementary hose streams, but should also be capable of operating to the hose streams without discharging the tank system. The proportioning system shall have sufficient pressure to operate against the highest expected residual water pressure as determined by hydraulic calculation of the system piping arrangement. Detailed layout drawings, performance data of the various proportioning methods, and the requirements for the proportioning equipment are provided in the proportioning section of the National Foam Engineering Manual and data sheets.

Under the Seal Method:
This application does not require installation of a foam dam except if the tube seal is less than 6"(152 mm) below the top of the pontoon, however the foam must be supplied from the roof of the tank and can not be discharged from the shell. Foam is discharged directly under the seal or secondary seal. In this application the edge of the pontoon or secondary seal performs like a foam dam to retain the foam over the seal while allowing it to flow laterally to the fire area. The discharge devices are typically connected to a ring main, installed near the edge of the roof and is supplied from a catenary system that consists of a flexible hose that attaches to the ring main and rides up and down with the stairway. The top end of this hose terminates at the platform at the top of the ladder, where it connects to a pipe running vertically down the shell and outside the dike. See Figures 3-14 & 3-15. Some tanks may have the discharge devices feed from a manifold at the center of the tank which is connected to a hose running from the tank roof to the base of the tank. See figures 3-16 & 3-17.

Note: National Foam does not recommend the installation of vapor seals for the discharge outlets, because the discharges are fed from a common ring main, allowing inconsistent pressures to occur at each discharge, which may result in failure of all vapor seals to rupture.

The number of foam discharge devices required is based on the circumference of the tank and the type of seal.

The rate of application and supply of foam concentrate shall be calculated using the area of the annular ring between the edge of the pontoon and the tank shell. In applications requiring a foam dam, it shall be calculated on the annular area between the foam dam and the tank shell. See Table below for application rates and discharge times.

Chart 3-9

Below the Seal Fixed Foam Discharge Protection for Open Top Floating Roof Tanks

Seal Type	Illustration	Minimum Application Rate gpm/ft^2	lpm/m^2	Minimum Disch. time (min)	Max. Spacing Between Discharge Outlets
Mechanical shoe seal	A	0.5	20.4	10	130 ft (39 m) Foam Dam Not Required
Tube seal w/ more than 6" (153mm) between top of tube and top of pontoon	B	0.5	20.4	10	60 ft (18 m) Foam Dam Not Required
Tube seal w/ less than 6" (153mm) between top of tube and top of pontoon	C	0.5	20.4	10	60 ft (18 m) Foam Dam Required
Tube seal w/ foam discharge below metal secondary seal*	D	0.5	20.4	10	60 ft (18 m) Foam Dam Not Required

* Secondary seal acts a foam dam

Design of System

The system design shall be based on the largest single hazard, when more than one tank is protected by the same system. It is not necessary to total all the individual requirements, since NFPA standards only require that the system be designed for protection of the greatest single hazard.

Criteria for designing a fire protection system for protection for a open top floating roof tank is as follows:

1. Identify the product stored in the tank.
2. Determine the best type of foam concentrate to use.
3. Determine the application rate required. This is based on the type of seal and the method of applying foam to the annular area.
4. Determine the annular area to be protected. This is determined by subtracting the diameter of the roof or foam dam (depending on application method) from the diameter of the tank.
5. Determine the solution requirement for protection of the tank. This is derived at by multiplying the annular area by the application rate.
6. Determine the quantity and size of the foam discharge devices required. The quantity of discharges is determined by the circumference of the tank and the maximum spacing allowed based on the type of seal. The solution requirement for each discharge device is derived by dividing the total solution flow required by the number of discharge devices. See National Foam data sheets for performance data required to select the proper size discharge device.
7. Determine required discharge time for operation to tank.
8. Determine the number of supplementary hose streams required and minimum operating time.
9. Determine the quantity of foam concentrate required for operation of the tank and hose streams.
10. Selection the proper type of proportioning equipment to meet the needs of the system.

Design Example

Hazard Information:

Tank Type	Open top floating roof
Tank Diameter	100' (30.4 m)
Tank Height	40' (12 m)
Product	Crude Oil
Height of Foam Dam	Not Applicable
Width of Annular area	12" (305mm)
Type of seal	shoe seal
Proportioning system	To be determined
Available water	1500 gpm (5678 lpm) @ 100 psi (6.9 bar)

1. Identify the product stored in the tank

   Based on the information provided the contents of the tank being protected is crude oil

2. Determine the best type of foam concentrate to use.

   When protecting a floating roof tank containing a hydrocarbon, the depth of the stored product and the potential of the fire burning for a long period of time, prior to application of foam, can result in a hot fuel layer at the top and a hot shell. This increases the difficulty for the foam to maintain a blanket and seal against the tank shell. Therefore, the agent of choice would be a fluoroprotein type foam concentrate.

3. Determine the application rate required. See chart 3-9.

   The application rate for crude oil is 0.5 gpm/ft^2 (20.4 lpm/m^2).

4. Determine the annular area to be protected. This is determined by taking the diameter of the tank less the diameter of the foam dam.

Area of 100' (30.4 m) diameter tank	=	7854 ft^2 (729 m^2)
Area of 98' (30 m) diameter foam dam	=	<u>7542</u> ft^2 (700 m^2)
Annular area	=	312 ft^2 (29 m^2)

5. Determine the solution requirement for protection of the tank.

   312 ft^2 (29 m^2) of surface area X 0.5 gpm/ft^2 (20.4 lpm/m^2) = 156 gpm (590 lpm) of solution required

6. Determine the quantity and size of the discharge devices required.
   Based on Chart 3-9, the tank can use 130 ft (40m) spacing between discharge devices based on the shoe type seal.

   The 100 ft (30.4 m) diameter tank has a circumference of 314 ft (96 m).

   Circumference = Π X *Diameter* (ft).

   Number of discharge devices is determined by dividing the circumference by the maximum spacing.

   314 ft. (96m) divided by 130 ft. (40m) = 2.4 or 3 discharge devices required.

   To determine the size of the discharge device, divide the total flow by the number of discharge devices.

   156 gpm (590 lpm) solution flow divided by 3 (# of discharge devices) = 52 gpm (197 lpm) per discharge device.

   Select a discharge device that will provide that flow at the available pressure. See National Foam data sheets for performance data required for selection the proper size discharge device.

7. Determine required discharge time for operation to tank.

   Based on Chart 3-9, the shoe seal requires 10 minutes operation.

8. Determine the number of supplementary hose streams required and minimum operating time.

   Based on the supplementary hose stream Charts 3-3 & 3-4. The 100 ft (30.4 m) diameter tank requires 2 hose streams each flowing 50 gpm (189 lpm). The hose streams have to operate for a minimum of 30 minutes.

9. Determine the quantity of foam concentrate required for operation of the tank and hose streams.

   Total quantity of foam concentrate required is as follows:

   Solution rate for tank X % of injection X time = foam concentrate required for tank
   Solution rate for H.S. X % of injection X time = foam concentrate <u>required for H.S.</u>
   Foam concentrate required total

Tank	156 gpm (590 lpm) X .03 X 10 minutes	=	47 Gal (178 L)
H.S.	100 gpm (378 lpm) X .03 X 30 minutes	=	<u>90 Gal (340 L)</u>
Total		=	137 gallons (519 L)

   If actual application rate is higher than the design rate, a proportionate reduction can be taken but no less than 70% of the required operating time.

10. Select the proper type of proportioning equipment to meet the needs of the system.

    Correct proportioning of the foam concentrate is essential to provide the foam solution flow required to protect the tank. While any of the proportioning methods described in the proportioning section of

National Foam's Engineering Manual may be used, balanced pressure and in line balanced pressure proportioning systems are recommended for this type of application. These types of proportioning systems allow the foam storage tank to be filled during operation or immediately after and do not require an extensive refilling procedure as with bladder tanks. This is especially important if there are multiple tanks protected by the same system and the possibility exists that more than one tank in a group may be on fire.

The proportioning system shall be sized for operation to the largest tank in the system, plus simultaneous operation to the supplementary hose streams, but should also be capable of operating to the hose streams without discharging the tank system. The proportioning system shall have sufficient pressure to operate against the highest expected residual water pressure as determined by hydraulic calculation of the system piping arrangement. Detailed layout drawings, performance data of the various proportioning methods, and the requirements for the proportioning equipment are provided in the proportioning section of the National Foam Engineering Manual and data sheets.

Portable Handline Method:
The application methods described previously are designed to apply foam to the entire seal. The handline method allows fire fighters to apply foam directly to the fire area. In this application, a hose station with two 1-1/2" valved hose connections is mounted on the platform at the top of the stairs. See Figure 3-19. The operator(s) can use the hand lines to attack the fire directly where it is burning, either from the windgirder or directly from the roof. To protect the fire fighters and provide a safe base of operation, a fixed discharge device shall be installed under the platform. This discharge shall have a minimum flow of 50 gpm (198.3 lpm) and shall be designed to cover the seal area a minimum of 40' (12.2 m) on either side of the platform. This application requires that a foam dam be installed. Also, a railing should be installed on the windgirder to protect the fire fighters. NFPA does not address application rates or minimum operating times since this is spot application and there is no way to determine the extent of the fire. National foam recommends that an adequate supply of foam concentrate be available to protect the entire seal area at an application rate of 0.3 gpm/ft^2 (12.2 lpm/m^2). NFPA normally limits this type of protection to tanks not exceeding 250' (76.2m) in diameter. See National Foam Data sheets for performance data on appropriate nozzles and discharge devices.

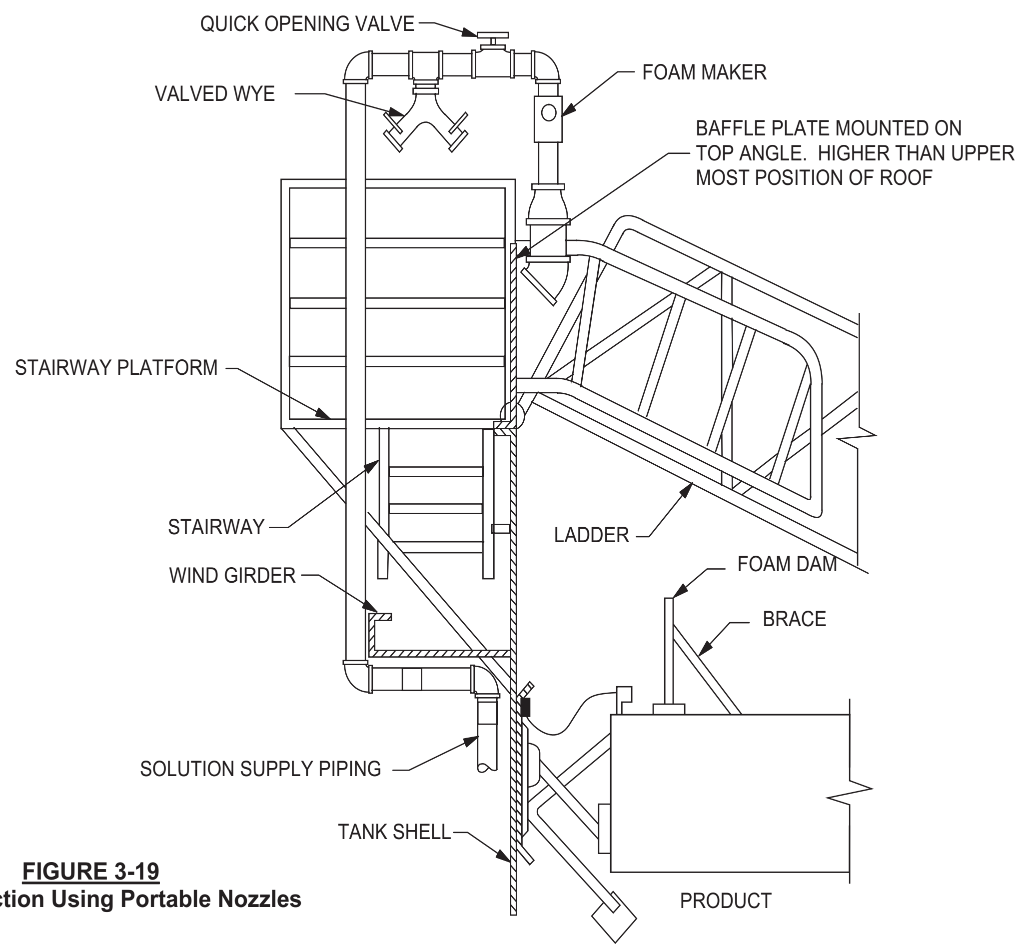


FIGURE 3-19
Seal Protection Using Portable Nozzles

COVERED FLOATING ROOF TANKS

Covered (internal) floating roof tanks are defined as vertical cylindrical tanks with fixed roofs (cone or geodesic dome) equipped with a ventilation system and containing double deck or pontoon type floating roof or a metal floating roof cover supported by liquid tight metal flotation devices. Construction shall comply with the requirements set forth in NFPA 30. Fixed foam fire protection systems generally are not required for this type of tank. However, some authorities and/or local regulations do require fixed protection. If fixed fire protection is required, NFPA has established the following guidelines.

Covered (internal) floating roof tanks can experience full surface fires as well as seal fires. The type of protection required is normally based on the construction of the floating roof. Tanks with the following types of roof construction are considered suitable for seal area protection:

- Steel double deck
- Steel Pontoon
- Full liquid surface contact, closed cell honeycomb, of metal construction conforming to API 650, Appendix H “Internal Floating Roof Requirements”

  The design guidelines established for open top floating roofs described previously would apply to the type of application.

Tanks with the following floating roof types do not fall under the design standards for seal protection of covered (internal) floating roof tanks.

- Roofs made from floating diaphragms
- Roofs made from plastic blankets
- Roofs made from plastic or other flotation material, even if encapsulated in metal or fiberglass
- Roofs that rely on flotation device enclosures that can be easily submerged if damaged
- Pan roofs

These tanks would require full surface protection and fall under the requirements for fixed roof tanks. The authority having jurisdiction should be consulted to determine the acceptable type of protection required for the specific hazard.

Foam systems for covered floating roof tanks shall be designed to cover the entire product surface in case the floating roof is destroyed or sinks. If the floating pan is pinned at the top of the tank, discharge outlets should be placed so that the tank is protected with the pan in the pinned position. Design of the foam system is the same as for fixed (cone) roof tanks, except that there is no requirement for separately valved laterals for each discharge device. See Figures 3-20 & 3-21. Also, any discharge devices mounted on the tank shell shall have deflectors designed to allow the roof to pass over the deflector without damaging it. See Figure 3-22. Subsurface foam injection is not recommended for this application. As with fixed roof tanks, supplementary handline protection is required for these tanks and would follow the same requirements. See Chart 3-3 & 3-4 regarding fixed roof requirements for number of supplementary hose streams required and discharge times. The authority having jurisdiction should be consulted to determine the acceptable type of protection required for the specific hazard.

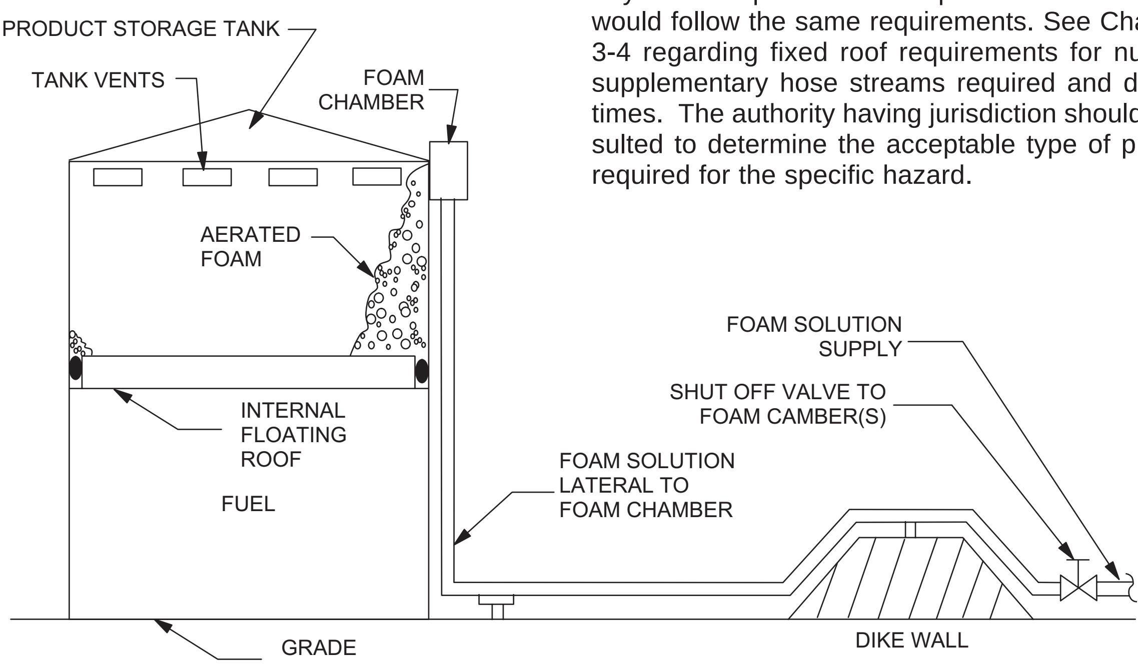


FIGURE 3-20
Surface Application Using Foam Chambers for Covered Floating Roof Tanks

Note: For tanks exceeding 200' (61 m) in diameter, foam discharge devices discharging at the shell will exceed the 100' (30.4 m) maximum travel distance recommended by NFPA. Since subsurface injection can not be used to reach the internal area on tanks over 200' (61 m) in diameter, it may be advisable to consider using some discharge device(s) capable of throwing the foam toward the center of the tank, rather than discharging at the shell. See Figure 3-23. See National Foam data sheets for performance data on discharge devices and nozzles.

Design Example

The design method would be the same as the design example for fixed roof tanks using surface method, page 3-5. The exception to this example would be when the tank diameter exceeds 200' (61m). In that particular case, the minimum number of discharge oultets, as indicated in Chart 3-1, would be 6 but, each additional discharge outlet would be a discharge nozzle instead of a foam chamber.

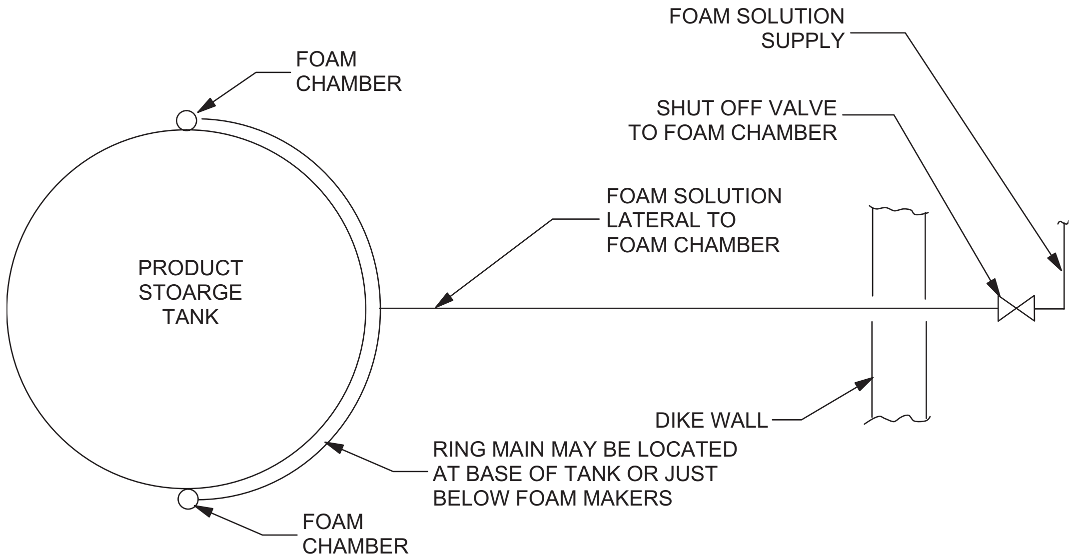


FIGURE 3-21
Surface Application Using Multiple Foam Chambers for Covered Floating Roof Tanks

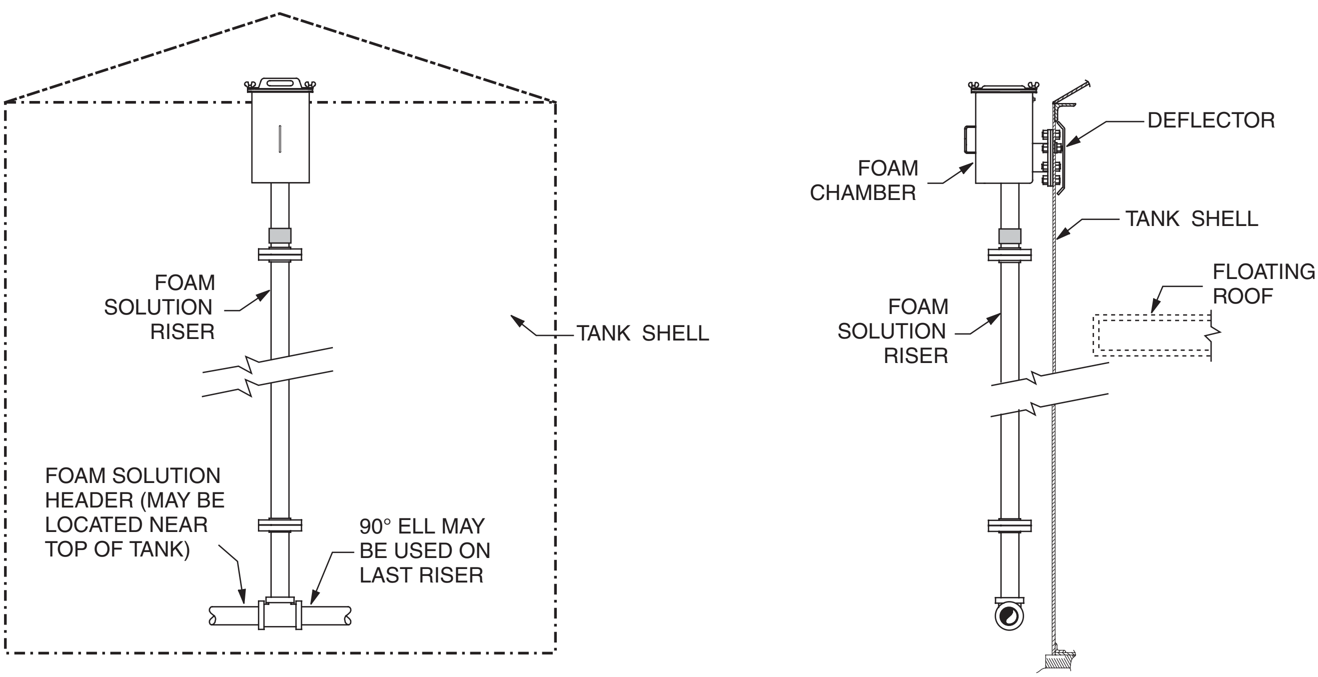


FIGURE 3-22
Covered Floating Roof Tank with Foam Chamber

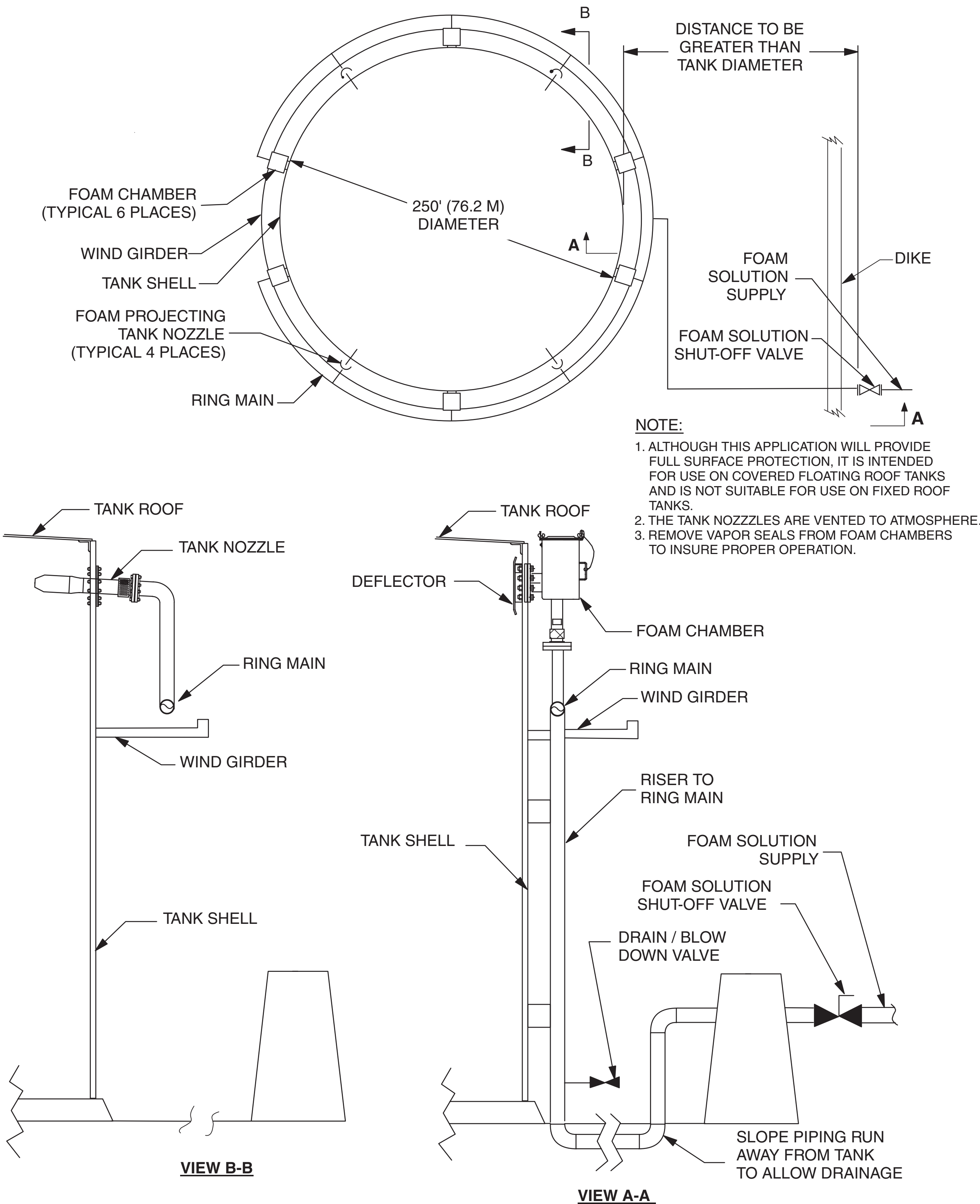


FIGURE 3-23
Covered Floating Roof Tank Over 200 Ft.(61M) Diameter
Full Surface Protection with Foam Chambers & Tank Nozzles

HORIZONTAL TANKS

NFPA does not recommend the installation of foam discharge outlets directly on horizontal tanks. An internal explosion in a horizontal tank will usually rupture the tank and spill the contents on the ground. Therefore, protection, if required, is normally for the dike area under the tanks. See dike protection for recommendations.

MULTIPLE SMALL TANKS

NFPA Standard No. 11 allows freedom for the designer to determine suitable fire protection for multiple small storage tanks located in a common diked area. Vertical fixed roof storage tanks should be designed with a weak shell to roof joint that allows the roof to be blow off during an internal explosion without damaging the side walls. However, when multiple tanks are located in a common dike area spaced in accordance with NFPA-30, by because of their smaler diameters, the distance between tanks is relatively close. Therefore, consider the possibility of protecting more than one tank, when determining the protection requirements. Individual discharge devices can be installed on vertical tanks to apply foam directly to the fuel surface, however, the discharge requirements and or proportioning system may overwhelm the tank and may be cost prohibitive. Consideration should be given to using handline nozzles, fixed monitors or for protection of the diked area. See appropriate sections for design details.

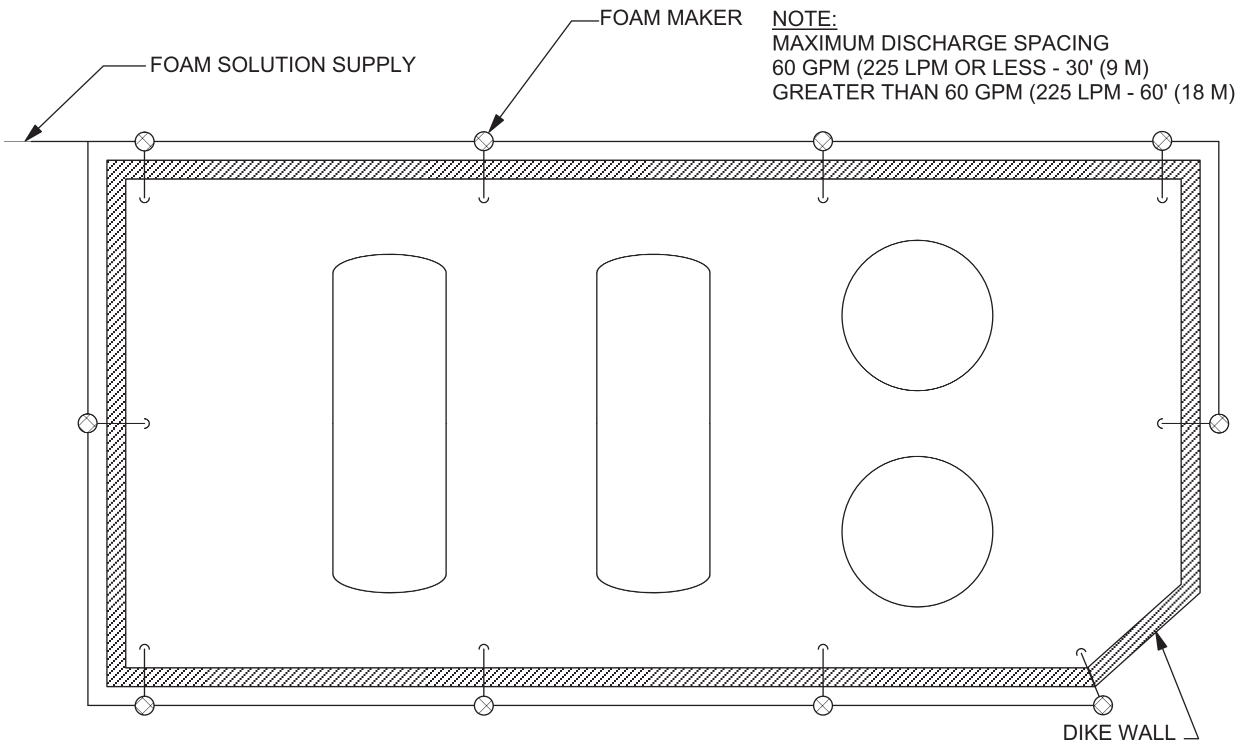
Many methods exist for protecting these tanks. The following information presents some of these possibilities.

DIKE PROTECTION

The Appendix of NFPA Standard No. 11 indicates that fixed protection on dikes surrounding storage tanks is desirable in various situations. There are many methods of protecting a diked area, however, the proper choice depends on the type of hazards located within the dike.

Fixed Foam Makers on the Dike:
The fixed foam maker method consists of installing piping around the outside wall of the dike and connecting it to a series of equally spaced discharge devices which deliver foam to the diked area. See figure 3-24. Since the foam makers deliver foam to the burning surface with a minimum of submergence, they qualify as a Type II discharge device, and require an application rate of 0.10 gpm/ft^2 (4.1 lpm/m^2) over the entire dike area. Refer to National Foam's Engineering Department for application rates for polar solvent liquids. The foam concentrate supply shall be sufficient for 20 minutes operation when protecting Class II hydrocarbons or 30 minutes when protectiong Class I hydrocarbons and polar solvent liquids.

To provide proper foam distribution, outlets for discharge devices with flows of 60 gpm (225 lpm) or less shall be located so that no point in the dike is more than 30 ft (9m) from the outlet. Discharge devices with flows exceeding 60 gpm (225 lpm), shall be located so that no point in the dike is more than 60 ft (18 m) from the outlet. Additionally, the distribution of foam makers shall be symmetric to ensure even coverage.



TYPICAL PIPING ARRANGEMENT
DIKE PROTECTION USING FIXED DISCHARGE OUTLETS

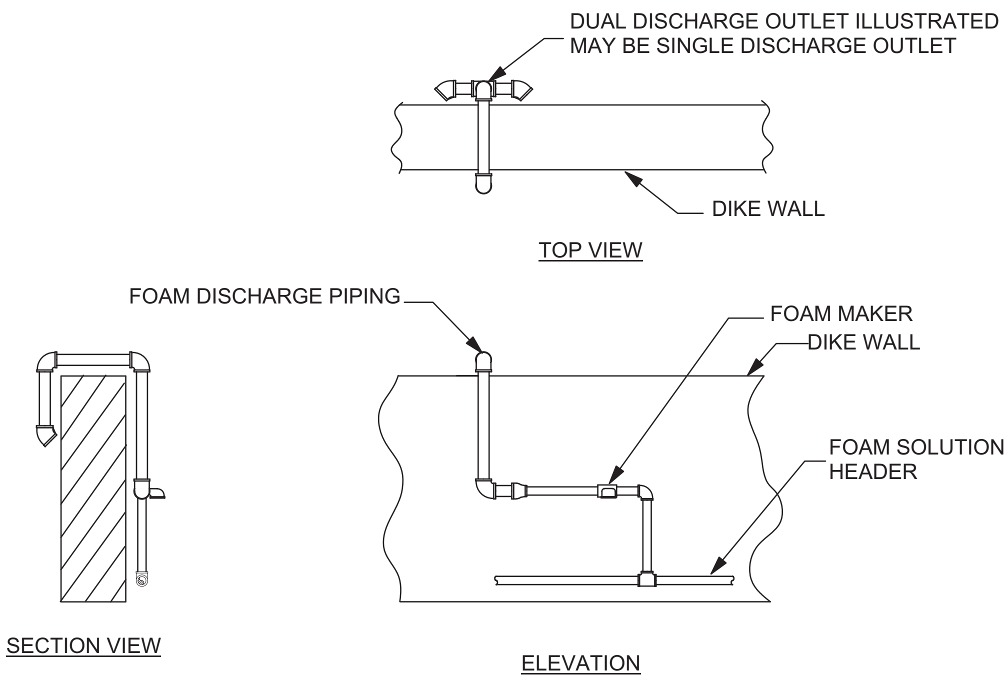


FIGURE 3-24
Typical Installation
Fixed Foam Maker Discharging Against Dike Wall

Monitor Protection:
Permanently mounted monitors provide flexibility for dike protection not available with fixed foam makers. See Figure 3-25. The monitors can be manually operated, automatically operated (oscillating), or remote controlled. Since the foam stream can be directed where needed, it is possible to cover an entire dike area during a major spill or a smaller area such as pumps, leaking valves, flanges, etc. When using manually operated or remote controlled equipment, extinguish and secure one area and then move on to the next section within the dike. This process provides reasonable protection to a diked area, with a limited water supply. When designing the system, careful consideration must be given to the size, quantity and placement of monitors so as to minimize the effects of wind and adverse weather conditions.

Additionally, properly sized monitors can be used for protection of vertical tanks located within the dike which do not exceed 60 feet (18m) in diameter.

Since monitors deliver the foam to the burning surface with considerable submergence and agitation, the minimum recommended application rate for hydrocarbons is 0.16 gpm/ft^2 (6.5 lpm/m^2) of protected area. A minimum of 20 minutes foam concentrate supply is required for Class II liquids, or 30 minutes supply for Class I liquids. The foam concentrate supply shall be adequate to protect the entire dike area, at the required application rate and discharge time.

NFPA does not recommend the use of monitors for protection for dike areas containing polar solvents. Some of the newer AR-AFFF foam concentrates, can protect polar solvents using monitors and nozzles without destroying the foam or the ability to extinguish the fire, provided that the discharge is banked against the tank shell or a dike wall and not plunged directly onto the product surface. Plunging of the foam may adversely effect the ability of the foam to extinguish the fire. Although the application rate would not be less than 0.16 gpm/ft^2 (6.5 lpm/m^2) of protected area, National Foam's engineering department should be contacted to determine the suitability of monitor application for the products being protected and for the proper application rate. The discharge duration for polar solvents would be 30 minutes.

Fixed Foam Spray Systems or Deluge Foam/Water Spray Systems:
First, we must differentiate between Foam Spray Systems and Foam/Water Spray Systems. Foam Spray Systems discharge foam only, then shut down once the foam concentrate supply runs out. This is necessary as some foam spray nozzles may not produce adequate results with water. Foam/Water Spray Systems work as dual agent systems and discharge foam and water sequentially in any order. Consult NFPA Standard No. 16 for Deluge Foam/Water Sprinkler and Foam/Water Spray Systems if the system discharges water and foam. In the following paragraphs, design guidelines of Foam/Water Spray Systems, and NFPA Standard No. 16 are explained.

Foam/Water Spray Systems provide foam to extinguish a fire, as well as cooling the surrounding exposures. Fixed water spray systems also provide cooling to exposures, however, they do not extinguish a flammable liquid fire.

Consider a battery of horizontal tanks located in a common dike. Installation of a Foam/Water Sprinkler System above the tanks, designed in accordance with NFPA Standard No. 30, may be the most effective type of protection. However, close spacing of the tanks could have an adverse effect on the spray patterns of overhead sprinklers. It may be advisable to locate the Foam/Water Spray nozzles so that the spray is directed at the shell of the tank. Spray nozzle located above the highest expected level of a spill, directed at the shell of the tank can accomplish a number of objectives. Foam, which is an extinguishing agent for flammable liquids, will be indirectly applied to the burning fuel, and will also have a cooling effect on exposures. Since the finished foam is produced by mechanical agitation of the solution, projecting the nozzle discharge against the tank produces additional agitation, and thus improves the foam quality. Also, since the foam is falling onto the fuel surface from a lower elevation than overhead sprinklers, submergence into the fuel is reduced.

Hydrocarbons will require a minimum application rate of 0.16 gpm/sq ft (6.5 lpm/sq m) over the entire dike area. Contact National Foam's Engineering department for required application rates for polar solvent liquids. The foam concentrate supply shall be adequate to supply a minimum of 10 minutes operation at the design flow.

Pay careful attention to the system flow to ensure the minimum application rate requirements to the entire area are achieved when using an indirect application.

PROTECTION OF POLAR SOLVENT STORAGE TANKS

Water-soluble liquids, other flammable liquids, and polar solvents that are destructive to foam, require "alcohol-resistant" foams. NF offers alcohol-resistant foam concentrates, that can be used with Type II application devices. Subsurface protection is not applicable to polar solvents. Specific design requirements are covered in the design guidelines for the specific type of hazard.

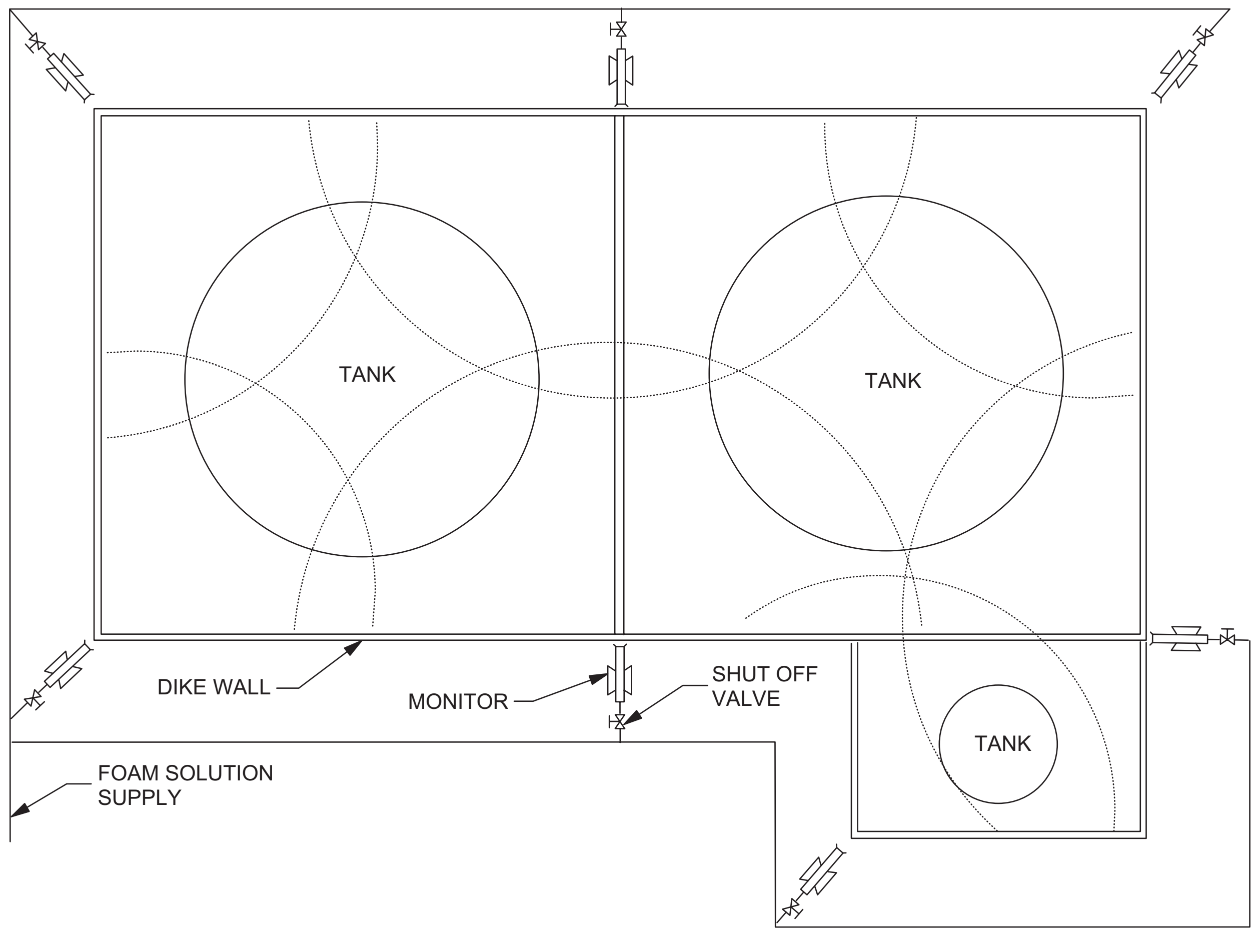


FIGURE 3-25
Typical Installation
Dike Protection Using Monitors

SECTION 4
LOADING RACK PROTECTION

National Foam

INDEX

SECTION 4
LOADING RACK PROTECTION

GENERAL OVERVIEW

Truck & rail car loading is one of the most hazardous operations in the manufacturing and handling of flammable liquids. Lives and valuable property are always threatened in a loading rack fire, and even a few minutes of uncontrolled burning may result in heavy losses. Foam is the only agent that can prevent a loading rack spill from igniting. If ignition is concurrent with the spill, foam is the preferred agent that can rapidly extinguish the spill fire and prevent re-ignition during cleanup operations.

NFPA does not have any standard that specifically addresses the design of fire protection systems for loading racks. The applicable sections of NFPA 11, 13, 15, 16, and 72 were used in developing the following design recommendations. As with any fire protection system, the final plans and design should be submitted to the authority having jurisdiction for approval prior to the start of any installation.

The total size of the rack, the flammable products involved, proximity of other hazards and exposures, drainage facilities, wind conditions, ambient temperatures, and available manpower must all be considered when designing a foam system for truck loading rack protection. Speed of system operations is always critical in minimizing property loss. Although the speed of operation is critical to minimizing the property loss, the intent of the system design is not for life safety. Regardless of the speed of the detection and system initiation, there is a delay in operation and discharge of foam due to the time required to charge the piping system.

Two basic methods for protecting loading racks are available. One method uses foam-water sprinklers mounted in the rack canopy, sometimes supplemented by directional foam-water nozzles mounted at a lower level to discharge foam directly under the trucks. The second method utilizes foam monitor mounted nozzles positioned to discharge foam directly into the rack area for full coverage.

FOAM-WATER SPRINKLER SYSTEMS

System design is usually based on the total curbed ground area below the rack canopy. Systems are primarily designed to protect the canopy, pumps, meters, and miscellaneous equipment associated with the loading and unloading operation in the event of a spill fire. Although most systems are designed to protect the curbed area only, it may be desirable to extend the coverage to protect the canopy area or the vehicle length, if it extends beyond the curbed area. The authority having jurisdiction should clearly define the area to be protected.

The deluge sprinkler system may be designed using air-aspirating foam-water sprinklers or standard non-aspirating sprinklers. Non-aspirating heads require the use of AFFF and Alcohol Resistant AFFF foam concentrates and are not suitable for use with protein and fluoroprotein type foam concentrates. Air-aspirating foam water sprinklers, although primarily used with protein and fluoroprotein type foam concentrates, can be used with any type of foam concentrate. See UL Directory for currently listed sprinklers and foam concentrates.

Standard orifice non-aspirating sprinkler heads are generally suitable to operate at approximately 7 to 15 psi (0.48 to 1.03 Bar). Since most 1/2 inch orifice heads have a “k” factor of approximately 5.5, a 9 psi (0.62 Bar) operating pressure will produce a discharge flow of about 16 gpm (60 lpm) per head. Foam-water sprinklers are designed to deliver approximately 16 gpm (61 lpm) of foam solution at 30 psi (2.07 Bar), which is also the minimum recommended operating pressure. The maximum pressure recommended is generally 60 psi (4.14 Bar), although most foam-water sprinklers are listed by Underwriters Laboratories up to 100 psi (6.89 Bar). Consult individual sprinkler manufacturers for detailed performance data. Also see UL directory for currently listed sprinklers along with the minimum listed application rate and discharge pressure.

According to NFPA 16, loading racks where hydrocarbon products are handled are required to have foam solution application of 0.16 gpm/ft^2. (6.5 lpm/m^2) of the area being protected. Higher application rates may be required for some water miscible / polar solvent products. Contact National Foam’s engineering department for recommendations. The discharge duration is a minimum of 10 minutes at the specified application rate. The authority having jurisdiction may require higher application rates or discharge times and should be consulted for final determination of requirements.

In accordance with NFPA 16, the deluge foam water sprinkler system can protect a maximum allowable coverage area per sprinkler of 100 ft^2 (9.3m^2). The design and installation of the sprinkler system, including spacing and location of foam-water sprinklers over the area being protected, must be in accordance with NFPA 13 for extra hazard occupancy. In addition the sprinkler system must be hydraulically calculated in accordance with the requirements of NFPA 13.

Although there are no specific requirements in NFPA for the installation of supplementary ground sweep nozzles, National Foam recommends their use, especially on applications with bottom loading. These nozzles are designed to discharge underneath the truck or rail car, increasing the spread of foam, thereby reducing the fire exposure to the bottom of the tanker and surrounding structure and reducing or minimizing damage. Typically two nozzles are installed in each bay, one located near the front wheels and the second located near the rear wheels. Both nozzles should be directed to discharge under the tank area. When using directional nozzles or sprinklers as supplementary ground sweep nozzles, the flow from these devises should not be considered in the design of the overhead sprinkler system for meeting the minimum application rate.

DESIGN CRITERIA

1. Determine type and size of hazard.
2. Determine application rate.
3. Determine number of sprinklers required.
4. Determine if ground sweep nozzles are required and quantity.
5. Determine total system discharge flow.
6. Determine water requirement.
7. Determine discharge time.
8. Calculate quantity of foam concentrate required.
9. Determine to size and best type of proportioning system to use.

Design Example

The preceding list describes the basic procedure in designing a loading rack sprinkler system. The following step-by-step example illustrates the design procedure for a loading rack with six bays and a curbed area 50’ wide (15.2m) X 90’ (27.4m) long. A 48’(14.6m) X 85’ (25.9m) canopy is installed over the loading area. The product being loaded is gasoline. Ground sweep nozzles are required by the customer.

1. Determine the design criteria.

Curbed area:	50 ft (15.2m) width x 90 ft (27.4m) length
Number of islands:	3
Number of bays:	6
Ground sweep nozzles:	Required by customer
Hazard:	Gasoline

2. Determine the minimum foam solution rate required by NFPA. The minimum application rate required by NFPA is 0.16 gpm/ft^2 (6.5 lpm/m^2) for the area to be protected.

Area to be protected :	50 ft (15.2m) width x 90 ft (27.4m) length = 4500 ft^2 (418.1m^2) total area to be protected
Design solution rate :	4500 ft^2 (418.1m^2) x 0.16 gpm/ft (6.5 lpm/m$^{2)}$ =720 gpm (2725 lpm)

3. Determine the minimum number of sprinklers required.

Number of sprinklers:	4500 ft^2 (418.1 m^2) divided by 100 ft^2 (9.3m^2) = 45 sprinklers

Note: This quantity does not include ground sweep nozzles.

After establishing the minimum number of sprinklers required, determine the number of rows of sprinklers and the number of sprinklers per row. According to NFPA, the spacing between sprinklers cannot exceed 12 ft (3.65 m) in any one direction with a proportionate reduction in distance in the other direction. Sprinklers shall be spaced so that the maximum area of protected by any one sprinkler shall not exceed100 ft^2 (9.3 m^2) with sprinklers located to provide a uniform application of foam over the entire area to be protected. For the rack in this example, nine rows of five sprinklers would be required.

4. If ground sweep nozzles are being provided (not required by NFPA), determine the number required.

Nozzles required:	2 nozzles per bay X 6 bays = 12 nozzles required

Note: There are no recommendations in NFPA for placement of these nozzles. Accepted practice is to locate two nozzles in each loading bay approximately 3 ft (0.9m) above grade. One should be located immediately ahead of the trailer wheels while the other is located behind the tractor wheels. Both nozzles should be aimed to direct the flow under the trailer. It may be desirable to install protective guards for these devices.

5. Determine the total design foam solution flow required for the system.

Note: The system should be hydraulically calculated in accordance with the procedure outlined in NFPA 13. A quick estimate can be developed by determining the design flow for each sprinkler and nozzle and multiplying it by the number of each type of sprinkler or nozzle. This estimated flow will be less than the calculated flow since it does not take into account actual pressure and flow conditions encountered in system operation.

Sprinkler solution flow:	16 gpm (60.6 lpm) /head X 45 heads = 720 gpm (2725 lpm)
Nozzle solution flow:	16 gpm (60.6 lpm) / nozzle X 12 nozzles = 192 gpm (727 lpm)
Total solution flow:	720 gpm (2725 lpm) +192 gpm (727 lpm) = 912 gpm (3452 lpm)

Sprinkler head and nozzle flows will vary depending on the type and size of head as well as inlet pressure. For the purpose of this design example we have used 16 gpm (60.6 lpm) which is the minimum flow at a 0.16 gpm/ft^2 (6.5 lpm/m^2). We have used the same flow rate for the ground sweep nozzles for this example.

6. To establish the residual water flow requirement, use the calculated foam solution flow derived in (Step 5) and multiply it by the % of water in the foam solution. If you are using a 3% foam concentrate, the water would be 97% of the solution. Calculate the pressure loss in the system, including pressure at sprinkler heads, elevation head, friction loss & proportioner loss, to determine residual water pressure requirement.

Water requirement:	912 gpm (3452 lpm) foam solution x .97 (97%) = 885 gpm (3350 lpm) water required at calculated residual water pressure at inlet to proportioner.

7. Determine time requirement. Per NFPA 16, 10 minutes operation is required regardless of product being loaded.

8. Determine the quantity of foam concentrate required.

   First determine the quantify of concentrate required to protect the rack at the design rate.

   Minimum foam solution rate (Step 2) x % injection x operating time = minimum foam concentrate quantity.

Minimum foam solution:	720 gpm (2725 lpm) x .03 (3%) x 10 minutes = 216 gallons (818 liters) foam concentrate required at minimum application rate.

   Note: If the calculated foam solution flow is higher than the minimum foam solution rate. NFPA 16 allows for a proportionate reduction in operating time to compensate for the increased flow rate. However, the time reduction may not be less than 70% of the required operating time.

   To determine if the minimum quantify of foam concentrate established above is sufficient, you must ascertain the quantity of foam concentrate required at the calculated foam solution rate.

   Calculated foam solution rate (Step 5) x % injection x operating time x 70% = foam concentrate quantity required at 70% of time.

Calculated foam solution:	912 gpm (3452 lpm) x .03 (3%) x 10 minutes = 192 gallons (727 liters) foam concentrate required at 70% of calculated solution flow.

   Compare the foam concentrate quantity at the design flow to the requirement at the calculated flow and select the higher of the two quantities. In this case the design requirement of 216 gallons (818 liters) of foam concentrate exceeds the 192 gallon (727 liters) requirement for the calculated flow. Therefore the 216 gallons (818 liters) of foam concentrate would be the minimum quantity of foam concentrate required for operation of the system.

9. After the flow rate and the residual pressure requirement at inlet to the proportioner have been calculated, verify that the calculated foam solution flow is within the allowable operating range of the proportioner. Also, verify that the calculated system pressure exceeds the proportioner minimum inlet pressure required for the calculated foam solution flow. Consult National Foam's Proportioning Section of the Engineering Manual and equipment data sheets for selection of the proportiong best suited to meet the parameters listed above.

   Note: Line proportioner or eductor type systems are not recommended for this type of application. Because of the fixed flow requirement and sensitivity to back-pressure, the potential for blockage of heads could cause the back-pressure to increase above the allowable limit, causing system failure.

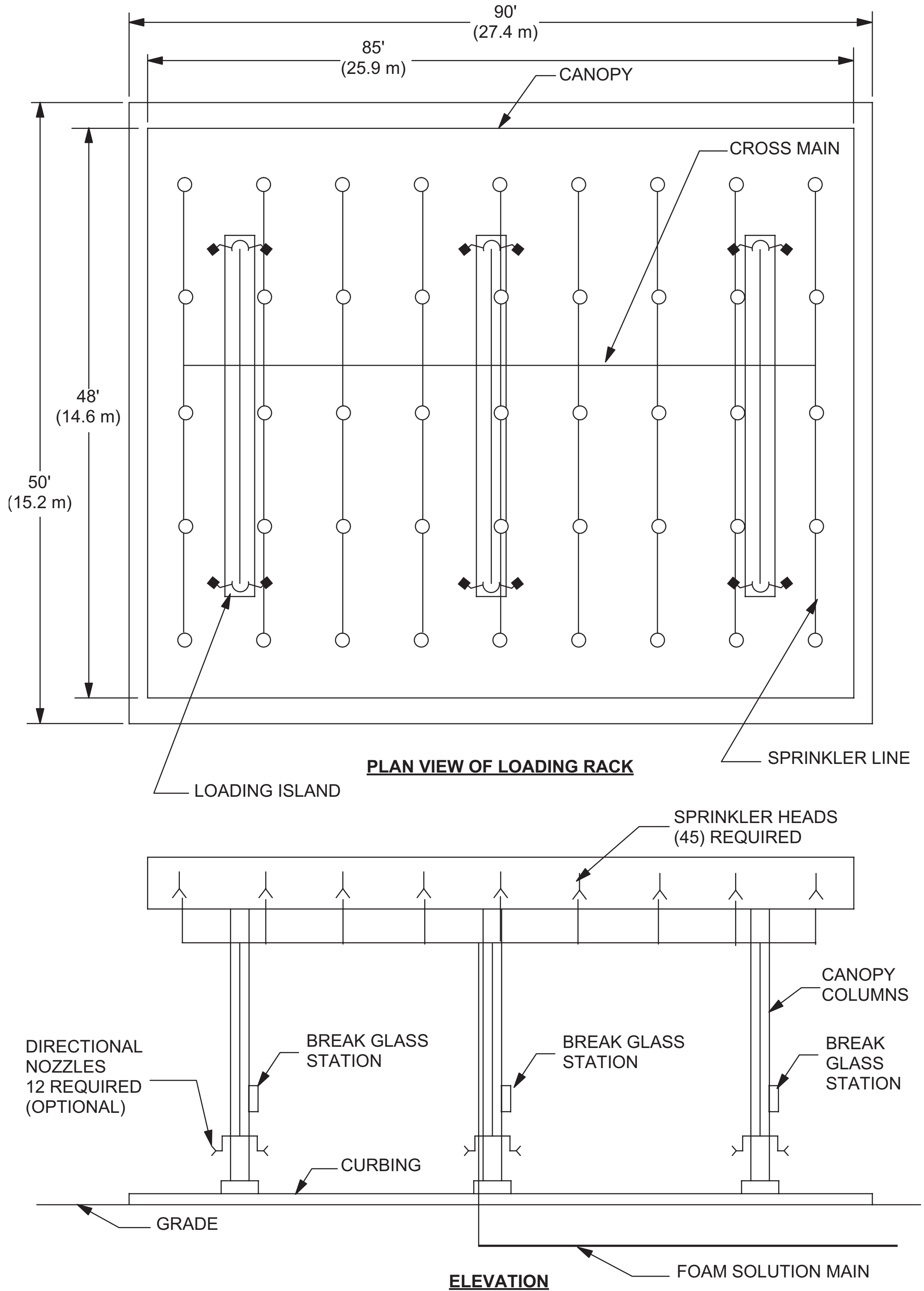


FIGURE 4-1
Loading Rack Foam-Water Sprinkler System

FOAM MONITOR SYSTEMS

As with foam water sprinklers, system design is usually based on the total curbed ground area below the rack canopy. Systems are primarily designed to protect the canopy, pumps, meters, and miscellaneous equipment associated with the loading and unloading operation in the event of a spill fire. Although most systems are designed to protect the curbed area only, it may be desirable to extend the coverage to protect the canopy area or the vehicle length, if it extends beyond the curbed area. The authority having jurisdiction should clearly define the area to be protected. Monitor protection is ideally suited to applications where there is no fixed canopy to support a sprinkler system.

According to NFPA 11, the following foam solution application rates and times apply for protection of loading racks:

Chart 4-1

Foam Type	Minimum Application Rate gpm/ft^2	lpm/m$_2$	Minimum Discharge Time minutes	Product being loaded
Protein Fluoroprotein	0.16	(6.5)	15	Hydrocarbons
AFFF, AR-AFFF	0.10*	(4.10)	15	Hydrocarbons
AR-AFFF	Consult NF		15	Polar Solvents

* If a fuel depth of more than 1" (25.4 mm) can accumulate within the protected area, the application rate should be increased to 0.16 gpm/ft^2 (6.5 lpm/m^2).

A very important factor in designing a foam monitor system is the proper choice of each monitor location. Traffic patterns, possible obstructions, wind conditions, and effective foam nozzle ranges will affect this choice. Every truck loading rack will have unique conditions limiting the possible monitor locations. The appropriate monitors and nozzles must be selected so that foam can be applied to the entire protected area at the required application rate. See nozzle data sheets for range and performance data.

Some installations where monitor locations are limited can be protected effectively with automatic oscillating foam monitors. These monitors are either electrically driven or water powered and will automatically traverse a preset arc of oscillation upon actuation of the foam system. In this manner, a large area of the rack may be protected from a single monitor location. See monitor and nozzle data sheets for range and performance data. When applying foam with oscillating monitors, the listed still air range will be reduced by approximately 10% with a typical monitor oscillation speed of 10 degrees per second

DESIGN CRITERIA

1. Determine type and size of hazard.
2. Determine foam concentrate and type of nozzle.
3. Determine application rate.
4. Determine quantity of monitor mounted nozzles required.
5. Determine total system discharge flow.
6. Determine water requirement.
7. Determine discharge time.
8. Calculate quantity of foam concentrate required.
9. Determine to size and best type of proportioning system to use.

Design Example

The preceding list describes the basic procedure in designing a loading rack sprinkler system. The following step-by-step example illustrates the design procedure for a loading rack with six bays and a curbed area 40' wide (12.2m) X 60' (18.3m) long. A 38'(11.6m) X 55' (16.8m) canopy is installed over the loading area. The product being loaded is gasoline. The customer wants to us AFFF through oscillating monitors with non-aspirating nozzles.

1. Determine the design criteria.

Curbed area:	50 ft (12.2m) width x 60 ft (18.3m) length.
Number of islands:	2
Number of bays:	4
Hazard:	Gasoline.

2. Customer has specified that he would like to use AFFF foam concentrate with oscillating monitors and non-aspirating nozzles.

3. Determine the minimum foam solution rate required by NFPA. See Chart 4-1. Assuming the product depth will not exceed 1", NFPA requires a minimum application rate of 0.10 gpm/ft^2 (4.1 lpm/m^2) for the area to be protected.

Area to be protected -	40 ft (12.2m) width x 60 ft (18.3m) length = 2400 ft^2 (223m^2) total area to be protected
Design solution rate -	2400 ft^2 (223m^2) x 0.10 gpm/ft (4.1 lpm/m) = 240 gpm (908 lpm)

4. Determine the number of monitor mounted nozzles required.

Select approximate location of monitor(s). Although one monitor may be capable of meeting the design requirements, it would be advisable to use two or more monitors because of potential physical obstructions. In selecting the monitor location(s), potential obstructions, wind conditions, and traffic patterns should be considered to minimize the possibility of blocking the foam stream(s) from the monitor(s). Two monitors were selected for this example.

Note: Depending upon the nozzle angle of elevation, there is an area in front of the monitor nozzle where no appreciable amount of foam will initially strike. These distances are identified as "NF" in the following calculations.

Nozzle Angle of Elevation Degrees (Radians)	NF (Distance Nozzle to Start of Foam Pattern) Feet (Meters)
0° (0)	15 (4.6)
5° (0.087)	20 (6.1)
10° (0.174)	25 (7.6)
15° (0.262)	30 (9.1)
22-1/2° (0.393)	30 (9.1)

Normally, the monitors are set back a minimum of 30 ft (9.1m) from the hazard to allow for the NF factor.

A. Measure the distance from monitor location to the hazard so that the required portion of the hazard will be adequately covered by the range of the nozzle.

B. Determine the minimum arc of oscillation that will allow required sweep over the hazard or required portion thereof. (If using fixed non-oscillating monitors, determine discharge pattern to insure complete coverage of the hazard.)

C. The flow "Q" from the monitor nozzle must provide a minimum foam solution application rate to the arc segment area of coverage obtained in Steps A and B. NFPA 11 states that the minimum foam solution application rate for this area shall be 0.16 gpm/ft (6.5 lpm/m) if protein or fluoroprotein type foam concentrate is used, and 0.10 gpm/ft (4.1 lpm/m) if AFFF foam concentrate is used. To ascertain that flow "Q" is sufficient to meet the minimum application rate required, use the following formula.

English Version:

$$Q = \left(\frac{\left(R^2 - NF^2\right)x0^0}{114.59}\right) \times AR$$

Q = Required flow in gpm
R = Maximum range selected in feet
NF = Distance from monitor nozzle to point on floor where first foam fall occurs in feet
0° = Monitor arc of oscillation in degrees
AR = Application rate required in gpm/ft^2

Metric Version:

$$Q = \left(\frac{\left(R^2 - NF^2\right)x0^0}{1.9996}\right) \times AR$$

Q = Required flow in lpm
R = Maximum range selected in meters
NF = Distance from monitor nozzle to point on floor where first foam fall occurs in meters
0° = Monitor arc of oscillation in radians
AR = Application rate required in lpm/m^2

$$\text{Flow} = \left(\frac{\left(78^2 - 30^2\right)x55^0}{114.59}\right) \times 0.1 = 249 \text{ gpm}$$

$$\text{Flow} = \left(\frac{\left(23.8^2 - 9.1^2\right)x55^0}{1.9996}\right) \times 4.1 = 942 \text{ lpm}$$

D. In Step C, the flow required for each nozzle to meet the minimum application rate was determined. Multiply this flow by the number of monitors operating to determine the total foam solution flow required.

   2 monitors x 249 gpm (942 lpm) = 498 gpm (1884 lpm) total solution flow required.

E. Select a nozzle with the required solution flow established in Step C. See nozzle data sheets for flow and range data.

F. After selecting the nozzle to meet the required solution flow, verify that the nozzle will provide the required range. Range charts are typically based on still air conditions. Because of adverse wind conditions, National Foam recommends using 75% of the still air range when designing a system. Also, remember that oscillation reduces the range approximately 10%.

5. Determine the total design foam solution flow required for the system.

   Note: In accordance with NFPA 11, the system must be hydraulically calculated following the procedures outlined in NFPA 13. A quick estimate can be developed by determining the design flow for each sprinkler and nozzle and multiplying it by the number of each type of sprinkler or nozzle. This estimated flow will be less than the calculated flow since it does not take into account actual pressure and flow conditions encountered in system operation.

Total solution flow:	249 gpm (942 lpm) /nozzle X 2 nozzles = 498gpm (1884 lpm)

6. To establish the residual water flow requirement, use the calculated foam solution flow derived in (Step 5) and multiply it by the % of water in the foam solution. If you are using a 3% foam concentrate, the water would be 97% of the solution. Calculate the pressure loss in the system, including pressure at sprinkler heads, elevation head, friction loss & proportioner loss, to determine residual water pressure requirement.

Water requirement:	498 gpm (1884 lpm) foam solution x .97 (97%) = 483 gpm (1828 lpm) water required at calculated residual water pressure at inlet to proportioner.

7. Determine time requirement. Per NFPA 16, 15 minutes operation is required regardless of product being loaded.

8. Determine the quantify of foam concentrate required. First determine the quantify of concentrate required to protect the rack at the design rate.

   Minimum foam solution rate (Step 2) x % injection x operating time = minimum foam concentrate quantity.

Minimum foam solution:	240 gpm (908 lpm) x .03 (3%) x 15 minutes = 108 gallons (409 liters) foam concentrate required at minimum application rate.

   Note: If the calculated foam solution flow is higher than the minimum foam solution rate. NFPA 16 allows for a proportionate reduction in operating time to compensate for the increased flow rate. However, the time reduction may not be less than 70% of the required operating time.

   To determine if the minimum quantify of foam concentrate established above is sufficient, you must ascertain the quantify of foam concentrate required at the calculated foam solution rate.

   Calculated foam solution rate (Step 5) x % injection x operating time x 70% = foam concentrate quantity required at 70% of time.

Calculated foam solution:	498 gpm (1884 lpm) x .03 (3%) x 15 minutes x 0.7 (70%) = 158 gallons (598 liters) foam concentrate required at 70% of calculated solution flow.

   Compare the foam concentrate quantity at the design flow to the requirement at the calculated flow and select the higher of the two quantities. In this case the design requirement of 108 gallons (409 liters) of foam concentrate is less than the 158 gallons (598 liters) required for the calculated flow. Therefore the 158 gallons (598 liters) of foam concentrate would be the minimum quantity of foam concentrate required for operation of the system.

9. After the flow rate and the residual pressure requirement at inlet to the proportioner have been calculated, verify that the calculated foam solution flow is within the allowable operating range of the proportioner. Also, verify that the calculated sys-

tem pressure exceeds the proportioner minimum inlet pressure required for the calculated foam solution flow. Consult National Foam's Proportioning Section of the Engineering Manual and equipment data sheets for selection of the proportiong best suited to meet the parameters listed above.

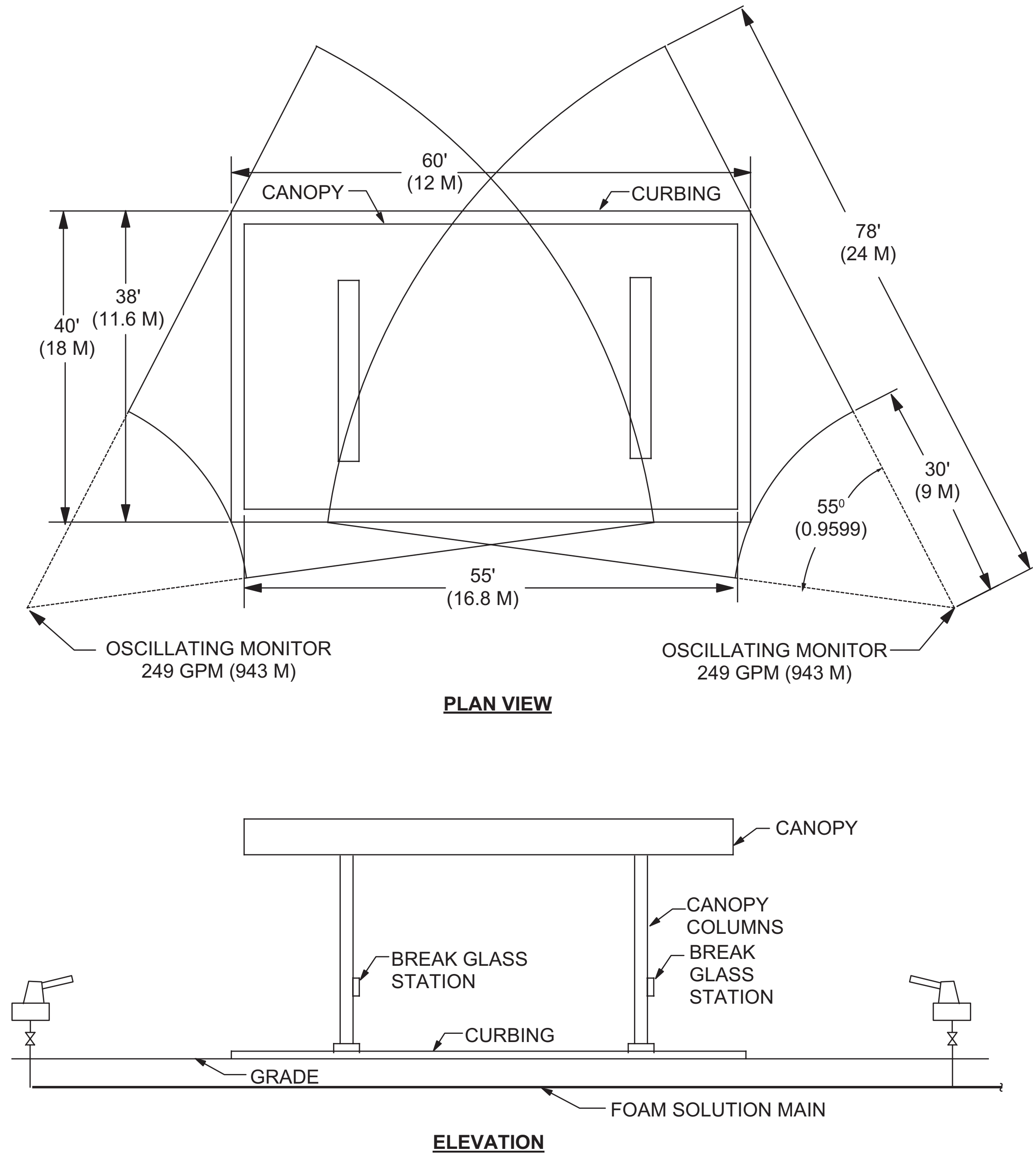


FIGURE 4-2
Loading Rack Foam Monitor System

PROPORTIONING

Correct proportioning of the foam concentrate to provide the foam solution flow required to protect the loading rack is essential. While any of the proportioning methods described in the proportioning section of National Foam's Engineering Manual may be used, balanced pressure proportioning systems and pressure tank type proportioning systems are most commonly recommended when using sprinklers. Water inlet pressures are often quite low and, therefore, it is necessary to confirm that the minimum proportioning system inlet pressure is adequate to facilitate proper system operation. Detailed layout drawings, performance data of the various proportioning methods, and the requirements for the proportioning equipment are provided in the proportioning section of the National Foam Engineering Manual and data sheets. It should be noted that National Foam does not normally recommend line proportioners (vacuum inducting type) for loading rack applications.

RECOMMENDED FOAM CONCENTRATES

Protein and fluoroprotein type foam concentrate are the recommended agents for protection of loading racks where hydrocarbon products are handled. Combining the excellent burnback resistance of protein foam with dry chemical compatibility, fluoroprotein type foam concentrates have proven on actual rack fires to be the most cost-effective and reliable foam concentrate for this application.

Aqueous film-forming foams (AFFF) can also be used for loading rack protection. They form a film blanket which results in rapid fire knockdown. Although it has a quicker knockdown time than the protein and fluoroprotein type foam concentrates, the burn back resistance, sealability against hot surfaces and ability to reseal upon disruption of the foam blanket are not as good. AFFF can be used through standard water sprinkler heads and other non-aspirating discharge devices. Although air-aspirating discharge devices are not required, it will also work well with these type devices.

Alcohol resistant - aqueous film-forming foams (AR-AFFF) are required when the loading rack will contain polar solvent-type flammables. They also provide excellent fire performance on hydrocarbons and can be used in applications where both types of flammables exist. It can be applied through standard sprinklers and non-aspirating discharge devices. Although air-aspirating discharge devices are not required, AR-AFFF will also work well with these type devices.

Consult the foam concentrate section of National Foam's Engineering Manual and data sheets for additional information on foam concentrates. Your local National Foam Representative or National's Engineering Department should be consulted for detailed system design and specifications.

FOAM SYSTEM AUTOMATION

Because of the flammable products involved, type of hazard, proximity of other hazards and exposures, drainage facilities, wind conditions, ambient temperatures, and other related factors, National Foam recommends automation of the system be considered when designing a foam system for protection of a loading rack. Speed of system operation is always critical in minimizing property loss. NFPA 16, 1999. Paragraph 1-4.1, states that "Foam-water deluge and preaction systems shall be provided with automatic and auxiliary manual tripping means. Exception: Manual operation only shall be permitted for foam-water deluge systems where acceptable to the authority having jurisdiction.".

Automation of a system involves detection of the fire condition, activation of the foam proportioning system and direction of the foam solution to the hazard and alerting the appropriate authorities. Detection and actuation equipment should be designed in accordance with the appropriate sections of NFPA 72. In the event of a fire, the releasing panel may initiate other ancillary functions such as shutting down product supply systems, opening gates, notifying fire departments, etc. In addition to the detection system, manual break-glass stations or other manual means of tripping the system should also be provided to allow initiation of the foam system for covering spills before a fire develops.

Many types of fire detection devices are available for protection of loading racks. Fire detection devices should be selected on the basis of cost-effectiveness, ease of installation, maintenance requirements, and freedom from false trips. Speed of system operations is always critical in minimizing property loss. Although the speed of operation is critical to minimizing the property loss, the intent of the system design is not for life safety. Regardless of the speed of the detection and system initiation, there is a delay in operation and discharge of foam due to the time required to charge the piping system. We believe the most effective type of detection system is the rate compensated fixed temperature or fixed temperature thermal type. Although it is not as fast a optical detection, we feel that it is more dependable, less prone to false trips, requires less maintenance and provides a response which is sufficiently fast for this type of application. Speed of response for thermal detectors will be dependant on the temperature setting, wind conditions and mounting locations. National Foam recommends the use of heat detectors for monitoring the loading rack for fires. Because of the harsh environment and conditions experienced in a loading rack, the maintenance requirements and the tendency toward false trips, National Foam does not normally recommend the use of optical detectors. However, applications such as racks without canopies may require the use of optical detectors. See applicable sections of NFPA 72A, 72B, 72C, 72D, and 72E for design recommendations for the detection and control equipment.

Your local National Foam representative or National's Engineering Department should be consulted for the automated system design best suited to a particular loading rack installation.

SECTION 5
AIRCRAFT HANGAR PROTECTION

National Foam

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SECTION 5
AIRCRAFT HANGAR PROTECTION

GENERAL OVERVIEW

In the past, commercial aircraft were relatively inexpensive compared to the cost of maintaining and repairing the hangar facilities. For this reason, common water deluge sprinkler systems were generally the only type of fixed fire protection installed in aircraft hangars. These systems were primarily designed to protect the hangar structure only. Control and extinguishment of any flammable liquid spill fire was a secondary consideration, therefore, the total loss of any aircraft actually involved in a spill fire was expected.

The value of commercial and military aircraft housed in a hangar may exceed several million dollars today. In many cases, the value of a single aircraft can exceed the total cost of the hangar structure. Therefore many hangars today require a reliable fixed fire protection system in the aircraft service, maintenance storage and paint facilities to prevent loss of the aircraft as well as the hangar facility.

Most commercial hangars are protected in accordance with the requirements of NFPA 409. Military hangars may be designed in accordance with NFPA 409 or with appropriate Armed Forces publications such as Air Force Manual ETL (Engineering Technical Letter), and Military Handbook 1008-Fire Protection for Facilities Engineering, Design and Construction. Military hangars may include requirements from both NFPA 409 and the Armed forces publications. The following is a general guideline for protection of hangars in accordance with the requirements of NFPA 409, however, design requirements for individual hangars may vary and design specifications and drawings should be thoroughly reviewed. As with any fire protection system, final design and plans should be presented to the authority having jurisdiction for approval.

HANGAR CLASSIFICATION

Fire Protection designed in accordance with NFPA 409, is still based on the specifics of the hangar such as size, construction, height of door and type of aircraft to be housed rather than the aircraft itself. Although the design is based on the facility, substantial protection is still afforded the aircraft housed in the facility. NFPA has four basic design groups based on the following criteria:

<u>Group I - A hangar with at least one of the following conditions:</u>

1. An aircraft access door height over 28 ft (8.5m).
2. A single fire area over 40,000 ft (3716m).
3. Housing aircraft with a tail height over 28 ft (8.5m).
4. Housing strategically important military aircraft as determined by the Department of Defense.

<u>Group II - A hangar with both of the following conditions:</u>

1. An aircraft access door height 28 ft (8.5m) or less.
2. A single fire area per construction type as defined in Chart 5-1.

Chart 5-1
Single Fire Area for Group II Hangar

	Single Fire Area			
	Equal or Greater Than		But not Larger Than	
Type of Construction	Ft^2	M^2	Ft^2	M^2
Type I (443) and (332)	30,001	(2,787)	40,000	(3,716)
Type II (222)	20,001	(1.858)	40,000	(3,716)
Type II (111)				
Type III (221)				
And Type IV (2HH)	15,001	(1,394)	40,000	(3,716)
Type II (000)	12,001	(1,115)	40,000	(3,716)
Type III (200)	12,001	(1,115)	40,000	(3,716)
Type V (111)	8,001	(743)	40,000	(3,716)
Type V (000))	5,001	(465)	40,000	(3,716)

Group III: A Group III hangar may be a freestanding unit for single aircraft, a row hangar housing multiple aircraft that has a common structural wall roof system and openings for each aircraft or an open bay capable of housing multiple aircraft with the following features.

1. An aircraft access door height 28 ft (8.5m) or less.

2. A single fire area per construction up to maximum fire area per construction type as defined in Chart 5-2.

Chart 5-2
Maximum Fire Area for Group II Hangar

Type of Construction	Maximum Single Fire Area Ft^2	M^2
Type I (443) and (332)	30,000	(2,787)
Type II (222)	20,000	(1.858)
Type II (111) Type III (221) And Type IV (2HH)	15,000	(1,394)
Type II (000)	12,000	(1,115)
Type III (200)	12,000	(1,115)
Type V (111)	8,000	(743)
Type V (000)	5,000	(465)

Note: Building Construction Types are described in NFPA 220.

Group IV: A hangar constructed of a membrane covered rigid steel frame.

PROTECTION OF GROUP I AIRCRAFT HANGARS

Protection Systems Options :

1. A foam water deluge system as described below. For aircraft having a wing area greater than 3000 sq. ft. a supplementary protection system is required.

2. A combination of an automatic sprinkler system in accordance with NFPA 13 **AND** a automatic low-level low expansion foam system.

3. A combination of an automatic sprinkler system in accordance with NFPA 13 **AND** a automatic low-level high expansion foam system.

Group I hangars housing other than unfueled aircraft, can have an approved foam water deluge system for the aircraft storage and servicing area. The deluge system shall be designed in accordance with applicable sections of NFPA 13 for extra-hazard occupancy and NFPA 16, however, the maximum floor area protected by one deluge sprinkler system (zone) can not exceed 15,000 ft (1394m). For hangars in excess of 15,000 ft (1394m) more than one deluge sprinkler system (zone) will be required.

Application rate for the foam water deluge system shall be a minimum of 0.20 gpm/ft^2 (8.1 lpm/m^2) of floor area when using air-aspirating foam/water sprinklers with AFFF or protein fluroprotein type foam concentrates. This application rate can be reduced to a minimum of 0.16 gpm/ft^2 (6.5 lpm/m^2) of floor area when using non-aspirating standard water sprinklers (open type) that use AFFF foam solution. Uniform sprinkler discharge shall be based on a maximum variation of 15%, however variation below the minimum requirement will not be permitted.

Foam-water sprinkler systems must have sufficient foam concentrate to allow operation of the maximum number of systems (zones) required, for a minimum of 10 minutes. If the calculated system flow exceeds the required flow, the system operating time may be reduced proportionally, but not less than 70% of the time required. Therefore, the system operating time must never be less than 7 minutes.

Notes:
1. Individual automatic sprinkler systems in Group I hangars, shall not exceed 52,000 sq. ft. The application rate shall be 0.17 gpm/sq. ft. over the hydraulically most remote 15,000 sq. ft.

2. A reserve supply of foam concentrate must be directly connected to the system and available if required.

3. If the foam proportioning system utilizes foam pumps to inject the foam concentrate into the water stream, two pumps and controllers are to be installed. Both pumps should be identical in flow rate and be capable of providing the maximum system demand flow.

Supplementary Protection Systems:

The supplementary system provides immediate protection to the hangar floor area under the aircraft, particularly the wing and fuselage section between the wings of the aircraft. This area is called the wing shadow area. Such areas are particularly vulnerable for the following reasons:

1. This area is shielded from the overhead ceiling sprinkler system.

2. If a fire occurs within an aircraft hangar, it would hit this area since the fuel tanks are generally located within the aircraft wings.

Configuration and positioning of aircraft in the hangar as well as location of servicing equipment and other permanent obstructions shall be considered in the design of the supplemental system. Protection of the entire aircraft servicing area could be required because of the possible aircraft positioning arrangement. The total area to be protected by a single system depends on the number and configuration of aircraft, their proximity and the drainage arrangements. If more that one aircraft is located within any drainage system, the supplementary system shall be capable of protecting all such aircraft. The supplemental system shall be designed to provide control of the fire within 30 seconds of activation and extinguishment within 60 seconds.

The application rate for the supplementary systems, using AFFF type foam concentrate, shall be 0.10 gpm/ft^2 (4.1 lpm/m^2) for the area under the wings, plus the fuselage area between the wings or the final hazard area determined necessary to protect the aircraft(s). When protein based concentrates are used with air aspirating nozzles, the application rate shall be increased to 0.16 gpm/ft^2 (6.5 lpm/m^2). The supplementary system shall be provided with sufficient foam concentrate to allow operation of the maximum number of systems (zones) required for a minimum of 10 minutes. If the calculated system flow exceeds the required flow, the system operating time may be reduced proportionally, but not less than 70% of the time required. Therefore, the system operating time must never be less than 7 minutes.

The supplemental system has traditionally been designed using oscillating monitors to provide the required coverage, however, systems using multiple fixed spray nozzles in lieu of monitors are gaining acceptance. Many of the military hangars are designed using the fixed nozzles. Both applications use the foam blanket to push the spill fire away from the underside of the aircraft. The monitors should be located close to the floor level so that the stream is flat and not above the level of the wings. The arc of oscillation should be set to allow the nozzle to achieve the required range but still maintain the required application rate. The quantity and location of the monitors is dependent on the area to be covered, location of the aircraft, water pressure available and permanently fixed obstructions. Fixed nozzle application uses several (usually 3 or 4) directional spray nozzles mounted on a manifold in place of each monitor. These nozzles are directional and usually have an adjustable spray pattern that can be field set to provide a pattern similar to that achieved with the oscillating monitor. Several of the spray nozzle manifolds would be located in the hangar in an arrangement similar to monitor applications. Locations for the monitors or spray nozzles shall be carefully selected so that they do not interfere with the movement of the aircraft in and out of the hangar. Although the use of air-aspirating nozzles is permitted, most systems today are designed for application of AFFF type foam using non-aspirating nozzles.

DESIGN FACTORS FOR OSCILLATING FOAM-WATER MONITOR SYSTEMS

1. Identify the hazard area.

2. Select approximate position for monitor location(s).

3. Measure the distance from monitor location to the hazard so that the hazard area protected by the monitor will be adequately covered by the range of the nozzle.

4. Determine the minimum arc of oscillation to sweep over the protected area.

5. Once the range and arc have been determined, the area of coverage can be calculated.

6. Calculate the area of coverage per monitor using the following formula:

$$A = \frac{Pi \times R^2 x\ 0}{360}$$

A = Area
Pi = 3.142 (Constant)
R = Range of coverage from monitor to feet
0 = Arc of oscillation of monitor
360 = Constant degrees in a circle

7. Once the area per monitor is determined, the flow can be determined by multiplying the area x the application rate (typically 0.10 gpm/ft^2). The result will be the required flow from the monitor in gpm.

8. Once the flow is known, a minimum inlet pressure can be established based on the K factor of the nozzle selected:

P = (Q/K)
P = Pressure (psi)
Q = Flow (gpm)
K = Constant for the nozzle.

9. Review the range data for the monitor or nozzle selected to determine if the range at the design flow and pressure exceeds the required range. If the range at the design pressure does not meet or exceed the required range, then a different nozzle needs to be selected or the available pressure has

to be increased. If the flow is increased above the design requirement to meet the required range, review the quantity of foam concentrate required at the new flow to insure that the supply of foam concentrate is adequate. Also, when using oscillating monitor decrease the listed range by 10% to compensate for the effects of the oscillation.

Note: Due to the fluidity of AFFF foams and the velocity at which they impact on the floor, the angle of elevation is not considered a factor since the monitor is typically field set. For reference purposes, use an average range based on the angles of elevation at given pressure.

High Expansion Foam System

A high expansion foam system is a suitable means of supplementary protection in aircraft hangars. These systems are designed to protect the under wing area of the aircraft at a depth of 3 feet in 1 minute. High expansion systems are to have sufficient foam concentrate and water supply for a minimum of 12 minutes of operation. The high expansion foam generators should be mounted at the ceiling or on an exterior wall utilizing outside air to generate the finished foam. All high expansion foam systems are to be designed in accordance with NFPA 409 and or meeting the requirements of the AHJ.

Foam-Water Hose Stations

The aircraft exterior is protected by the ceiling sprinkler system and the low level supplementary system. Hose stations are required to allow personnel to manually fight a fire inside the aircraft's interior, extinguish minor fires or to blanket a fuel spill in the hangar.

In accordance with NFPA Standard 409, foam-water hand hose stations must be installed in all Group I and Group II aircraft hangars, to allow for manual fire control. Although they are not required for Group III hangars, National Foam recommends installation of hose stations be considered. Sufficient hose stations, conforming to the applicable portions of NFPA Standard 14 and NFPA Standard 11, shall be provided and so located as to allow foam to be applied to all sides of all aircraft located in the hangar, the aircraft interior and the servicing area. The hose streams shall be designed to provide a minimum flow of 60 gpm, with adequate nozzle pressure. They shall be properly racked or reeled and shall have a shutoff nozzle or shutoff valve at the nozzle inlet.

The foam handline system shall be designed to provide 20 minutes operation to two hose stations operating simultaneously. Foam concentrate proportioning to the hose stations may be accomplished by any of the following methods:

1. Hose stations may be connected directly to the central foam concentrate proportioning and distribution system. Usually this involves one or more zones designed specifically to supply the hose stations.

2. Hose stations may be supplied from a separate centrally located proportioning system dedicated to supplying only the hose station.

3. Hose stations may be a complete self-contained stationary unit requiring only a water source, and include the foam concentrate storage vessel, proportioning system, hose (properly racked or reeled), and shutoff nozzle. These units are usually an atmospheric tank with an eductor or a small bladder tank system containing adequate foam concentrate to supply 20 minutes operation. Therefore, each hose station can be operated independent of any other system or hose station.

   System design should be evaluated to determine what is the most cost effective method to provide a reliable hose station system. See National Foam data sheets for performance data on applicable equipment.

PROTECTION OF GROUP II AIRCRAFT HANGARS

The fire protection requirements for a Group II hangar shall be one of the following:

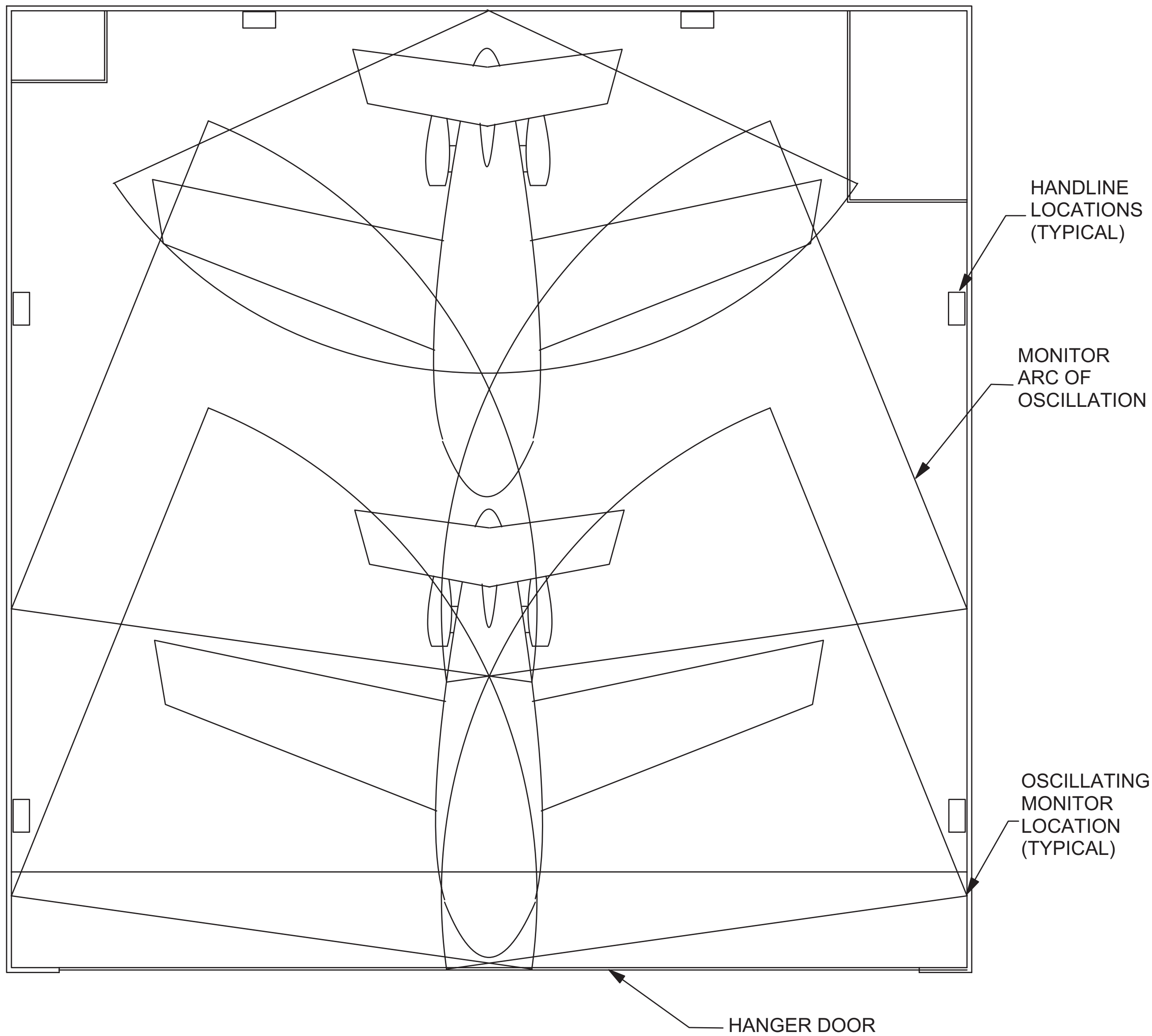
1. In accordance with the requirements for a Group I hangar (see protection of Group I Aircraft Hangars above.) *Exception: when utilizing air aspirating discharge devices in a Group II Hangar, the discharge rate is permitted to be reduced to 0.16 gpm/sq. ft. of floor area.*

2. A closed head foam/water sprinkler system, utilizing a 0.16 gpm/sq. ft. application rate over the entire aircraft storage and service floor area. (supplementary hose streams as described in the Group I criteria are also required).

3. A combination of a automatic sprinkler system and a automatic high expansion foam system.

4. A combination of a automatic sprinkler system and a low level low expansion foam system.

Note: Group II aircraft hangar storage and service areas housing unfueled aircraft shall be provided with automatic sprinkler protection.



<u>FIGURE 5-1</u>
Aircraft Hangar
Monitor Protection

PROTECTION OF GROUP III AIRCRAFT HANGARS

Fixed fire protection is not required for Group III aircraft hangars. Normally, only portable fire extinguishers are required for Group III aircraft hangars.

However, if any hazardous operations are performed, or the authorities having jurisdiction require a fire suppression system, it shall be designed in accordance with the design requirements of a Group II hangar.

PROTECTION OF GROUP IV AIRCRAFT HANGARS

1. For hangars where the fire area is greater than 12,000 sq. ft. and the aircraft is **fuelled**, the fire protection system shall be in accordance with one of the following:

   A. A low level low expansion foam system over the entire storage and servicing area utilizing a 0.1 gpm/sq. ft. application rate.

   B. A low level high expansion foam system over the entire storage and servicing area utilizing a 3 cu ft./min/sq. ft. application rate.

2. For hangars where the fire area is greater than 12,000 sq. ft. and the aircraft is **un-fuelled**, the fire protection system shall be in accordance with one of the following:

   A. A low level low expansion foam system over the entire storage and servicing area utilizing a 0.1 gpm/sq. ft. application rate.

   B. A low level high expansion foam system over the entire storage and servicing area utilizing a 3 cu ft./min/sq. ft. application rate.

   C. Automatic sprinkler protection in accordance with the following: NFPA 13 section on closed head sprinkler systems, utilizes quick response sprinkler heads, and has a design density of 0.17 gpm/sq. ft. over 5,000 sq. ft.

PROPORTIONING SYSTEMS

Because of the rapid response time required for hangar fire protection systems, the proportioning equipment must be designed to minimize the time delay between the detection of the fire and the delivery of the foam to the fire area. Although any type of proportioning system can be used, the proportioning system design typically incorporates proportioning devices installed directly in each system riser in order to minimize foam solution transit time to the discharge devices. The two most common systems to meet this objective are these types of foam concentrate proportioning:

1. Bladder (Diaphragm) Tank Pressure Proportioning System. See the proportioning system section of the engineering manual for specific details of operation. It is ideally suited to applications where the foam concentrate storage tank is located close to the system risers. Water and foam concentrate pipe sizing between the proportioner and the tank is critical for proper operation and should be reviewed by National Foam engineering department. It does not require any external power for operation other than the system water pressure. It is well suited where power is unreliable, however, a bladder tank may not be cost effective on larger systems.

2. In-Line Balanced Pressure Proportioning System. See proportioning system section of the engineering manual for specific details of operation. This type of system involves atmospheric foam concentrate storage tanks and foam concentrate pumps that require a reliable external power source and more maintenance than a bladder tank system. It is ideally suited to applications where the proportioners are located a relatively long distance from the pumping equipment, the risers have different flow rates and pressures or there will be future expansion of the system. It may not be cost effective on small systems.

Systems that have foam concentrate lines installed underground or that exceed 50 ft (15m) in length must supervise the piping for loss of foam concentrate. This is usually accomplished by installing a jockey pump.

Detailed layout drawings, performance data of the various proportioning methods, and the requirements for the proportioning equipment are provided in the proportioning section of the National Foam Engineering Manual and data sheets.

RECOMMENDED FOAM CONCENTRATES

Hangar fires are normally spill type fires with fuel depth of less than 1 in. (25.4mm). Also, the primary focus is on the quick knock down of the fire to prevent damage to the aircraft. Because of the type of hazard and fuel depth, the ability to seal against hot metal surfaces, burn back resistance and ability to reseal upon disruption of the foam blanket are secondary to the quick knockdown. Aqueous film-forming foams (AFFF) or High Expansion foams (Hi-Ex) are the agents of choice for this application.

Protein and fluoroprotein type foam concentrates can be used, however, they require higher application rates, air-aspirating discharge devices and do not provide the quick knockdown ability of the AFFF. Also they are not as fluid as the AFFF and do not flow as quickly across the floor. Fuels typically found in this type of application do not normally contain polar solvents. Although the alcohol resistant - aqueous film-forming foams (AR-AFFF) will function similar to the standard AFFF they are not typically used in protection of this type of hazard.

Note: Piping arrangement to sprinkler and supplementary protection zones should have test connections provided in the piping arrangement, to allow for testing of the system at design flow without discharging to the hangar service area.

Consult the foam concentrate section of National Foam's Engineering Manual and data sheets for additional information on foam concentrates. Your local National Foam representative or National's Engineering Department should be consulted for detailed system design and specification.

FOAM SYSTEM AUTOMATION

Because of the cost of the aircraft stored in these facilities and the quick response time required, the foam fire protection system must be automated as outlined in NFPA 409. Automation of a system involves detection of the fire condition, activation of the foam proportioning system including direction of the foam solution to the hazard and alerting the appropriate authorities. Detection and actuation equipment shall be designed in accordance with the appropriate sections of NFPA 72. In the event of a fire, the releasing panel may initiate other ancillary functions such as shutting down product supply systems, opening gates, notifying fire departments, etc. In addition to the detection system, manual pull stations are required and shall be located inside and outside of the aircraft servicing area. They shall be located so that they are unobstructed, readily accessible and located in the normal paths of exit from the area.

Many types of fire detection devices are available for protection of aircraft hangars. Fire detection devices should be selected on the basis of cost-effectiveness, ease of installation, maintenance requirements, and freedom from false trips. Speed of system operations is always critical in minimizing property loss. Although the speed of operation is critical to minimizing the property loss, the intent of the system design is not for life safety but for protection of the hangar and aircraft. Regardless of the speed of the detection and system initiation, there is a delay in operation and discharge of foam due to the time required to charge the piping system. Deluge type overhead sprinkler zones are normally initiated by a rate of rise, rate compensated fixed temperature or fixed temperature thermal type detection system. The supplementary protection is normally initiated by an optical detection system but must also be initiated by operation of any of the overhead systems in its area of protection. See applicable sections of NFPA 72 for design recommendations for the detection and control equipment.

Your local National Foam representative or National Foam's Engineering Department should be consulted for the automated system design best suited to a particular aircraft hangar installation.

Since the preferable methods of automatically actuating the primary and supplementary systems are different, the supplementary system is nearly always intended to flow first. System activation, regardless of type, must accomplish the following steps:

1. If the overhead system trips first, the associated supplementary system(s) must also trip.

2. If a supplementary system trips first, it will not trip the associated overhead system. However, neither will it prevent the overhead system from tripping.

SECTION 6
HELIPORT PROTECTION

National Foam

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SECTION 6
HELIPORT PROTECTION

GENERAL OVERVIEW

With today's demands for rapid transportation to areas that are difficult to reach quickly, there has been an increase in the use of helicopters for transportation in both the business and medical fields. The widespread use of helicopters today has generated increasing concerns for the safety of crew and passengers as well as minimizing loss to the heliport landing pad and the helicopter. Although the extent of fire protection required is determined by the authority having jurisdiction, most heliports today are protected by application of foam using hose lines, oscillating monitors or fixed nozzles. To help in provide a guideline for minimum safety standards, the National Fire Protection Association (NFPA) has developed and adopted NFPA Standard 418, Standard for Heliports.

Heliports may be land based, on marine vessels and on offshore drill rigs. The requirements for marine vessels and offshore drill rigs are determined by USCG and ABS rules and differ from the requirements for land based. See National Foam's Marine Vessels / Drilling Rigs for additional information on marine vessels and offshore platform heliport requirements.

PROTECTION FOR HELIPORTS

Fire protection for land based heliports is based on the largest helicopter that will use the facility. Heliports have been divided into three classifications based on the size of the largest helicopters that the facility will accommodate. The extent of fire protection required is based on the classification of the heliport.

DEFINITIONS

Before designing fire protection systems for heliports, it is important to know some of the common terminology.

Heliport: Facility designed to accommodate operation of helicopters. This includes the landing area and all related facilities.

Landing Pad: Minimum load bearing area designed for touchdown of a helicopter.

Critical Area: The area calculated to be one half the overall length of the helicopter multiplied by three times the width of the widest portion of the fuselage.

Overall Length: The length of the helicopter from the main rotor fully extended to the tail rotor fully extended.

Practical Critical fire Area: The area for foam discharge purposes calculated as one half of the fuselage length multiplied by three times the fuselage width.

HELIPORT CLASSIFICATIONS

NFPA 418 groups heliport protection based on the Practical Critical Fire Area (PCFA). The PCFA is based on many factors that include; size of helicopters, fuel capacities, actual fire experience and fire tests. The following terms cover the three current heliport classifications.

Chart 6-1

H-1: Helicopter overall length up to but not including 50 ft (15.2 m), with a practical critical fire area of 375 ft^2 (34.8 m^2).

H-2: Helicopter overall length from 50 ft (15.2 m) up to but not including 80 ft (24.4 m) with a practical critical fire area of 840 ft^2 (78.0 m^2).

H-3: Helicopter overall length from 80 ft (24.4) up to but not including 120 ft (36.6) with a practical critical fire area of 1440 ft^2 (133.8 m^2).

When designing the fire protection system for a heliport, the classification of the heliport remains top priority.

FOAM FIRE PROTECTION DESIGN

NFPA 418 requires a low expansion foam fire fighting system be installed for all roof top heliports. In addition to extinguishment of fires, the foam system can prevent the ignition of fuel spills by covering the spill. NFPA recognizes two types of protection for heliports. The first is foam hose lines, which can be either a portable installation using an eductor and nozzle or pick-up nozzle with hose and a supply of foam concentrate in pails, stored in a cabinet. It may also be a permanently installed porportioning system piped to hose reels or racks. The second method is a fixed proportioning system permanently piped to monitors or fixed spray nozzles strategically located around the periphery of the landing pad.

Exception:

1. Heliports on parking garages, unoccupied buildings or other similar unoccupied structures do not require the installation of a low expansion foam system.

2. For H-1 heliports, two portable foam extinguishers each having a rating of 20-A-160-B shall be permitted to satisfy the requirement.

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In addition to the foam system, portable fire extinguishers are also required. A minimum of two means of access to the landing pad shall be provided for firefighters. The means of access may be the same as the means of egress.

Hose lines are the preferred method of protection, when personnel trained in the operation of the equipment are available. The use of hose lines provides better direction of foam to the fire and quicker control of the fire.

FOAM HANDLINE REQUIREMENTS

The foam system design is based on protection of the Practical Critical Fire Area of the largest helicopter that uses the heliport. NFPA 418 has established the size of the practical critical fire area for each heliport category based on the largest helicopter that may use that category heliport. The size of the practical critical fire area is as follows:

Chart 6-2

Heliport Category	Practical Critical Fire Area
H-1	375 ft^2 (34.8 m^2)
H-2	840 ft^2 (78.0 m^2)
H-3	1440 ft^2 (133.8 m^2)

The application rate required for application of foam to the practical critical fire area is determined by the type of foam concentrate used. Application rates are as follows:

Chart 6-3

Type of Foam Concentrate	Application Rate
AFFF	0.1 gpm/ft^2 (4.1 lpm/m^2)
Fluoroprotein	0.16 gpm/ft^2 (6.5 lpm/m^2)
Protein	0.20 gpm/ft^2 (8.1 lpm/m^2)

The quantity of foam concentrate required is based on two minutes operation at the above application rate. The 2 minute discharge is based on control of the practical critical fire area within one minute plus a 100% reserve quantity for extinguishment. The water supply shall be from a reliable source and shall be adequate to supply the system at the design rate for the minimum discharge time.

Note: NFPA 418 does not allow for a reduction time of operation when the actual discharge exceeds the design requirements. The quantity of foam shall be based on the actual discharge rate for the specified time.

The number of hose lines required has not been defined in NFPA 418. The size and quantity of nozzles for the hose lines is based on the discharge rate required to apply foam to the practical critical area at the specified application rate. After the required flow rate has been determined, select standard nozzles, with available flows that can be handled by one operator, to supply foam at the required rate. Typical nozzle flows available are 60 gpm (227 lpm), 95 gpm (360 lpm) or 125 gpm (227 lpm).

Design of System

Criteria for designing a fire protection system for a heliport using hose lines is as follows:

1. Identify the Helicopter Category.

2. Determine the best type of foam concentrate to use.

3. Determine the application rate required. This is based on the type of foam concentrate.

4. Determine the method or application.

5. Determine the solution requirement for protection of the heliport. This is derived at by multiplying the Pratical Critical Fire Area by the application rate.

6. Determine the quantity and size of discharge devices required.

7. Determine the required discharge time for operation to heliport.

8. Determine the quantity of foam concentrate required.

9. Select the proper type of proportioning equipment to meet the needs of the system.

Design Example

Hazard Information:

Type Hazard:	Helipad
Largest Helicopter:	110 ft (33.5 m) overall length
Size of Pad;	120 ft x 120 ft (36.6 m x 36.6 m)
Foam Concentrate:	AFFF
Type of Protection:	Hose lines
Proportioning System:	To be determined
Available Water:	1500 gpm (5678 lpm) @ 100 psi (6.9 bar)

1. Identify the Helicopter Category.

   The largest helicopter has an overall length 110 ft (33.4m). Based on Chart 6-1 this would be an H-3 category heliport.

2. Determine the best type of foam concentrate to use.

   The foam specified is AFFF. This would be the foam of choice as it has the lowest application rate and is best suited to spill type fires.

3. Determine the application rate required. See Chart 6-3.

   The application rate for AFFF type foam concentrates is 0.1 gpm/ft^2 (4.1 lpm/m^2).

4. Determine the method or application.

   Hose line protection has been specified.

5. Determine the solution requirement.

   The area required to be protected is the practical critical fire area. Base on Chart 6-2, the practical critical fire area for the H-3 category heliport is 1440 ft^2 (133.8 m^2). The required application rate is 0.1 gpm/ft^2 (4.1 lpm/m^2) as defined previously.

   1440 ft^2 (133.8 m^2) practical critical fire area X 0.1 gpm/ft^2 (4.1 lpm/m^2) = 144 gpm (545 lpm) of solution required.

6. Determine the quantity and size discharge devices required.

   Based on the required flow of 144 gpm (545 lpm), we would use two standard nozzles with a flow of 95 gpm (360 lpm).

   Total solution flow to the hazard = 95 gpm (360 lpm) Solution flow x 2 nozzles = 190 gpm (720 lpm) total solution flow.

7. Determine required discharge time for operation to heliport.

   Based on hose line protection, the required discharge time is 2 minutes.

8. Determine the quantity of foam concentrate.

   Since the actual application flow is higher than the design rate, the actual flow would be used to calculate the quantity of foam concentrate required:

   Solution rate X % of injection X time = foam concentrate required.

   190 gpm (720 lpm) solution X .03 X 2 minutes = 12 gallons (46 liters).

9. Select the proper type of proportioning equipment to meet the needs of the system.

   Correct proportioning of the foam concentrate is essential to provide the foam solution flow required to protect the hazard. While any of the proportioning methods described in the proportioning section of National Foam's Engineering Manual may be used, due to the small size of the proportionig requirements, line proportioners or small bladder tank would be the best choice of proportioning systems

   The proportioning system shall have sufficient pressure to operate against the highest expected residual water pressure as determined by hydraulic calculation of the system piping arrangement. Detailed layout drawings, performance data of the various proportioning methods, and the requirements for the proportioning equipment are provided in the proportioning section of the National Foam Engineering Manual and Data Sheets.

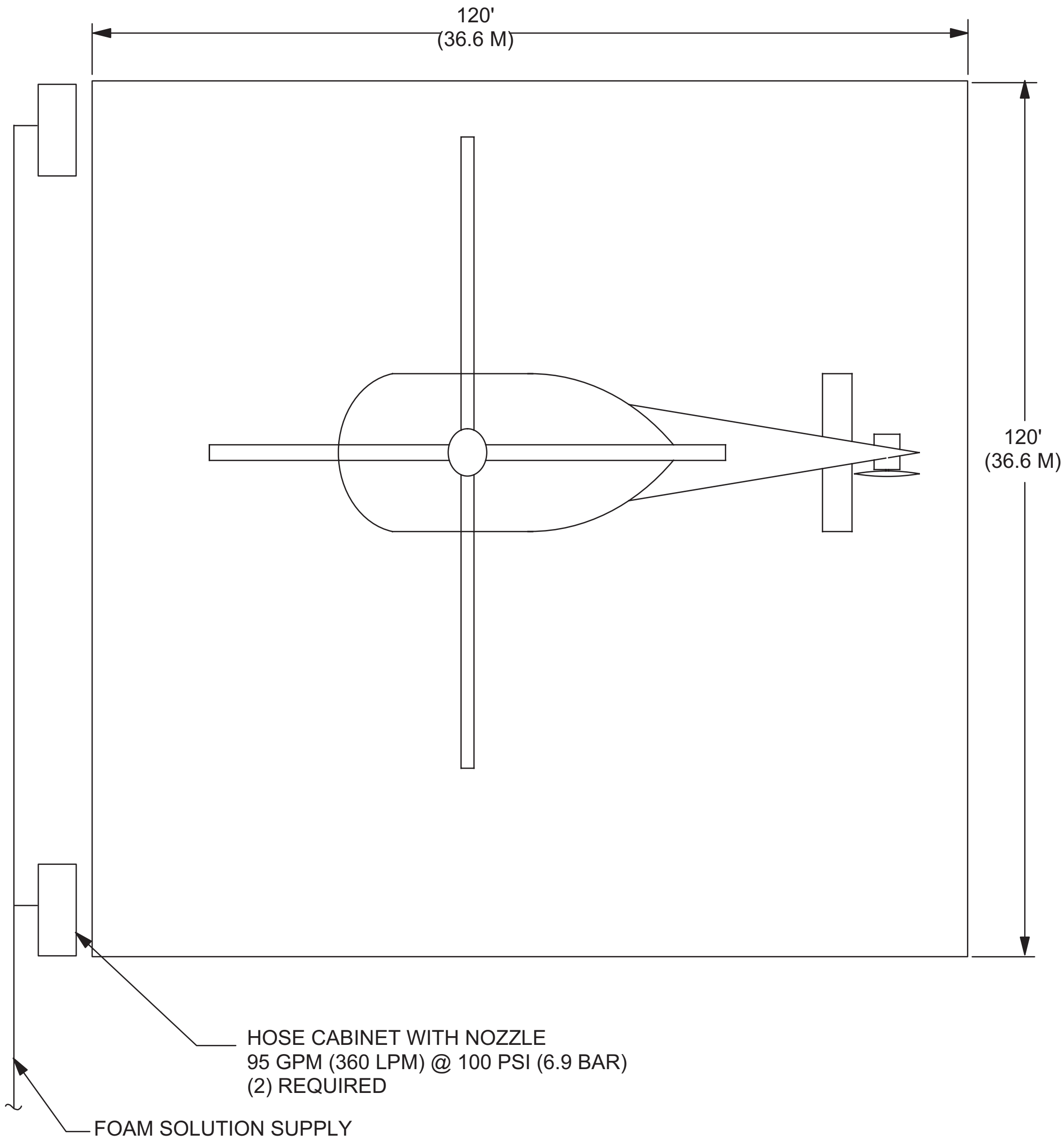

FIGURE 6-1
Helipad Protected by Hose Lines

FIXED SYSTEMS

In some applications it may be advisable to install a fixed foam protection system. The authority having jurisdiction or the lack of trained personnel to operate hose lines may require the installation of a fixed system. The fixed foam fire protection system has the foam proportioning equipment permanently piped to fixed application devices.

The application rate for fixed systems would be the same as with hose streams. See Chart 6-3. However, the area of application is the entire landing pad not just the practical critical area. Also the discharge time increases to 5 minutes.

Note: NFPA 418 does not allow for a reduction in time of operation when the actual discharge exceeds the design requirements. The quantity of foam shall be based on the actual discharge rate for the specified time.

The fixed installation may use fixed monitors, oscillating monitors or fixed spray nozzles to protect the area. The system design has not been defined by NFPA other than the application rate, area and discharge time. The size, number and location of the discharge devices are left to the discretion of the designer. In addition to the size of the helicopter, other conditions such as wind conditions, points of egress, approach and departure patterns should be considered. Also, the system discharge must cover all sides of the helicopter as there is no way to determine the origin of a fire. The number of discharge devices required is dependent on the flow of the device, range, and spray pattern.

Design of System

Criteria for designing a fire protection system for a heliport using fixed discharge devices is as follows:

1. Identify the Helicopter Category.
2. Determine the best type of foam concentrate to use.
3. Determine the application rate required. This is based on the type of foam concentrate.
4. Determine the method or application.
5. Determine the solution requirement for protection of the heliport. This is derived at by multiplying the total landing pad area by the application rate.
6. Determine the quantity and size of discharge devices required.
7. Determine the required discharge time for operation to heliport.
8. Determine the quantity of foam concentrate required.
9. Select the proper type of proportioning equipment to meet the needs of the system.

Design Example

<u>Hazard Information:</u>

Type Hazard:	Helipad
Largest Helicopter:	110 ft (33.5 m) Overall length
Size of Pad:	120 ft x 120 ft (36.6 m x 36.6 m)
Foam Concnetrate:	AFFF
Type of Protection:	Oscillating monitors
Proportioning System:	To be determined
Available Water:	1500 gpm (5678 lpm) @ 100 psi (6.9 bar)

1. Identify the Helicopter Category.

   The largest helicopter has an overall length 110 ft (33.4m). Based on See Chart 6-1 this would be an H-3 category heliport.

2. Determine the best type of foam concentrate to use.

   The foam specified is AFFF. This would be the foam of choice as it has the lowest application rate and is best suited to spill type fires.

3. Determine the application rate required. See Chart 6-3.

   The application rate for AFFF type foam concentrates is 0.1 gpm/ft^2 (4.1 lpm/m^2).

4. Determine the method or application.

   Oscillating monitors have been specified.

5. Determine the solution requirement.

   The area required to be protected is the total landing pad area. Based on a 120 ft x 120 ft (36.6 m x 36.6 m) landing pad, the area to be is 14,400 ft^2 (133.8 m^2). The required application rate is 0.1 gpm/ft^2 (4.1 lpm/m^2) as defined previously.

   14400 ft^2 (1338 m^2) fire area X 0.1 gpm/ft^2 (4.1 lpm/m^2) = 1440 gpm (5451 lpm) of solution required.

6. Determine the quantity and size discharge devices required.

   Based on the required flow of 1440 gpm (5451 lpm), we would use four standard oscillating monitors with a flow of 400 gpm (1514 lpm).

   Total solution flow to the hazard = 400 gpm (1514 lpm) Solution flow x 4 nozzles = 1600 gpm (6057 lpm) total solution flow.

7. Determine required discharge time for operation to heliport.

   Based on fixed discharge protection, the required operating time is 5 minutes operation.

8. Determine the quantity of foam concentrate.

   Since the actual application flow is higher than the design rate, the actual flow would be used to calculate the quantity of foam concentrate required:

   Solution rate X % of injection X time = foam concentrate required.

   1600 gpm (6057 lpm) solution X .03 X 5 minutes = 240 gallons (943 liters)

9. Select the proper type of proportioning equipment to meet the needs of the system.

   Correct proportioning of the foam concentrate is essential to provide the foam solution flow required to protect the hazard. While any of the proportioning methods described in the proportioning section of National Foam's Engineering Manual may be used, due to the small size of the proportioning requirements, a small bladder tank would be the best choice of proportioning systems

   The proportioning system shall have sufficient pressure to operate against the highest expected residual water pressure as determined by hydraulic calculation of the system piping arrangement. Detailed layout drawings, performance data of the various proportioning methods, and the requirements for the proportioning equipment are provided in the proportioning section of the National Foam Engineering Manual and data sheets.

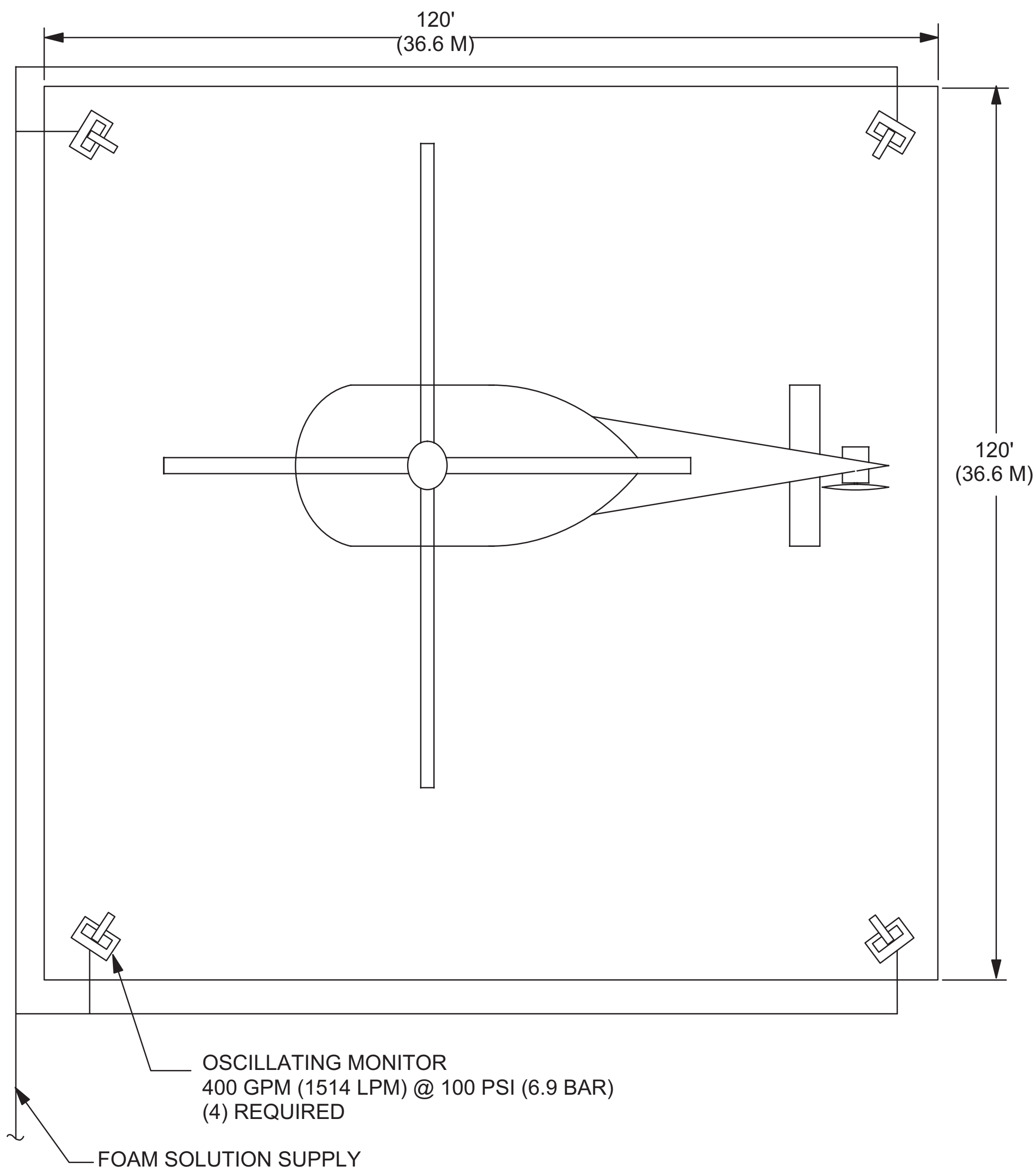

FIGURE 6-2
Helipad Protected by Fixed Oscillating Monitors

PROPORTIONING SYSTEMS

Commonly, heliports are protected by the semi fixed type system. These systems can be as simple as a hose rack and hose connected to a water supply, a foam concentrate supply, and a foam pick up type nozzle, or line proportioner and nozzle combination.

Although, any type of proportioning system can be used for heliports, usually the system demand is very small and the proportioning system is very simple. In addition, most heliport systems are operated manually. Hose line operation is ideally suited to the use of eductors, either portable or permanently piped to the system, or small bladder tank systems. For fixed applications the bladder tank is the preferred method of proportioning.

The proportioning system must have a sufficient foam concentrate supply to allow system operation at the required discharge rate for the required discharge time specified previously. NFPA does not allow a proportionate reduction in system operating time, when the calculated system flow exceeds than the required flow. Therefore, the quantity of foam must be adequate to supply the actual flow for the required time.

Detailed layout drawings, performance data of the various proportioning methods, and the requirements for the proportioning equipment are provided in the proportioning section of the National Foam Engineering Manual and data sheets.

RECOMMENDED FOAM CONCENTRATES

The normal type of fire that occurs at a heliport is a spill fire with fuel depth of less than 1”. Heliports require a foam with ability to quickly knock down the fire to prevent damage to the helicopter and landing pad. Therefore, aqueous film-forming foams (AFFF) are the agent of choice for this application.

Protein and fluoroprotein type foam concentrates can be used, however they require higher application rates, air-aspirating discharge devices and do not provide the quick knockdown ability of the AFFF. Also they are not as fluid as the AFFF and do not flow as quickly across the floor. Fuels typically found in this type of application do not normally contain polar solvents. Although the Alcohol resistant - aqueous film-forming foams (AR-AFFF) will function similar to the standard AFFF they are not typically used in protection of this type of hazard.

Consult the foam concentrate section of National Foam’s Engineering Manual and data sheets for additional information on foam concentrates. Your local National Foam representative or National’s Engineering Department should be consulted for detailed system design and specification.

FOAM SYSTEM AUTOMATION

Although many of these systems are designed for manual operation, some degree of automation may be desirable, especially for fixed systems. System automation normally consists of manual pull stations at strategic locations such as the point of egress, to remotely initiate the system and alert the proper authorities. Because these areas are usually manned during operation, automatic detection systems are normally not used to detect the fire and initiate operation of the system. Detection and actuation equipment should be designed in accordance with the appropriate sections of NFPA 72.

Your local National Foam representative or National’s Engineering Department should be consulted for the automated system design best suited to a particular loading rack installation.

PORTABLE FIRE EXTINGUISHERS

At least one portable fire extinguisher as specified in the following table shall be provided for each takeoff and landing area, parking area and fuel storage area. Fire extinguishers shall comply with NFPA 10, Standard for portable fire extinguishers.

Category	Helicopter Overall Length	Minimum Rating
H-1	Up to but not including 50 ft (15.2 m)	30-A-240-B
H-2	From 50 ft (15.2 m) up to but not including 80 ft (24.4 m)	30-A-240-B
H-3	From 80 ft (24.4 m) up to but not including 80 ft (24.4 m)	30-A-240-B

SECTION 7
WAREHOUSE PROTECTION

National Foam

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SECTION 7
WAREHOUSE PROTECTION

GENERAL OVERVIEW

Warehouses in the past have typically been protected with closed head wet pipe or preaction systems. With the growing concern for flammable liquids being stored or used in the manufacturing process foam-water sprinkler systems are now being used to protect these types of hazards, which may be hydrocarbons, polar solvents of a combination of both. Foam-water sprinkler systems are designed to discharge foam or water through the same discharge device. The system normally discharges foam until the foam concentrate supply is exhausted and then it discharges water until it is manually shut off. The system can also be designed to discharge water first, followed by foam for a specific period and then water until manually shut off. In general, the discharge devices provide coverage similar to that of standard sprinklers, although directional or specialty type discharge devices are acceptable for specific applications.

The foam-water sprinkler and spray systems may be deluge type systems or closed head wet pipe, dry pipe and preaction systems or a combination depending on the location and type of hazard in the facility that is being protected. Also, existing water sprinkler systems can be converted for application of foam. When rack storage is used for flammable products, usually in-rack protection is also required.

Foam-water sprinklers and spray nozzles can also be divided into two basic groups, air aspirating or non-aspirating. While most systems today use non-aspirating sprinklers, air-aspirating sprinklers are required when using protein or flouroprotein type concentrates.

FOAM-WATER SPRINKLER SYSTEMS

Design of the foam-water sprinkler system generally falls under one or more of the following:

NFPA 13	Installation of Sprinklers Systems
NFPA 16	Installation of Deluge Foam -Water Sprinkler and Foam-Water Spray Systems
NFPA 30	Flammable and Combustible Liquids Code
AJH	Authority Having Jurisdiction. Some authorities have their design criteria for both closed head and deluge type systems.

DELUGE FOAM-WATER SPRINKLER SYSTEMS

Deluge foam-water systems employ open discharge devices and a piping network connected to a water supply through an automatic valve, typically referred to as a deluge valve. Automatic detectors located in the same area as the sprinklers, or manual pull stations, signal a control system that opens the deluge valve allowing foam solution to flow to the discharge devices. Deluge systems are generally used in areas requiring an immediate application of foam over a large area. Reference should be made to NFPA 16 for guidance in developing foam-water deluge systems.

CLOSED HEAD FOAM-WATER SPRINKLER SYSTEMS

Closed head foam-water systems consist of automatic sprinkler type devices with a heat sensitive element, and a piping network connected to a water supply through an automatic valve. The automatic valve used in closed head systems may be referred to as an alarm check valve (wet pipe system), a dry pipe valve (dry pipe system) or a preaction valve (Preaction system). Flow is limited to those discharge devices that open due to the heat intensity at that particular device. Actual flow through these systems is not predictable. Ultimate flow demand (or discharge) of these systems are educated approximations of the total number of sprinklers that will activate (open) under expected fire scenarios. In reality, more or less than the expected number of sprinklers may function. In actual operation, as long as, the flow is within the design limits of the proportioner, proper proportioning will result. Reference should be made to NFPA 16 or NFPA 30 for guidance in developing closed head foam-water sprinkler systems.

Note: NFPA 16 is a recommended practice and as such does not define specific requirements. NFPA-30 also makes reference to foam-water sprinkler systems.

Note: When selecting a proportioning method, it is important to consider that at flows below the minimum rated capacity of a proportioner and bladder tank combination, lean proportioning may occur. For foam pump systems, whether balanced pressure (back pressure control) or (in-line balanced pressure), low flow conditions may result in rich proportioning.

WET PIPE SYSTEMS

Wet pipe foam-water sprinkler systems may contain foam solution or water in piping under pressure at all times. Heat from a fire causes the element in the sprinkler head to release, which allows discharge from that head. Wet pipe systems are reliable and simple, since only those sprinklers affected by the heat of the fire will discharge.

Note: When using wet pipe systems, water is used to initially fill the sprinkler grid. Premix solutions deteriorate over time, (depend on such things as pipe size, temperature, materials and type of foam concentrate), resulting in the initial discharge approaching the characteristics of water only. The amount of discharge time required for freshly proportioned solution to reach the discharging sprinkler(s) is affected by the size and configuration of piping, actual flow determined by the number of open heads and available pressure, etc.

DRY PIPE SYSTEMS

Dry pipe sprinkler systems consist of closed head sprinklers and the piping grid charged with low air pressure, to maintain the dry pipe valve in a closed position. As the fire causes the sprinkler heads to open, the air pressure is released from the piping grid, allowing the dry pipe valve to open. Water flows through the proportioner and becomes foam solution which discharges only through the sprinkler heads that have opened. Dry pipe systems are normally installed in areas subject to freezing, but are not recommended for closed head foam-water service, because they have a slower response time than wet pipe or preaction type systems.

PREACTION SYSTEMS

Preaction foam-water sprinkler systems are best described as a combination of a deluge system and an empty (or dry) pipe system. Closed head sprinklers are connected to the piping system which is filled with air, generally at a very low supervisory pressure. Detectors are located in the hazard area sense a fire and send a signal to the control system, that initiates the opening the preaction valve, allowing the piping grid to fill with foam solution. Foam solution will not be discharged until a sprinkler head opens. Loss of supervisory air pressure in the piping as a result of physical damage to the pipe will signal a trouble condition, but will not open the deluge valve.

Note: When the preaction valve opens, the initial surge of water through the proportioner may exceed the proportioners ability to maintain the proper injection of foam concentrate. As a result, the initial charge of foam solution may not be the proper concentration. When the system flows returns to operation within the design limits of the system, proper proportioning will be maintained.

Preaction systems are generally used in areas where the piping and/or sprinkler heads are subject to freezing or physical damage.

DISCHARGE DEVICES

Sprinklers

Foam-water sprinklers can be classified as aspirating or non-aspirating. Air-aspirating foam-water sprinklers are open style sprinklers that draw air into the solution stream, causing the foam to start expanding prior to contact with the deflector, with continued expansion after contacting the deflector. Air-aspirating sprinkler heads are designed to produce foams with longer drainage times and higher expansions than non-aspirating sprinklers. Air-aspirating foam-water sprinklers are the only sprinklers recommended for use with protein & fluoroprotein concentrates, however they can also be used with AFFF and AR-AFFF type foam concentrates. Because the air-aspirating sprinklers are only available in an open head configuration, they can only be used for deluge type systems.

Conventional water sprinklers are used with AFFF and AR-AFFF foam solutions but can not suitable for use with protein & fluoroprotein concentrates. These AFFF & AR-AFFF type foam solutions exhibit high foamability even through non-aspirating devices. AFFF & AR-AFFF type foam solutions use a film, created as the foam breaks down, to extinguish the fire. Therefore, they do not require the expansion and drainage times of the protein and flouroprotein type foams.

Sprinklers are fixed orifice devices, and as such, flow is directly related to inlet pressure. Sprinkler heads, including foam-water sprinklers are generally classified by the nominal orifice diameter and “K” factor. Flow through a sprinkler head is determined by the formula:

$$Q = K\sqrt{P}$$

Q = Flow is gpm (lpm)
P = Pressure in pounds per square inch (bar)
K = Orifice constant for a given sprinkler head

Typically, closed head foam-water sprinkler systems have utilized nominal 1/2” and 17/32” orifice, conventional sprinkler heads. Sprinklers shall be installed in accordance with NFPA 13. Also, the maximum area protected by a single sprinkler shall not exceed 100 ft^2 (9.3 m^2). Consult National Foam Engineering Department for use of other size sprinklers.

Directional Spray Nozzles

Directional spray nozzles are generally used to direct foam around or under obstructions such as tanks, pumps, and piping. The same design considerations apply for air-aspirating and non-aspirating spray nozzles.

CHOOSING THE PROPER FOAM SYSTEM

Although there are many considerations that effect the selection of correct foam-water sprinkler system to meet the application, the following are concerns which must be addressed:

1. Type of flammable liquid being protected.

2. Type of foam-water sprinkler system (Also, new system or retrofit of existing).

3. Application density and area of coverage.

4. Minimum discharge Device pressure available.

5. Proportioning range required.

6. Proportioning type.

7. Discharge time required.

8. Type of foam concentrate.

DESIGN CRITERIA

Design Density & Discharge Application Area

Deluge type foam-water systems are fairly straight forward in terms of design density or application rate and the protected area. For deluge type systems the entire area under the sprinkler system is the protected area for design purposes. NFPA 16 requires a minimum density of 0.16 gpm/ft^2 (6.5 lpm/m^2) of protected area for hydrocarbon type flammable liquid storage. The design density shall never be less than the density established by NFPA or the local authority having jurisdiction. The actual density required is based on the type of flammable liquid stored and the type of foam concentrate used to protect the hazard. Many of the polar solvent type liquids, as well as some hydrocarbon products, require application rates higher than specified in the standards. Contact National Foam's engineering department to determine the correct density for the application.

Densities and required discharge area for closed head sprinkler systems tend to be more complex. The density and design area can vary depending on the NFPA standard applied or the guideline established by authority having jurisdiction for the design of the system. Typical densities have ranged from 0.16 gpm/ft^{2}t (6.5 lpm/m^2) to 0.6 gpm/ft^2 (24.6 lpm/m^2) with design areas ranging from 1,500 ft^2 (139.4 m^2) to 5,000 ft^2 (232m^2 - 465m^2). NFPA 16 requires a minimum density 0.16 gpm/ft^{2}t (6.5 lpm/m^2) over 5,000 ft^2 (465.5 m^2). NFPA 30 defines different densities and design areas dependant upon the type of storage, class of the flammable liquid, sprinkler orifice, sprinkler response time, size and type of storage container and height of ceiling. Insurance carriers may use 0.25 gpm/ft^{2}t (10.3 lpm/m^2) over 3000 ft^2 (278.7 m^2). NFPA 30 has normally used as the guideline, when in-rack sprinklers are required. In rack sprinklers are normally based on a minimum flow of 30 gpm (114 lpm) per sprinkler. System design is normally based on operation of 3 to 6 heads per level, with a maximum of three levels operating. The in-rack requirement is in addition to the requirements for the overhead sprinklers. Because of the range of guidelines used for system design requirements, the authority having jurisdiction should be consulted to determine the acceptable design guidelines.

Operating Time

NFPA 16 requires a minimum discharge time of 10 minutes at the maximum design flow. This is the generally accepted time requirement. However, NFPA 30 requires 15 minutes operation while some authorities having jurisdiction may require 20 minutes operation.

Design Example

Type System:	Deluge
Design Standard:	NFPA 16
Dimensions:	90 ft (27.4 m) x 50 ft (15.2 m)
Stored Product:	Class IB hydrocarbons
Type of Storage:	Rack storage, 10 gallon relieving style metal containers
Ceiling Height:	25 ft (7.6 m)
Storage Height:	20 ft (6.1 m)
In Rack Sprinklers:	No
Type of Sprinkler:	Standard Orifice
Sprinkler Response Time:	Standard Response
Proportioning System:	Bladder tank
Foam Concentrate:	AFFF, 3%
Available Water Press.:	To be determined

1. Determine the area to be protected:

   Design area = 90 ft (27.4 m) length x 50 ft (15.2 m) width = 4500 ft^2 (418 m^2).

2. Determine density or application rate required.

   Using NFPA 16 as the design guide the minimum density is 0.16 gpm/ft^2t (6.5 lpm/m^2).

3. Determine the solution requirement.

   Solution = area protected x density [NFPA 16 limits the maximum area protected by a single system to 5,000 ft^2 (465.5 m^2). In this application the design area is less than the maximum area allowed, therefore, the design area shall be used in the calculation.]

   Solution = 4500 ft^2 (418 m^2) area x 0.16 density = 720 gpm (2725 lpm).

4. Determine the quantity of foam concentrate required:

   Foam concentrate required = Solution X % of injection x discharge time..

   In this example we are using a 3% AFFF and the discharge time is 10 minutes per NFPA 16.

   720 gpm (2725 lpm) solution x 0.003 injection % x 10 discharge time = 216 gallons (818 liters) of foam concentrate required.

   Note: If actual application rate is higher than the design rate, a proportionate reduction can be taken but no less than 70% of the required operating time.

5. Select appropriate proportioning equipment.

   In this example, a bladder tank was specified as the type or proportioning required. For this application we would select a 300 gallon (1135 liter) bladder tank. To meet the solution requirement of 720 gpm (2725 lpm) we would select a 4" ratio controller.

6. Determine the pressure required to operated the system by hydraulic calculation in accordance with NFPA 13.

7. The above design example is based strictly on design requirements and does not take into account increased flow due to high water pressure.

Design Example

Type System:	Wet Pipe
Design Standard:	NFPA 30
Dimensions:	90 ft (27.4 m) x 50 ft (15.2 m)
Stored Product:	Class IB hydrocarbons
Type of Storage:	Rack storage, 10 gallon relieving style metal containers
Ceiling Height:	25 ft (7.6 m)
Storage Height:	20 ft (6.1 m)
In Rack Sprinklers:	No
Type of Sprinkler:	Standard Orifice
Sprinkler Response:	Standard Response Time
Proportioning System:	Bladder Tank
Foam Concentrate:	AFFF, 3%
Available Water Press.:	To be determined

1. Determine the area to be protected:

   Hazard area = 90 ft (27.4 m) length x 50 ft (15.2 m) width = 4500 ft^2 (418 m^2).

   Per NFPA 30 based on the above parameters the design area shall be 3000 ft^2 (178.8 m^2).

2. Determine density or application rate required.

   Per NFPA 30 based on the above parameters the minimum density is 0.3 gpm/ft^2 (6.5 lpm/m^2).

3. Determine the solution requirement.

   Solution = design area protected x density.

   Solution = 3000 ft^2 (178.8 m^2) area x 0.30 density = 900 gpm (3407 lpm).

4. Determine the quantity of foam concentrate required:

   Foam concentrate required = Solution X % of injection x discharge time.

   In this example we are using a 3% AFFF and the discharge time is 15 minutes per NFPA 30.

   900 gpm (3407 lpm) solution x 0.03 (injection %) x 15 discharge time = 405 gallons (1533 liters) of foam concentrate required.

   Note: If actual application rate is higher than the design rate, a proportionate reduction can be taken but no less than 70% of the required operating time.

5. Select appropriate proportioning equipment.

   In this example, a bladder tank was specified as the type or proportioning required. For this application we would select a 400 gallon (1514 liter) bladder tank. To meet the solution requirement of 900 gpm (3407 lpm) we would select a 4" ratio controller.

   Note: Although the tank selected has a nominal capacity of 400 gallon (1514 liter) the actual capacity would allow it to store full 405 gallons (1533 liters).

6. Determine the pressure required to operated the system by hydraulic calculation in accordance with NFPA 13.

7. The above design example is based strictly on design requirements and does not take into account increased flow due to high water pressure.

PROPORTIONING

To provide the foam solution flow required to protect the warehouse, correct proportioning of the foam concentrate is essential. While any of the proportioning methods described in the proportioning section of National Foam's Engineering Manual may be used, balanced pressure proportioning, in-line balanced pressure and bladder tank type proportioning systems are most commonly preferred when using sprinklers.

The following conditions shall be considered, when selecting a proportioning system:

1. The actual calculated system discharge at the proper foam percentage for the most hydraulically demanding condition.

2. The actual calculated system discharge at the proper foam percentage for the most hydraulically demanding condition.

3. Foam liquid pressure adequate for the highest anticipated water pressure.

The flow range for deluge type systems are relatively easy to establish. Each system or operational zone will have design flow to provide the required density over the protected area. Since the sprinkler heads are open, all heads will always discharge when the system operates. The only variation to flow would be from fluctuations in water pressure.

Flow ranges for closed head systems are much more difficult to determine. At best they are estimations of likely total fire area at the time of the incident. Flow ranges are to be specified by the designer. Maximum flow is based on required density over the design area. Minimum flow is generally specified as a minimum number of heads opening at one time. Proportioning equipment must be selected to cover this range of flows or the range of flows modified to fall within the range of the selected proportioner. Foam solution flow above or below the proportioner range will result in loss of proportioning accuracy.

When hydraulically designing water sprinkler systems, minimum requirements are of primary concern. If water supplies are capable of providing more than the required minimum, so much the better. No consideration of friction factor transitions are necessary or increased flow from the actual discharge occurring closer to the supply than the most remote area used for hydraulic calculation. All these variations are strictly positive in relation to the minimum design requirement. This is not the case when foam-water systems are designed.

Flows less than design, (i.e., fewer heads open up), may severely impact the ability of the foam system to proportion accurately. On the other hand, increased flows due to higher water pressure, etc. can severely affect operation of the system. The flow increase may exceed the flow range of the proportioner, exceed the pump capacity on pump type systems or affect the quantity of foam concentrate required to meet the minimum operating time. In addition to high water pressure, low water pressure can also have an adverse effect on the system operation.

Because many sprinkler systems are designed for operation from municipal water supplies, the available water pressure is often low. This results in systems with large flows and relatively low water pressure. As flows increase, proportioners require higher inlet pressures to overcome the effects of proportioning. Therefore, it is necessary to confirm that the minimum proportioning system inlet pressure is adequate to facilitate proper system operation at the required flow.

It should be noted that bladder tank systems will proportion below nominal injection rate at flows below the published minimums. On the other hand, ILBP systems tend to proportion above nominal injection rates at flows below the published minimums.

Systems that have foam concentrate lines installed underground or that exceed 50' (15 m) in length must supervise the piping for loss of foam concentrate. This is usually accomplished by installing a jockey pump.

Note: Piping arrangement to sprinkler zones should have test connections provided in the piping arrangement, to allow for testing of the system at design flow without discharging to the warehouse service area. See Figure 7-1 for typical arrangement.

Detailed layout drawings, performance data of the various proportioning methods, and the requirements for the proportioning equipment are provided in the proportioning section of the National Foam Engineering Manual and data sheets. It should be noted that National Foam does not normally recommend line proportioners (vacuum inducting type) for sprinkler applications.

RECOMMENDED FOAM CONCENTRATES

Warehouse fires are normally spill type fires with fuel depth of less than 1". Also, the primary focus is on the quick knock down of the fire to prevent damage to the aircraft. Because of the type of hazard and fuel depth, the ability to seal against hot metal surfaces, burn back resistance and ability to reseal upon disruption of the foam blanket are secondary to the quick knockdown. Aqueous film-forming foams (AFFF) are the agent of choice for this application.

Many applications today contain polar solvent-type flammables and require Alcohol Resistant-Aqueous Film-Forming Foam (AR-AFFF) type concentrates. AR-AFFF type concentrates provide excellent fire performance on hydrocarbons and can be used in applications where both types of flammables exist. It can be applied through standard sprinklers and non-aspirating discharge devices. Although air-aspirating discharge devices are not required, AR-AFFF will also work well with these type devices.

Protein and fluoroprotein type foam concentrates can be used, however, they usually require higher application rates, air-aspirating discharge devices and do not provide the quick knockdown ability of an AFFF. Also they are not as fluid as the AFFF and do not flow as quickly across the floor. They are not suitable for retrofit of existing sprinkler systems because of the requirement for an air-aspirating discharge device

Consult the foam concentrate section of National Foam's Engineering Manual and data sheets for additional information on foam concentrates. Your local National Foam representative or National's Engineering Department should be consulted for detailed system design and specification.

FOAM SYSTEM AUTOMATION

Most foam-water sprinkler systems installed in warehouses are automated in one form or another. Many of the facilities or a portion of the facility are unmanned during part of the day. Because of this, automation is required to provide quick response to a fire thereby minimizing property loss.

Wet pipe and dry pipe sprinkler systems operate automatically upon fusing of the thermal element in the sprinkler head(s). The thermal element, either a glass bulb or fusible link, break at a preset temperature, thereby opening the sprinkler head allowing water to discharge. The system normally has remote annunciation of the system operation through a water motor alarm or through a remote annunciation panel.

Foam-water deluge and preaction systems shall be provided with automatic and auxiliary manual tripping means. Automation of a system involves detection of the fire condition, activation of the foam proportioning system, direction of the foam solution to the hazard and alerting the appropriate authorities. Detection and actuation equipment shall be designed in accordance with the appropriate sections of NFPA 72. In the event of a fire, the releasing panel may initiate other ancillary functions such as shutting down product supply systems, opening gates, notifying fire departments, etc. In addition to the detection system, manual break-glass stations or other manual means of tripping the system shall be provided.

Many types of fire detection devices are available for protection of warehouses. Fire detection devices should be selected on the basis of cost-effectiveness, ease of installation, maintenance requirements, and freedom from false trips. Speed of system operations is always critical in minimizing property loss. Although the speed of operation is critical to minimizing the property loss, the intent of the system design is not for life safety but for protection of the product stored and the facility. Regardless of the speed of the detection and system initiation, there is a delay in operation and discharge of foam due to the time required to charge the piping system. We believe the most effective type of detection system is the rate compensated fixed temperature or fixed temperature thermal type. Although it is not as fast a optical detection, we feel that it is more dependable, less prone to false trips, requires less maintenance and provides a response which is sufficiently fast for this type of application. Speed of response for thermal detectors will be dependent on the temperature setting, thermal drafts and mounting locations. National Foam does not normally recommend the use of optical detectors, because of the cost, maintenance requirements and the tendency toward false trips, however, some applications may require their use. See applicable sections of NFPA 72 for design recommendations for the detection and control equipment.

Your local National Foam representative or National's Engineering Department should be consulted for the automated system design best suited to a particular warehouse installation.

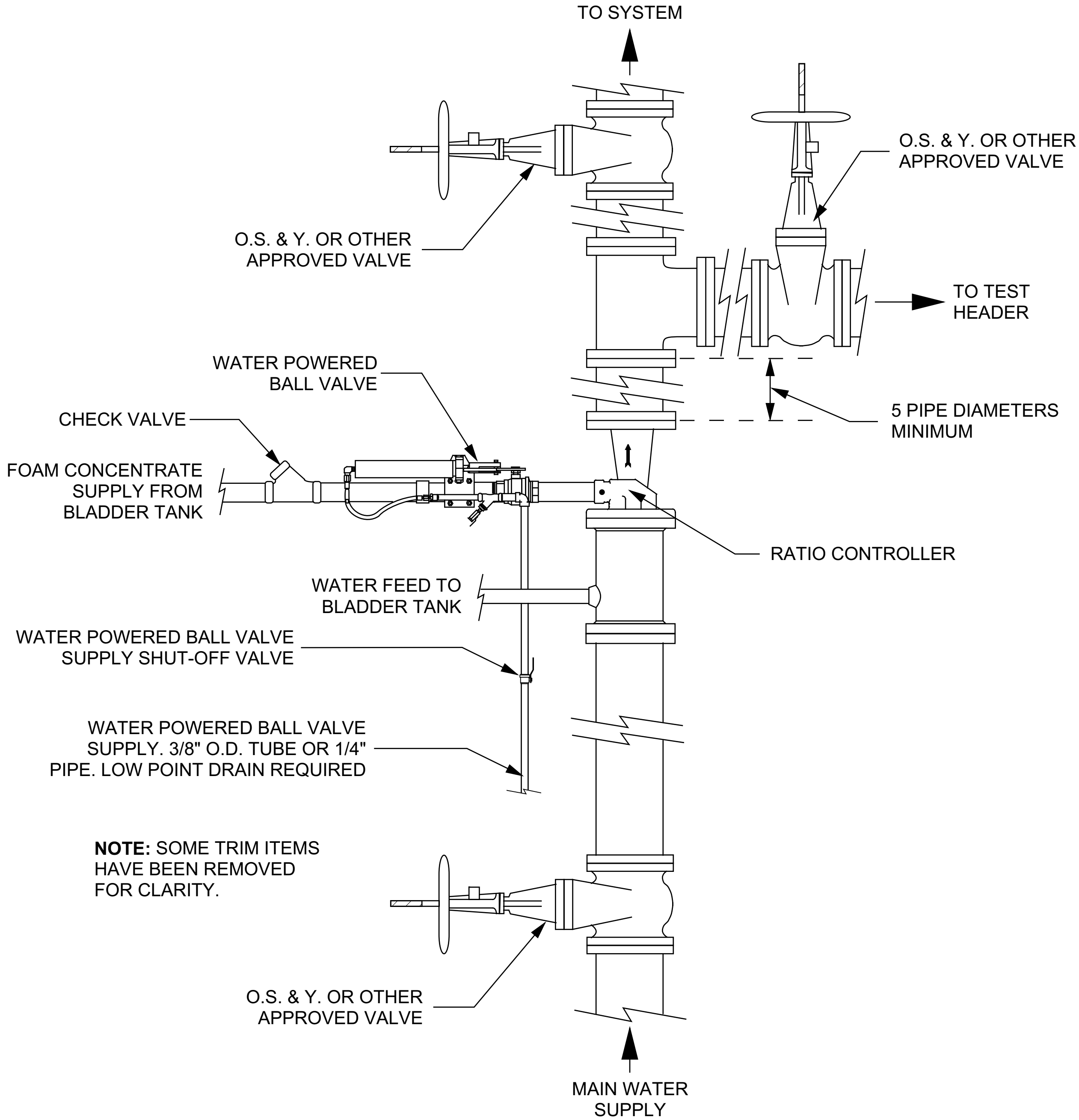
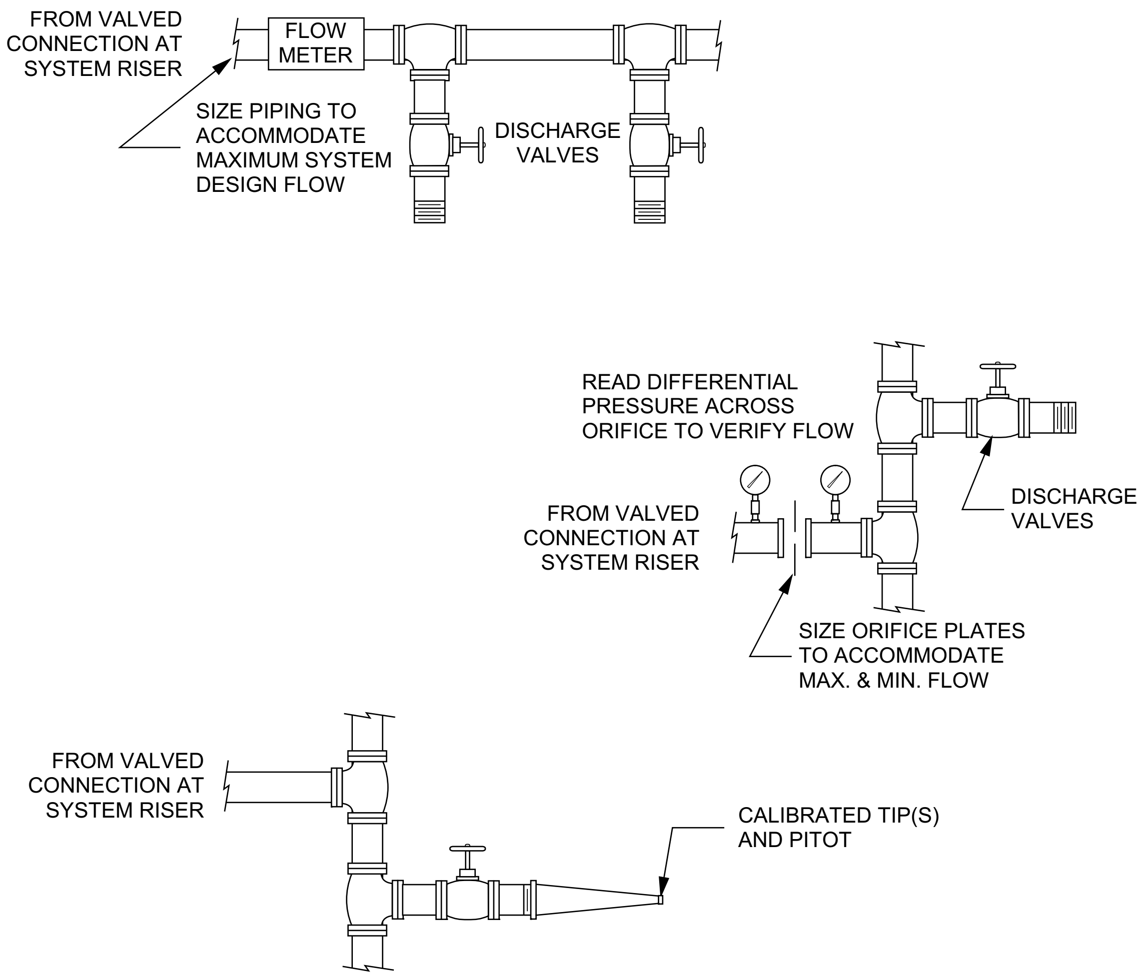


FIGURE 7-1
Typical Riser Detail



<u>FIGURE 7-2</u>
Typical Test Headers

SECTION 8
MARINE VESSELS/DRILLING RIGS

National Foam

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SECTION 8
MARINE VESSELS/DRILLING RIGS

GENERAL OVERVIEW

Every U.S. flag tanker must be equipped with a cargo deck foam system meeting U.S. Coast Guard (USCG) regulations per The Code of Federal Regulations, Title 46 and other applicable requirements. Approved foam systems are listed in the USCG Equipment Lists. The foam system designed for each vessel must be submitted for approval to the Coast Guard District in which the construction will take place. In addition to cargo deck protection, for which foam is required, foam is also acceptable for protection of machinery spaces, cargo pump rooms, helidecks and heli-refueling areas.

Tank vessels registered in other countries may also require foam protection. Requirements are set forth by authorities having jurisdiction similar to the USCG, such as Det Norsk Veritas in Norway, SBG in Germany, and the British Ministry of Transport. Foam system design requirements may vary, but the trend is for many governments to conform to the IMO (International Maritime Organization) Resolution A-271 (VIII), SOLAS (International Convention for the Safety of Life at Sea, 1974 and ABS (American Bureau of Shipping). These recommendations are similar to those of the USCG. All foam liquid concentrates, foam proportioning and foam equipment referred to on the following pages are USCG approved, and in most cases, meet the requirements of ABS, SBG, Det Norsk and Lloyd's Register of Shipping of London, UK.

DECK FOAM SYSTEMS

Rate of Application (For Hydrocarbon Products)

The minimum required foam application rate is calculated as 0.016 gpm/ft^2 (0.65 lpm/m^2) of the total cargo tank deck area or 0.24 gpm/ft^2 (9.8 lpm/m^2) of the single largest cargo tank, whichever is greater. The total cargo tank area is defined as the total length of the cargo tanks times the breadth of that tank.

Quantity of Foam Liquid Concentrates

A supply of foam liquid must be provided sufficient to operate the foam system for at least 20 minutes. If the actual rate of foam application exceeds the minimum required rate, the quantity of liquid must be sufficient for 20 minutes operation at the actual rate of application, i.e., the highest expected foam solution flow. The required quantity of foam concentrate is to be a single foam storage tank providing an uninterrupted and continuous foam application.

Spacing of Foam Nozzles

Piping and foam nozzle stations must be installed so that the required rate of application can be applied to any portion of the open deck of the cargo area. See Figure 8-1 for typical piping arrangement.

Monitor mounted and portable foam nozzles are installed at each foam station for this purpose. A minimum of 50% of the required rate of application must be from a monitor nozzle. In determining the spacing of nozzles along the deck, the nozzle range is limited to 75% of the listed straight stream range for wind conditions. Also, the capacity of each monitor must be at least 0.073 gpm/ft^2 (3 lpm/m^2) of deck area protected by that monitor.

Two monitors, one port and one starboard separated by a minimum of half of the beam of the vessel, must be located at the housefront or aft of the cargo deck area. The foam proportioning system is designed for operation of either port or starboard monitor nozzle station only. In addition, provision must be made at each monitor station for supplementary operation of at least one portable foam nozzle.

Design Examples

For an example of deck foam system requirements, assume a tanker with a total cargo deck length of 400 ft (122m) and a breadth of 80 ft (24.3m), and with a largest single cargo tank length of 80 ft (24.3m) and a breadth of 40 ft (12.2m).

The (MRFAR) minimum required foam solution application rate is based on the greatest demand created by the following:

<u>Based on the cargo tank deck area</u>:

- 400 ft. x 80 ft = 32,000 ft^2
- 32,000 ft^2 x 0.016 gpm/ft^2 = 512 gpm minimum required foam solution flow.
  OR

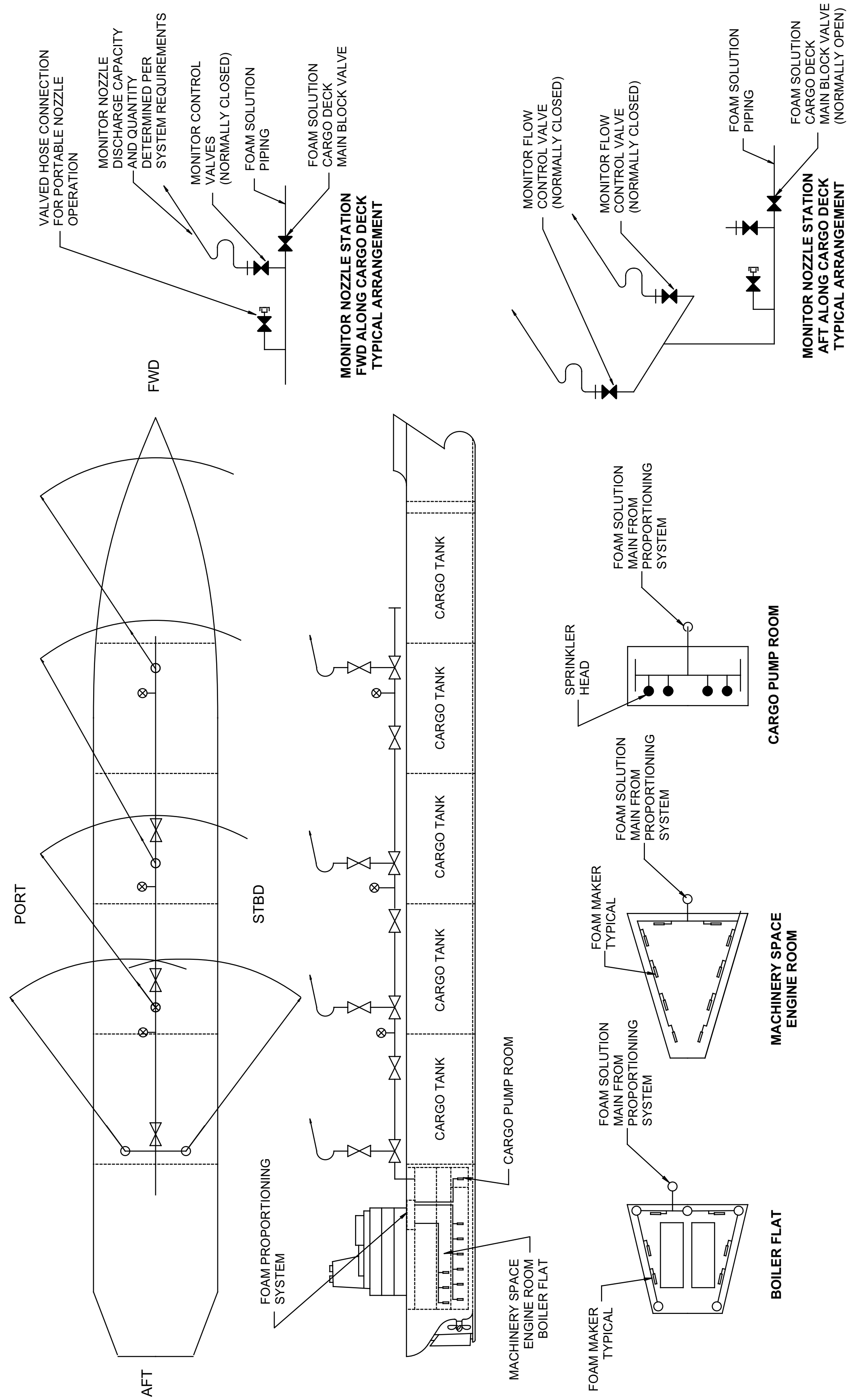


FIGURE 8-1
Typical Cargo Deck Foam System Piping Layout

Based on the largest single cargo tank area:

- 80 ft x 40 ft. = 3,200 ft^2
- 3,200 ft^2 x 0.24 gpm/ft^2 = 768 gpm minimum required foam solution flow.
  OR

Based on the (rectangular) area forward protected by that monitor:

- 90 ft length x 80 ft. beam = 7,200 ft^2
- 7,200 ft^2 x 0.073 gpm/ft^2 = 525.6 gpm minimum required foam solution flow.

The 768 gpm foam solution flow being the greater requirement would be the basis for the foam system design.

The total cargo area is defined as the product of the maximum beam of the vessel multiplied by the total longitudinal extent of cargo tank space. Individual tank area is defined as the horizontal sectional area. Area protected by the largest monitor is defined as the area entirely forward of the monitor.

The selection of the foam nozzles is determined by the foam solution flow required in conjunction with the expected water supply pressure for that particular ship. Assuming a pressure of 75 psi (5 Bar) at the nozzles, one PC-100 monitor nozzle and one JS-10B portable nozzle operating simultaneously would have a combined foam solution rate of 792 gpm (2998 lpm), 706 gpm (2672 lpm) and 86 gpm (326 lpm) respectively. This foam nozzle combination is acceptable since it exceeds the 768 gpm minimum foam solution requirement.

The range of the PC-100 Nozzle at 75 psi (5 Bar) is listed as 140 ft. (42.7m). The allowable straight stream range for determining the spacing of the monitor stations down the cargo deck center is to be based on 75% of 140 ft (42.7m) or 105 ft. (32.0m). This example would require two stations on the housefront and three foam stations along the deck center to provide an acceptable foam application.

The quantity of foam liquid concentrate must be adequate for 20 minutes of operation (some authorities require 30 minutes) at the actual rate of application expected. If we assume the proportioning system used would proportion at an actual foam concentrate injection percentage of 3.1%, the foam concentrate quantity is determined as follows:

792 gpm (2998 lpm) solution x 0.031% x 20 minutes = 491 gallons (1858.5 liters).

A foam concentrate storage tank of at least 500 gallon (1893 liters) capacity would be recommended for this system.

Foam Systems for MTBE, ETBE and TAME Blended Gasolines in Excess of 17.4% by Volume:

Aer-O-Foam XL-3 foam concentrate (only) foam systems for foam application to MTBE (methyl tertiary butyl ether), ETBE (ethyl tertiary butyl ether) and TAME (tertiary amyl methyl ether) are designed as indicated above, except the application rates to be used are as follows:

1. 0.019 Gpm/ft^2 (0.78 lpm/m^2) X cargo deck area.
   OR
2. 0.29 Gpm/ft^2 (11.8 lpm/m^2) X largest single tank area.
   OR
3. 0.09 Gpm/ft^2 (3.7 lpm/m^2) X area protected by largest monitor.

Enclosed areas over cargo deck tanks, such as midship house, containing MTBE, ETBE and TAME blended gasolines in excess of 17.4% in gasoline by volume require a minimum foam solution rate of 0.19 gpm/ft^2 (7.75 lpm/m^2) for a minimum of 5 minutes.

Enclosed areas, such as cargo pump room, which may handle MTBE, ETBE and TAME blended gasolines in excess of 17.4% in gasoline by volume, require a minimum foam solution rate of 0.19 gpm/ft^2 (7.75 lpm/m^2) for a minimum of:

3 Minutes operation for fixed piped foam systems;
5 Minutes operation for portable or semi-portable foam systems.

FOAM PROPORTIONING

When considering proportioning in terms of foam systems, the selection of NF proportioning equipment is extensive. Each type of proportioning system carries certain advantages. Each component of a foam system whether simple or complex, requires careful consideration. In foam systems, proportioning is the mixing of foam concentrate with water to produce a foam solution. The foam solution is piped to a foam maker, which induces air into the foam solution, causing expansion of the foam solution, producing a finished foam. Correct proportioning maintains a consistent percentage of foam concentrate injection into the water supply.

Proper proportioning through any proportioner is mandatory. If proportioning is too “lean” (less than the design percentage of foam concentrate to water), the overall foam quality decreases. The drainage time decreases and the bubbles break faster. Also, the resistance to heat decreases. Therefore, lean foam may or may not put out the fire. On the other hand, if proportioning is too "rich" (greater than the design percentage of foam concentrate to water), the foam shows stiffness and non-fluidity or reluctance to flow around obstructions. In addition, the foam concentrate supply is depleted more rapidly and hence may not adequately meet minimum operation time requirements.

The most commonly used USCG approved proportioning method is balanced pressure proportioning, utilizing a common proportioner with a positive displacement type foam concentrate pump to inject the foam concentrate into the water supply. The foam concentrate storage tank and the foam proportioning station is be located aft of the cargo tank area bulkhead in an accessible location and outside of any protected space. The foam proportioning station is most often located on the main deck level in the vicinity of the crew's quarters.

Fireboats and offshore supply vessels commonly use an in-line balanced pressure (ILBP) proportioning system. When it is necessary to operate under one or more of the following conditions, ILBP is recommended.

1. Simultaneous operation of water or foam from some or all discharging systems.

2. Multiple foam maker operation with pressure differences between foam maker points.

3. Systems located in different areas, which are remote from the foam concentrate storage tank and foam pump.

4. Capability of selectively operating with foam or water at each proportioning station.

5. Ability to choose the size proportioner best suited for the area to be protected and still use the same foam concentrate pump skid and foam storage tank for other areas.

An ILBP Proportioning System consists of a foam concentrate pump and storage tank and requires foam concentrate piping to each ILBP module. The supply to the foam concentrate main is provided by a positive displacement foam concentrate pump. A pressure regulating valve in the foam concentrate pump return line maintains constant pressure in the foam concentrate main at all design flow rates up to foam pump capacity. A jockey pump will be required where concentrate pipe exceeds 50 ft. length.

An ILBP Module must be located at or within close proximity to each foam nozzle, hose station and all other foam discharge systems. Each ILBP Module has inlet connections to receive both foam concentrate and water for proportioning. The foam solution produced then flows to the foam-making device to be expanded and then discharged.

ILBP Proportioning Systems allows the selection of either foam or water to every discharge device within the foam system. Monitor or nozzle systems can be switched from foam flow to water flow, water flow to foam flow, or shutdown completely without affecting the correct proportioning of the other discharging devices.

Pressure Proportioner and Bladder Tank type proportioning systems are also Coast Guard approved and are satisfactory for small foam systems, auxiliary areas and helideck protection.

The pressure proportioner is a pressure vessel which takes advantage of the pressure of the incoming water supply by utilizing a small volume of that water to force the foam concentrate contained inside the tank through an operating head(proportioner) and into the flowing water stream. A standard pressure proportioner type has no physical separation between the stored concentrate and the incoming water.

On the other hand, the bladder type, also known as a diaphragm or bag tank, has physical separation between the pressurized water and the foam concentrate.

<u>General Notes / Considerations:</u>

1. The deck foam system must be designed to produce and discharge foam within three minutes after notification of a fire situation.

2. Operating Instructions must be located conspicuously at the foam proportioning location.

3. The water supply must be sufficient to meet the demands of both the foam system and fire main system requirements.

4. The minimum permitted inlet pressure to any type of foam maker is 50 PSI (25.9kPa).

5. Recommended deck foam system testing should be annually for 30 seconds minimum discharging foam. Minimum testing requirement is biennial for 15 seconds discharging foam.

6. A representative foam concentrate sample shall be sent to the manufacturer or a qualified approved lab for analysis annually, preferably before performing the annual test.

MACHINERY SPACES

The cargo deck foam proportioning system may be used for protection of machinery spaces including tank tops, boiler flats, intermediate flats and cargo pump rooms. The minimum rate of application for machinery spaces is 0.16 gpm/ft ^{2} (6.5 lpm/m ^{2}) of protected area, and the minimum required quantity of foam liquid concentrate must be adequate for 3 minutes operation. It is not necessary to figure machinery space foam application simultaneously with cargo deck foam application. The foam application requirement for the cargo deck system normally will exceed the requirement for machinery spaces, therefore, it is only necessary to connect the machinery space systems to the same foam proportioning station.

In machinery spaces, protection is required on an area containing fuel oil pumps, piping or associated equipment, or on any area on which a fuel oil spill might accumulate. Any areas in the same space (not separated by watertight decks or bulkheads) must be protected simultaneously. In addition where drainage to lower areas can occur, coamings should be installed to contain the foam application at that level.

Design Example

Assume there is a boiler flat area of 1500 ft ^{2} (139.4m ^{2}) and an engine room area of 3000 ft ^{2} (279m ^{2}), both requiring foam protection, and both located in the same non-watertight space.

The minimum required foam application rate for the boiler flat is determined as follows:

- 1500 ft ^{2} (139.4m ^{2}) x 0.16 (6.5 lpm/m ^{2}) = 240 gpm (908.4 lpm) of foam solution.
- Five MBS-9SA foam makers (marine bilge type floor nozzle) could be used for this area, each sized for 48gpm (181.7 lpm) @ 50 psi (25.9kPa).

The minimum required foam application rate for the engine room is determined as follows:

- 3000 ft ^{2} (278.7m ^{2}) x 0.16 (6.5 lpm/m ^{2}) = 480 gpm (1816.8 lpm) of foam solution.
- Nine MBS-9SA foam makers (marine bilge type floor nozzle) nozzles could be used for this area, each sized for 54gpm (204.4 lpm) @ 50 psi (25.9kPa).

The combined minimum required foam application rate is 720 gpm (2725 lpm) since both areas would have to be protected simultaneously. The supply of foam concentrate would be determined as follows:

- 720 gpm (2725 lpm). x 0.03% x 3 minutes = 64.8 gallons (245.3 liters).

Since the foam proportioning system capacity and foam concentrate supply for the cargo deck foam system exceed these requirements, the machinery space protection can be operated from the cargo deck foam system, via a separately valved line.

Cargo pump rooms also may be connected to the same foam proportioning station and liquid supply serving the cargo deck system. The required foam rate of application is 0.16 gpm/ft. ^{2} (6.5 lpm/m ^{2}) of cargo pump room deck area. The quantity of foam liquid concentrate must be adequate for three minutes operation at that rate. This is normally applied through B-1 foam/water sprinklers, pendent style. Since the cargo pump room is separate from the machinery spaces and the cargo tanks, the pump room system need not operate simultaneously with either of those systems. The cargo pump room foam system can, therefore, be connected to the cargo deck foam system as a separately valved line. The total foam solution flow rate to the pump room must meet or exceed the minimum flow rate of the foam system proportioning equipment.

Foam system operation in machinery spaces and cargo pump rooms is considered as secondary protection.

Since each tank vessel must be approved on an individual basis by the appropriate government authority, contact our Engineering Department for final design incorporating current regulations.

For protection of polar solvents, contact our Engineering Department for U.S. Coast Guard design parameters.

NATIONAL UNIVERSAL FOAM SYSTEM CARGO DECK DESIGN

Criteria for Universal Foam Systems may be divided into two areas requiring different calculation methods depending on whether the cargo to be carried is a hydrocarbon product or a water soluble polar solvent flammable liquid.

<u>For Hydrocarbon Product Cargo Tank Deck Protection</u>: The (MRFAR) minimum required foam application rate is based on the greatest demand created by the following:

- 0.016 Gpm/ft ^{2} (0.65 lpm/m ^{2}) x total cargo area
  OR
- 0.24 Gpm/ft ^{2} (9.78 lpm/m ^{2}) x largest single tank area
  OR

- 0.073 Gpm/ft² (2.80 lpm/m²) x area protected by largest monitor

The total cargo area is defined as the product of the maximum beam of the vessel multiplied by the total longitudinal extent of cargo tank space. Individual tank area is defined as the horizontal sectional area. Area protected by the largest monitor is defined as the area entirely forward of the monitor.

Fixed protection for boiler and machinery spaces and pump rooms.

The minimum required foam application rate is determined by:
- MRFAR = 0.16 gpm/ft² (6.50 lpm/m²) x (area of protected surface)

For Polar Solvent / Water Miscible Product Cargo Deck Protection:
The (MRFAR) minimum required foam application rate is based on the greatest demand created by the following:

There are two methods approved by the USCG for calculating the required foam solution rate for cargo tank deck systems. One is similar to the hydrocarbon calculation method except it uses higher multiplication factors.

The first method requires all or certain tanks to be dedicated to certain classes of flammable liquid products. The three classes, and their member flammable liquids, for use with Universal are Listed in National Foam's Design Manual for USCG Approved National Universal CG6% Foam Systems. The foam application rate multiplication factors are 0.16 gpm/ft² (6.5 lpm/m²), 0.24 gpm/ft² (9.8 lpm/m²) and 0.35 gpm/ft² (14.2 lpm/m²) for product classes A, B and C, respectively.

The second method can result in high foam solution rates; however, if certain tanks are dedicated substantial reductions in the required foam solution rate can be obtained without lowering the level of fire protection.

Method 1. The MRFAR (minimum required foam application rate) is based on the greatest demand created by the following:

1. Highest product class application rate used x total cargo area.
   OR
2. Highest product class application rate used in either tank) x area of tank pair.

Exception - If both tanks carry hydrocarbons:

- MRFAR = 0.24 gpm/ ft² (9.8 lpm/m²) x (area of tank pair)
  OR
3. Highest product class application rate used in monitor area x 0.45 (18.3 lpm/m²) x area protected by monitor.

Method 2. The MRFAR (minimum required foam application rate) is based on the greatest demand created by the following:

1. 0.05 Gpm/ft² (2.0 lpm/m²) x total cargo area
   OR
2. 0.5 Gpm/ft² (20.0 lpm/m²) x largest single tank area
   OR

(3) 0.25 Gpm/ft² (10.0 lpm/m²) x rectangular area forward protected by that monitor or 330 gpm (1250 lpm, whichever is higher.

The MRFAR will be the highest foam solution flow obtained from the above calculations.

A pair of tanks is defined as two adjacent tanks that share a common bulkhead. Diagonally placed tanks that meet at a corner are not to be considered, nor included, in the calculations.

Fixed Foam Protection For Boiler Room, Machinery Spaces And Cargo Pump Rooms:
Since the fuels present in the boiler and machinery spaces usually are hydrocarbons, the required rate for these areas may be found in the hydrocarbon design section.

The MRFAR for the cargo pump room is determined by the highest product class application rate used x area of protected surface.

APPLICATION DEVICE REQUIREMENTS

Cargo Tank Protection:

Monitor nozzles and handheld foam nozzles shall be provided such that the MRFAR required is obtained and can be applied to any part of the cargo deck.

In addition, 50% or more of the required flow must be from monitor nozzles. In practice, this usually means several monitor and foam hydrant stations at symmetrical intervals supplied by a foam solution supply line running down the approximate center of the cargo deck.

To insure accessibility, another requirement is that two monitor stations be available at the house front, or aft of the aft cargo tank bulkhead if the house is forward of the aft cargo tank bulkhead.

Consideration must also be made to manpower requirements when allowing for staffing of monitor nozzle and handline operation. A minimum of two persons is recommended for operation of each handline, one for hose valve control and hose movement and one for control of the portable nozzle.

In designing the cargo deck system, 75% of the listed still air range of the monitor nozzles shall be used in determining monitor spacing.

Fixed Protection for Boiler, Machinery Spaces and Pump Rooms:
Fixed nozzles or foam devices must be located so as to blanket the protected area with foam. All points within the area to be protected should be no further than 30 feet from a foam discharge device; less if there are obstructions. Some devices may have specific spacing limitations, check with manufacturer.

FOAM CONCENTRATE REQUIREMENT

Enough foam liquid concentrate must be provided to meet the requirement of the individual foam system demand with the highest foam requirement. It is not required to have enough foam concentrate for more than one system to operate at full flow for the required times. The foam concentrate injection percentage used in calculating the required foam concentrate quantity should be based on the actual tested proportioning percentage at the actual system flow for the particular proportioning device, and not the nominal proportioning percentage.

For Hydrocarbon Cargo Tank Deck System:
The foam liquid concentrate requirement is calculated as follows:

- (Highest Actual Foam Solution Flow) x (Actual Percentage of Injection) x (20 Minutes)

Note: Some regulations require 30 minutes.

For Polar Solvent Cargo Tank Deck System:
The foam liquid concentrate requirement is calculated as follows:

- (Highest Actual Foam Solution Flow) x (Actual Percentage of Injection) x (30 Minutes)

For Machinery Spaces, Boiler Room and Cargo Pump Room:
The foam liquid concentrate requirement is calculated as follows:

- (MRFAR - minimum required foam application rate) x (Actual Percentage of Injection) x (3 Minutes)

The largest amount of foam concentrate calculated above will be the minimum required quantity to be stored in a single tank for foam system operation.

HELIDECK FOAM PROTECTION

Helidecks with no fueling operations do not require foam fire protection. Consult USCG regulations for fire protection utilizing water systems.

Helidecks with hydrocarbon fueling operations require special foam system design criteria as follows:

Foam System Solution Flow Requirement:

For AFFF and AR-AFFF foam concentrates a MRFAR (minimum required foam application rate) of 0.1gm/ft^2 (4.1 lpm/m^2) is required for a design area based on the diameter of the swept rotor area of the largest helicopter to land.

For protein foam concentrates a MRFAR (minimum required foam application rate) of 0.16 gpm/ft^2 (6.5 lpm/m^2) is required for a design area based on the diameter of the swept rotor area of the largest helicopter to land.

Foam Application Devices:
Portable foam nozzles are required at a minimum of two access points. The nozzles must have a flow rate of at least 90 gpm at 100 psi(340 lpm at 6.9 Bar) with spray and straight stream discharge pattern capability. Each nozzle must be provided with a shutoff valve and an adequate length of 1-1/2" hard rubber “booster type” hose to access any point on the helicopter deck. A continuous flow type hose reel with a corrosion resistant finish and/or constructed of corrosion resistant materials must be provided for hose and nozzle storage when not in use. If additional flow is required, the two nozzles may be supplemented with additional hand line or monitor mounted nozzle stations. A shutoff valve must be installed for each monitor nozzle, which may be located at the base of the monitor. A spray stream feature is not required for a monitor mounted nozzle. When additional nozzles are used, they must be located in a manner to facilitate coverage of the entire hazard area and be readily accessible.

Time of Application and Foam Concentrate Requirement:
The foam system must be capable of operating at the actual foam solution flow rate for 5 minutes.

Foam System Requirements:

The foam system must be capable of operating within 10 seconds of initiation. The system must be capable of operating all application devices simultaneously at a minimum nozzle inlet pressure of 50 psi(3.4 Bar).

Each monitor nozzle and portable nozzle station must be designed in a manner to protect against icing and freezing.

Helideck with Fueling Facilities:

For AFFF and AR-AFFF foam concentrates a MRFAR (minimum required foam application rate) of 0.1gm/ft^2 (4.1 lpm/m^2) is required for the fueling area.

For protein foam concentrates a MRFAR (minimum required foam application rate) of 0.16 gpm/ft^2 (6.5 lpm/m^2) is required for the fueling area.

The quantity of foam concentrate required for the fueling area is based on providing a minimum of five minutes operation at the actual foam solution flow. If the foam system is designed for operation to the helideck and the fueling areas, the foam concentrate is to be calculated to provide five minutes operation for foam application to both areas.

MARINE FOAM LIQUID CONCENTRATES

National Foam Aer-O-Foam XL-3 foam concentrate represents the single most significant improvement in foam technology since mechanical foams were first introduced. Aer-O-Foam XL-3 Fluoroprotein foam concentrate is available for 3% proportioning and is suitable for use with fresh or sea water.

Aer-O-Foam Regular concentrates can be used with fresh or sea water. Special Aer-O-Foam "cold foam" type foam concentrates are available for use in frigid climates or where heating of the foam concentrate in storage is not feasible.

The Aer-O-Foam protein base concentrates are designed for use on hydrocarbon-type flammable liquid fires through NFPA Type II devices and air-aspirating foam nozzles.

National Foam Universal CG6% is approved for application on polar solvents at 6% injection as well as hydrocarbon products.

National Foam Aer-O-Foam XL-3, Aer-O-Foam 3% Regular and Universal CG6% foam concentrates have U.S. Coast Guard approval.

National Foam recommends foam application in machinery spaces, boiler flats and pump rooms as a secondary system. The USCG recognizes the 1981 amendments to the 1974 SOSAS treaty which require a gas, high expansion foam or pressure water spray type fire system as the primary means of protection in the enclosed spaces mentioned. Information contained in this manual relating to foam application in the above areas is intended when foam is selected as a secondary system.

Proper Storage And Maintenance Of Foam Concentrates:

All National Foam concentrates are designed and tested to provide a minimum storage life of ten years. When properly stored and maintained, National Foam products have lasted considerably longer.

Storage in shipping containers is acceptable, but care should be exercised with metal pails and 55-gallon drums to protect them from external corrosion.

Properly constructed large capacity tanks offer the optimum conditions for prolonged storage.

A carbon steel or stainless steel foam concentrate storage tank, should be constructed with an expansion dome capacity of at least 2% of the tank volume. The tank should be closed to the atmosphere with a pressure-vacuum vent mounted on the expansion dome. The foam concentrate level in the tank should be maintained at a point halfway into the expansion dome.

Interior surfaces of a foam storage tank should not be painted or coated. All foam concentrates are very fluid materials. Any lesion in the surface of a coating will be penetrated by the foam concentrate, thereby lifting the coating away from the tank shell in sheets or flakes. Most foam concentrates can be stored safely in tanks of mild steel construction. Consult the description labels on the foam concentrate container for each foam concentrate for acceptable tank construction materials and recommended ambient storage temperatures.

Maximum recommended storage temperatures should not be exceeded. Excessive temperature may cause deterioration in any foam concentrate.

The minimum usable temperature of a foam concentrate is not its freezing point. This minimum temperature is the point at which the foam concentrate will proportion properly through venturi-type devices such as line proportioners and portable nozzle pickup tubes.

Positive displacement type foam proportioning systems, such as balanced pressure proportioning, in-line balanced pressure proportioning, bladder tanks and pressure proportioners, allow foam concentrates to be used at temperatures considerably lower than those listed. Quality foam concentrates are not adversely affected by excessively low temperatures, but they may become too viscous to proportion properly. Freeze-thaw cycling is not detrimental to National Foam products.

The following are some basic guidelines for improving foam concentrate storage life:

1. Keep foam concentrate tank filled into expansion dome.

2. Storage tanks should be fitted with a pressure-vacuum vent. A pressure-vacuum vent reduces condensation and evaporation, which are harmful to the foam concentrate. This vent requires periodic inspection and cleaning.

3. Avoid long-term storage at temperatures above the maximum recommended.

4. Never mix different foam concentrates in common storage tanks.

5. Avoid dilution of foam concentrates with water.

6. Avoid contamination with foreign ingredients, chemicals or oils.

7. Valves, couplings or piping that will be in continual contact with the foam concentrate should not be constructed of dissimilar metals. The use of dissimilar metals may cause galvanic corrosion.

8. Utilize National Foam's Technical Service Department for periodic analysis of your foam concentrate supplies.

TESTS AND APPROVALS

Introduction

All NF products undergo extensive testing from their conception in the research laboratory through rigid quality control standards prior to reaching the market. NF's foam concentrate products are approved and listed by independent testing agencies such as Underwriters Laboratories and Factory Mutual. Also, certain concentrates are approved by the US Coast Guard and other federal agencies. These approvals are the customer's assurance that NF has demonstrated through extensive fire testing and evaluations that the product complies with the rigid requirements and specifications of the testing authority.

In special cases, fire tests are conducted to determine foam effectiveness on a particular flammable liquid and to determine the minimal application rates the hazard requires. Application rates for polar solvent or alcohol-type fuels are determined by the foam concentrate manufacturer through actual fire testing. The approvals for each particular foam concentrate are provided in their respective data sheets.

Foam Concentrate Evaluation

Periodic testing of foam concentrate supplies through a good maintenance program can help sustain the integrity of the foam concentrate. NF's Technical Service Program offers analytical evaluations of foam concentrates to ensure the integrity of the foam concentrate. The Technical Service Report includes the results of at least four laboratory tests.

Technical Service Laboratory Tests

1. pH - determine if a pH value of the foam concentrate lies within its original specified limits.

2. Specific Gravity - determines if the foam concentrate is diluted, or if it is concentrated due to evaporation.

3. Sediment - measures the undissolved solids or particles in a foam concentrate. Problems with dispersion occur with sediments in excess of 0.5%.
   Note: Ensure that the foam sample represents the overall foam supply.

4. Foam Quality - the quality of a good foam is the sum total of its expansion, its 25% drainage time, and ultimately, its fire performance. Procedures for these tests are outlined in NFPA Standard 11.

Note: Synthetic foam concentrates may require additional tests to evaluate surface tension, viscosity and the effectiveness of the aqueous film or polymeric membrane.

If the Technical Service Report for the foam concentrate sample reveals results consistent with its original specifications, it is considered satisfactory and suitable for fire service. Significant deviation from the original specifications in any of the test results may indicate one of the following problems:

1. Contamination
2. Improper storage conditions
3. Chemical change
4. Any combination of the above

At this point, fire tests are recommended. Fire tests on foam samples are conducted within specially designed fire modeling equipment using a protocol developed to simulate full scale UL Standard (UL 162, 6th Edition) fires. Hydrocarbon and/or polar fuels are used as appropriate.

FOAM-WATER SPRINKLERS

Foam-Water Sprinklers provide an effective means of extinguishing fires in ships' pump room and other areas in which flammable liquids are being handled, processed or stored.

The foam-water sprinkler is constructed of brass and is available for either pendent or upright mounting with 1/2" male national pipe thread inlet.

They may be used in combination with MBS Type Foam Makers.

FD47-1-1/2 TYPE CONTINUOUS FLOW HOSE REELS

FD47-1-1/2 (MBF) Marine Brass Fitted and galvanized model continuous flow hose reels when equipped with a JS-10B or F60-P portable foam nozzle are indispensable in high-hazard flammable liquid locations. These reels allow foam hose lines to be brought into action within seconds of foam system actuation. Supplied with non-collapsible hose, continuous flow reels are suitable for even the most difficult environments, such as helidecks and offshore drilling platforms.

MBS-TYPE FOAM MAKER (Marine Bilge Floor Nozzles)

MBS-Type Foam Makers are designed to apply foam to cover deck / floor areas in pump houses, engine rooms or any location where flammable liquids are processed or handled and to apply foam to manifold pits and bilge areas on ships and barges.

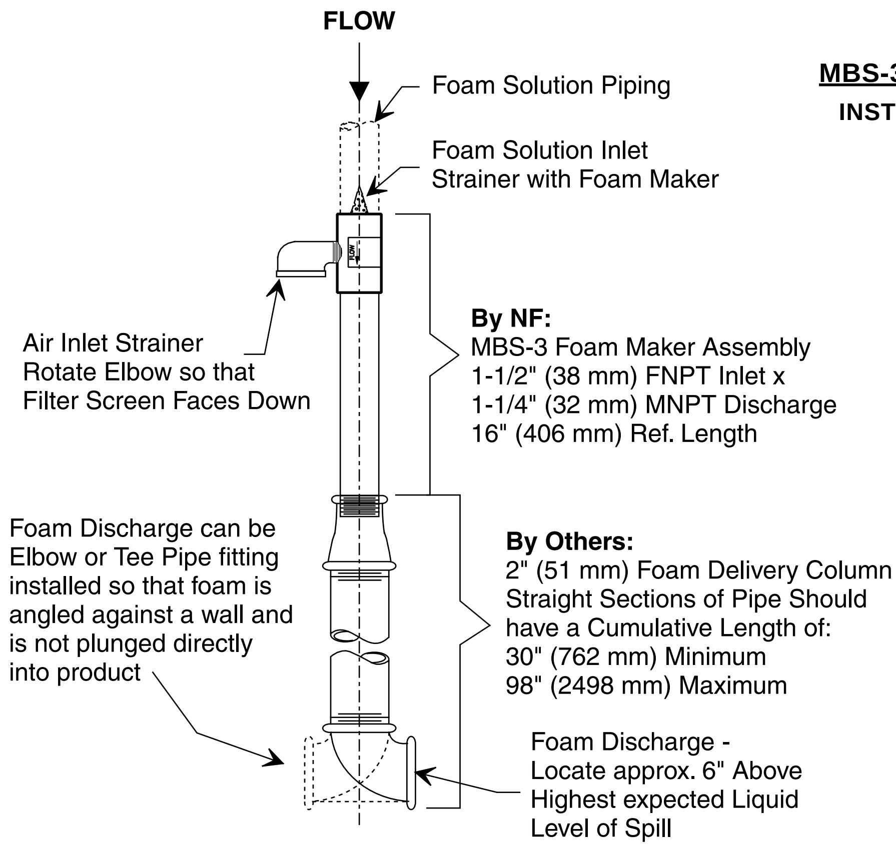
Foam solution can be supplied to the nozzles by the proportioning systems described in Section 2 of this Engineering Manual.

The foam maker has a selective orifice allowing foam systems to be fine tuned to the protected area and the ship's hydraulic characteristics. Although systems should not be operated at pressures lower than 50 psi (345 kPa) at the foam maker, higher pressures (up to 125 psi I862 kPa) are permissible.

Foam discharges from the MBS discharge tube at low velocity from the delivery column and spreads swiftly over the entire floor area. If a spill but no ignition should occur, foam solution can be applied immediately, thus preventing a fire.

The MBS foam maker is designed so that standard steel pipe and malleable iron fittings can be used for the delivery column and discharge outlet. See Figure 8-3 for typical piping arrangements.

MBS-3 TYPE FOAM MAKER
INSTALLATION ASSEMBLY



MBS-9 TYPE FOAM MAKER
INSTALLATION ASSEMBLY

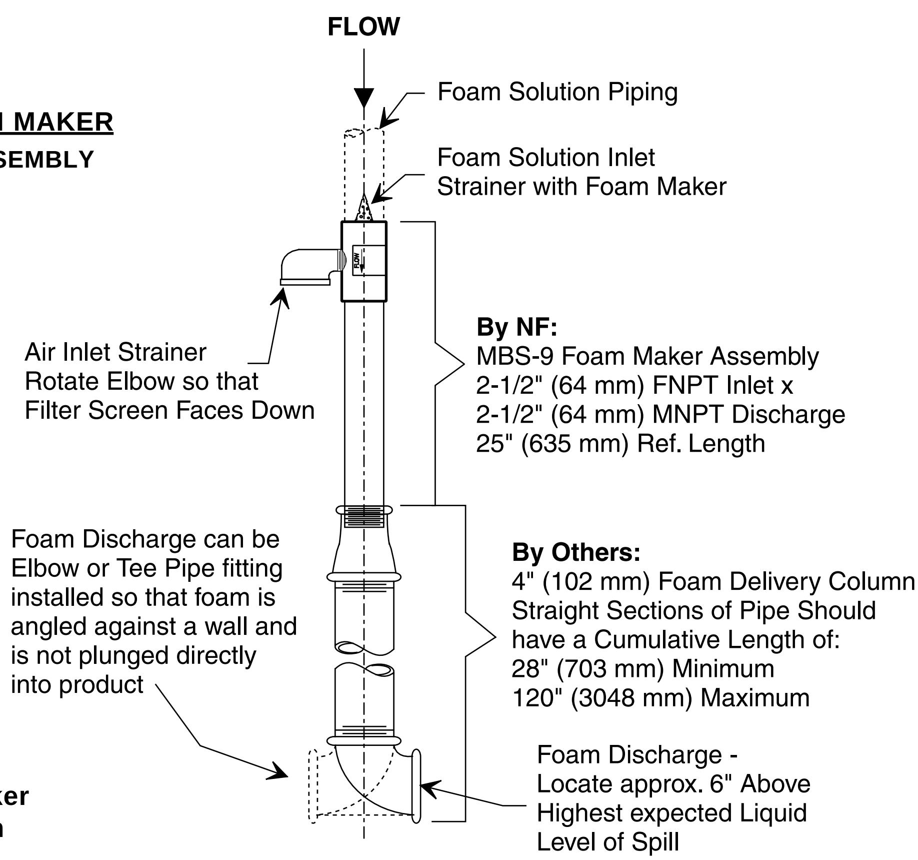


FIGURE 8-2
MBS Type Foam Maker
Typical Installation

INSTALLATION NOTES

1. NF furnishes MBS-Type Foam Maker Assembly only, consisting of - Foam Maker, with sized selective Orifice, Foam Solution Inlet Strainer and Air Inlet Strainer.

2. Piping, fittings and installation by others:
   - Pipe - Schedule 40 steel
   - Fittings - 150# Class Malleable Iron or Steel

   Piping configurations indicated are typical and can be modified to suit on-site conditions following recommendations and limitations stated.

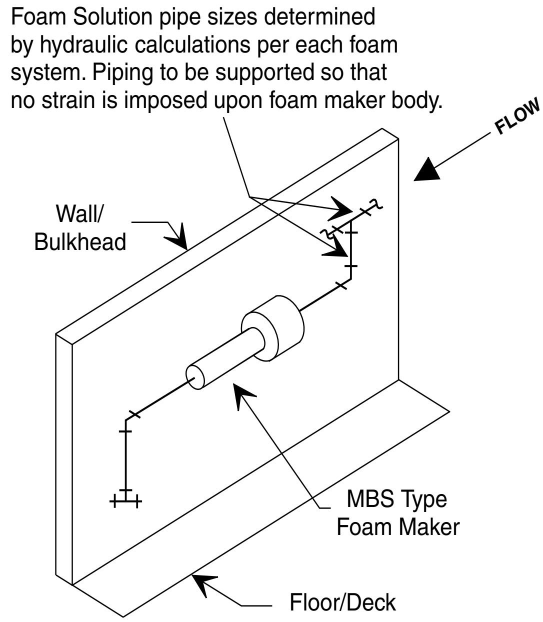
3. MBS-Type Foam Makers of different models and/or orifice sizes must be installed properly in accordance with the foam system design to assure proper foam application rate is applied to the respective hazard area.

4. To prevent clogging, strainer and screen shall not be painted.

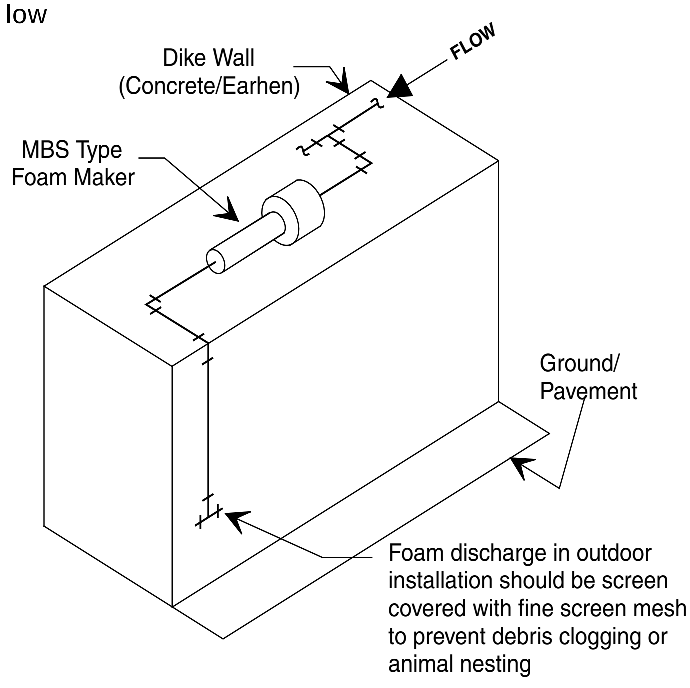
5. Foam Maker can be installed in any position. Foam Maker air inlet strainer is not to be used as the low point piping drain.

6. Maximum peripheral spacing between MBS-3 Type Foam Makers in clear ares is 30 Feet (9.2 M). Additional foam makers may be necessary to assure that no point in the protected area shall be more than a horizontal distance of 15 Feet (4.6 M) from an MBS-Type Foam Maker and to provide even foam distribution in areas where obstacles may hinder foam flow.

7. Maximum peripheral spacing between MBS-9 Type Foam Makers in clear ares is 60 Feet (18.3 M). Additional foam makers may be necessary to assure that no point in the protected area shall be more than a horizontal distance of 30 Feet (9.2 M) from an MBS-Type Foam Maker and to provide even foam distribution in areas where obstacles may hinder foam flow.



INDOOR LAYOUT (TYPICAL)



OUTDOOR INSTALLATION (TYPICAL)

FIGURE 8-3
MBS Type Foam Maker
Typical Installation

APPENDIX

PROPOSAL REQUEST DATA REQUIRED

MARINE VESSEL

Builder / Owner: ____
Hull No. / Vessel Name: ____
Location: ____
Vessel - Type: ____

Tanker ______ Chemical Carrier________ Containership ______ Fire Boat ________
Drilling Rig ______Other (explain) ________________________________

Regulations: (“Authorities Having Jurisdiction”)
U.S.Coast Guard, (USCG) ___________________
American Bureau of Shipping, (ABS)___________
International Maritime Organization, (IMO) ______
Safety of Life at Sea, (SOLAS) _______________
Lloyd’s Register of Shipping __________________
Other (indicate) ____________________________

Product / Area(s): ____

Hydrocarbons - ____

Polar Solvents and / or Alcohols (describe/list) ________________________________

Other (describe/list) ____

Vessel Dimensions: _______________ ft.0.A.length x_______ ft. beam x __________ ft. depth

Cargo Deck Area: _________________ ft. length x _________ ft. beam

Largest Single Cargo Tank: _________ ft. length x _________ ft. beam

Cargo Pump Room: _____ FWD ____ AFT ____ ft. length x_____ ft. beam

Machinery Space (s): ______ft. length x ______ ft. beam
(Dimensioned drawing is recommended showing layout configuration of each level)

Foam Proportioning System Location:
Aft ____ Fwd _____ Main Deck Level _____Other (explain) ________________________

Water Pump (s): (available for foam system):_________GPM / _________ PSI
Location: ____
Tank Top ______ Main Deck (Deepwell Pump)_______ Other (explain) ____________________

Foam Concentrate (_____ % of injection)
_____ Protein/Fluoroprotein _____AFFF_____ AR-AFFF (National Universal)

Electrical voltage and requirements on board:
Phase, Hertz, volt ____
Motor enclosure type ____
Starter enclosure type ____

APPENDIX

PROPOSAL REQUEST DATA REQUIRED

HELIDECK-MARINE

Builder / Owner: ____

Hull No. / Vessel Name: ____

Location: ____

Vessel - Type: ____

_____ Offshore Drilling Rig _____Ship (describe) _____ Other (describe) ______________________

Regulations:(“Authorities Having Jurisdiction”)

U.S. Coast Guard, USCG ___________________

American Bureau of Shipping, ABS ___________

International Maritime Organization, IMO _______

Department of Energy, DOE (British) ___________

Norwegian Maritime Directorate, NMD _________

Det Norske Veritas, DNF (Norway) ___________

Other (indicate) ____________________________

Hazard Dimensions: (fill in design parameter)

_____ ft. Largest rotor blade diameter of helicopter expected to land.

_____ ft. x ______ft. Helideck area.

_____ ft. x ft., “The Prescribed Area”, the area equal in size to 0.75 (L)2, where L is the overall length of the longest helicopter expected to land, measured along its rotors in a fore an aft line.

Helicopter Refueling/Fuel Storage: ____ ft. x _____ ft.

Located _____ ft. above / below / same as helideck

Fuel storage tank _____ ft.diameter X ______ ft. high

Foam Proportioning System Location:

Located _______ ft. above / below / same as helideck

Water Supply (Pump): (available for foam system) ______ gpm @ ______ psi rating

Located _______ ft. above / below / same as helideck

Foam Concentrate (_____ % of injection)

_____ Protein/Fluoroprotein _____AFFF_____ AR-AFFF (National Universal)

Electrical voltage and requirements on board:

Phase, Hertz, volt ____

Motor enclosure type ____

Starter enclosure type ____

MARINE EQUIPMENT LIST

Some National Foam equipment listed is commonly used with National Foam Universal CG6% or Aer-O-Foam XL-3 foam concentrates, which are USCG approved in conjunction with specific foam proportioning systems and foam making devices. Listed foam equipment combinations should be reviewed by National Foam before releasing a purchase order.

Some National Foam equipment listed on the data sheets may not have a specific marine approval, but are suitable for marine application and environment. NF should be contacted to review the foam equipment selection and to provide any clarification before finalizing a design plan or issuing a purchase order.

Data Sheet Name	Data Sheet Number
Aer-O-Foam 3% Regular	NFC100
Aer-O-Foam 3% Cold Foam	NFC110
Aer-O-Foam XL-3	NFC120
Aer-O-Water 3EM	NFC210
Aer-O-Water 6EM	NFC220
Aer-O-Lite 3%	NFC300
Aer-O-Lite 3% Cold Foam	NFC310
Aer-O-Lite 6% Cold Foam	NFC320
Universal Plus 3% X 6%	NFC410
Universal Gold 3%	NFC420
Universal CG6%	NFC430
Sampling and Testing Procedure	NFC960
Ratio Controller - Model RCT (2” Threaded)	NPR080
Ratio Controller - Model RCF (3” Thru 8” Flanged)	NPR090
Ratio Controller - Model RCW (3” Thru 8” Wafer)	NPR100
Balanced Pressure Proportioning Systems	NPR130
Diaphragm Valve - Back Pressure Service	NPR140

SECTION 9
MARINE DOCK PROTECTION

National Foam

INDEX

SECTION 9
MARINE DOCK PROTECTION

GENERAL OVERVIEW

The loading and off-loading of tank ships and barges are two of the most hazardous operations in the handling of flammable liquids. At marine docks through which critical raw materials pass or which are principal shipping points for finished products, a major loss could interrupt and otherwise adversely affect plant operations anywhere and everywhere in the production, handling and shipping phases.

While fire equipment cannot prevent explosions caused by improper product transfer procedures or collisions, properly designed foam systems can rapidly extinguish the resultant fires. Foam can also prevent the ignition of product spills in and around docks and maintain the security of the spill area until the product can be recovered.

There are three areas of consideration when designing a foam system to protect a marine dock.

1. The primary focus of the system should be on the product transfer area(s) of the dock or pier, such as the loading areas, hoses, valve and pump manifolds and product control buildings. These are the most likely locations for spill fires, so a foam system(s) should be designed to rapidly cover such areas.

2. Since many docks and piers have areas under and around their support pilings or caissons where product spills could easily spread, an under-dock foam system should be provided.

3. A marine dock system should also provide a measure of protection for the tank vessel berthed at the dock since many of the older ships and most barges do not have their own foam systems. Additionally there is the possibility of a ship's foam system being inoperative or inaccessible. It should be noted that adverse wind conditions and the size of some tankers can make complete protection of the vessel by means of a foam system on the dock virtually impossible. In this situation, fire boats or tug/supply boats with foam fire fighting capability would be necessary to successfully handle a ship fire.

System Design

While no standards specifically address the requirements for the design of marine dock foam systems, the NFPA Standards for protection of flammable liquid spill areas and the U.S. Coast Guard regulations for deck foam systems on tank vessels do provide basic guidelines. These standards and regulations normally specify a MRFAR (minimum required foam application rate) of 0.016 gpm/ft^2 (0.65 lpm/m^2) of) of the area to be protected when hydrocarbon products are handled. For AFFF and AR-AFFF foam concentrates a MRFAR (minimum required foam application rate) of 0.1gm/ft^2 (4.1 lpm/m^2) is required for the fueling area. If polar solvent or alcohol type flammables are involved, higher application rates may be required. The manufacturer of the foam system should be consulted for verification.

Foam Monitor Systems

The most practical method for applying the required amount of foam to dock areas is by the use of fixed monitor nozzles. These permit the effective coverage of large areas without extensive piping. The National Foam PC series of nozzles offers a broad spectrum of delivery rates and stream ranges for both foam and water. These nozzles can be mounted on manually controlled, automatic oscillating or completely remote controlled monitors. National Foam's line of monitors and nozzles is the most extensive in the industry and allows versatility in system design.

In determining the spacing of nozzles along the dock, the nozzle range is limited to 75% of the listed straight stream range for wind conditions. Adverse wind conditions will reduce the effective range of any foam nozzle. Because most marine dock facilities are subject to extremes in weather, care must be taken in locating foam monitor nozzles. The foam system should be designed with monitor positioning to provide some overlapping coverage areas to compensate for wind variations.

The anticipated elevation of an empty tanker's cargo deck above the level of the dock, especially at high tide, should be considered when locating the monitors in a foam system. We recommend that suitable towers be provided for the foam monitors to permit foam throw onto the ship's deck. Placing monitors on towers also removes them from congested areas on the dock and reduces the possibility of obstructions in a fire or product spill emergency. Towers should be designed to accommodate the nozzle thrusts, plus the wind velocities expected in the worst weather conditions. Provision should also be made for valving in a protected location at the dock level to isolate each individual tower, its piping, and monitor in case they become damaged in a explosion or by being rammed into.

The total design capacity of a foam monitor systems will be dependent upon the total area being protected. Since some large tanker docks may be thousands of feet long and hundreds of feet wide, a foam system to cover the entire area simultaneously would obviously be impractical. Systems should be designed so that the critical areas containing personnel, loading arms, control buildings, etc. will be covered quickly and effectively. The entire dock area may then be covered by progressively operating different segments (monitor nozzles) of the foam system and shutting down those segments in which extinguishment has been accomplished. Precedent for this design approach exists in NFPA standards for protection of large diked areas and in the U.S. Coast Guard regulations for deck foam systems.

As an example, a system contains eight monitor mounted PC-100 foam nozzles. A PC-100 nozzle delivers 1000 GPM (3785 lpm) of foam solution at 150 PSI (1034 kPa) inlet capacity of 8,000 GPM (30,280 LPM). A more practical approach would be to design this system to operate only four monitors simultaneously, reducing the required capacity to only 4,000 GPM (15,140 LPM). The system could then adequately provide initial protection to a single loading arm area and any fire beyond that area would be handled by switching progressively from one group of monitors to another.

Portable foam nozzles and hose stations should be located throughout the dock area and along critical walkways and access ramps to provide supplementary protection to the monitors and for quickly covering spills to prevent ignition.

Under-Dock Systems

In most marine facilities, there are areas under the piers or docks which are inaccessible to foam equipment operated from the dock itself.

A flammable product spill might spread into these areas and fire could threaten the dock structure. A fixed foam delivery system should be provided to completely cover these hazardous areas.

In the past, many foam systems provided under-dock protection by mounting small foam making devices or foam/water sprinklers below the dock structure. The difficulties generated by marine life growth and system clogging normally existing in such an environment make this type of system extremely difficult to maintain. These problems are compounded in some dock installations where high tide may submerge the foam discharged devices.

National Foam has developed a unique system to minimize most of these problems. Using high-back pressure foam makers located above the dock or even on shore, foam can be delivered under the dock without using foam makers or sprinklers. The only element in the system exposed to the difficult conditions under the dock is the delivery piping, which can be lined or coated for protection.

Under-dock system should be designed for an application rate of 0.16 gpm/ft2 (6.5 lpm/m^2) of the area to be protected. No special nozzles are required at the termination of the delivery piping. Pipe discharge should be directed at pilings or support members of the dock. All piping downstream of the high back pressure foam makers should symmetrical.

Foam Systems for Docks

National Foam has designed and supplied hundreds of foam systems for use on docks, piers and other shoreline facilities. Such systems are designed to meet the requirements of the specific marine docking facility and, if necessary, the vessel carrying the flammable products. Complete foam specifications can be provided for foam systems intended for new docks, or for retrofitting those already in existence. In conjunction with an experienced marine architect and shipbuilding firm, National Foam can provide a complete foam system to meet most requirements.

FOAM PROPORTIONING

Balanced Pressure Type Proportioning Systems

Any type of proportioning system may be used to supply a marine dock foam system, however, balanced pressure type proportioning systems are most commonly recommended. Standard balanced pressure systems are used when all the discharge devices are intended for foam operation only. This method automatically provides correct proportioning over a broad range of flows and pressures and allows a variety of discharge devices to be operated or shut down as fire fighting needs require.

In-Line Balanced Pressure Proportioning

Certain dock systems require delivery of foam or water from some or all discharge devices. When it is necessary to operate under one or more of the following conditions, an ILBP system is recommended.

1. Simultaneous operation of water or foam from some or all discharging systems.

2. Multiple foam maker operation with pressure differences between foam maker points.

3. Systems located in different areas, which are remote from the foam concentrate storage tank and foam pump.

4. Capability of selectively operating with foam or water at each proportioning station.

5. Ability to choose the size proportioner best suited for the area to be protected and still use the same foam concentrate pump skid and foam storage tank for other areas.

An ILBP Proportioning System consists of a foam concentrate pump and a foam concentrate storage tank and requires foam concentrate piping to each ILBP module. The supply to the foam concentrate main is provided by a positive displacement foam concentrate pump. A pressure regulating valve in the foam concentrate pump return line maintains constant pressure in the foam main at all design flow rates up to foam pump capacity. A jockey pump will be required where concentrate pipe exceeds 50 ft. length.

An ILBP Module must be located at or within close proximity to each foam nozzle, hose station and all other foam discharge systems. Each ILBP Module has inlet connections to receive both foam concentrate and water for proportioning. The foam solution produced then flows to the foam-making device to be expanded and discharged.

ILBP Proportioning Systems allows the selection of either foam or water to every discharge device within the foam system. Monitor or nozzle systems can be switched from foam flow to water flow, water flow to foam flow, or shutdown completely without affecting the correct proportioning of the other discharging devices.

Pressure Proportioner and Bladder Tank type proportioning systems are also approved and are satisfactory for small foam systems and auxiliary areas.

The pressure proportioner is a tank with a proportioner mounted on top, which takes advantage of the pressure of the incoming water supply and uses a small volume of that water to force the foam concentrate contained inside the pressure vessel via an operating head into the flowing water stream. A standard pressure proportioner has no physical separation between the stored concentrate and the incoming water.

The bladder tank type, also known as a diaphragm or bag tank, has physical separation between the pressurized water and the foam concentrate via the internal rubber diaphragm.

Foam System Automation

Many modern marine dock facilities use highly automated product transfer procedures since rapid foam system operation greatly reduces the possibility of a major loss in a dock fire. Control centers are used to monitor practically all of the transfer operation, often with a minimum of personnel. Complete remote controlled monitor and under-dock systems with fully automated actuation can be provided with operation from the same control centers.

Recommended Foam System Operating Time

Sufficient foam concentrate should be incorporated into the system to provide a minimum of thirty (30) minutes operating time on hydrocarbon products and fifty (50) minutes operating time on polar solvents.

Recommended Foam Concentrates

Since most dock facilities include relatively large complements of portable dry chemical type extinguishing equipment, foam liquids employed in these systems should be compatible with dry chemical agents. National Foam's XL fluoroprotein foams or Universal Foam (AFFF) are the agents of choice in systems designed for hydrocarbon product protection. Design, application rates and system run times are the same for both types of foam. When polar solvent or alcohol type flammable liquids are handled at the dock, National Foam's Universal foam concentrates are recommended. Application requirements for certain other polar solvent flammable liquids may vary. Consult the foam manufacturer for recommended rates on the most common polar materials.

GENERAL NOTES / CONSIDERATIONS

1. The deck foam system should be designed to produce and discharge foam within three minutes after notification of a fire situation.

2. Operating Instructions should be located conspicuously at the foam proportioning location.

3. The water supply must be sufficient to meet the demands of both the foam system and fire main system requirements.

4. The minimum permitted inlet pressure to any type of foam maker is 50 PSI (25.9kPa). Nozzle inlet pressures of at least 100 PSI (51.8kPa) are recommended to obtain the range sometimes necessary for dock foam systems.

5. Recommended foam system testing should be annually for 30 seconds minimum discharging foam.

6. A representative foam concentrate sample shall be sent to the manufacturer or a qualified approved lab for analysis annually, preferably before performing the annual test.

FOAM CONCENTRATES

National Foam Aer-O-Foam XL-3 foam concentrate represents the single most significant improvement in foam technology since mechanical foams were first introduced. Aer-O-Foam XL-3 Fluoroprotein foam concentrate is proportioned at 3% and is suitable for use with fresh or sea water.

Aer-O-Foam Regular concentrates can be used with fresh or sea water. Special Aer-O-Foam “cold foam” type foam concentrates are available for use in frigid climates or where heating of the foam concentrate in storage is not feasible.

National Foam Universal Gold is approved for application on polar solvents at 3% injection as well as hydrocarbon products.

Proper Storage And Maintenance Of Foam Concentrate
All National Foam concentrates are designed and tested to provide a minimum storage life of ten years. When properly stored and maintained, National Foam products have lasted considerably longer.

Storage in shipping containers is acceptable, but care should be exercised with metal pails and 55-gallon drums to protect them from external corrosion.

Properly constructed large capacity tanks offer the optimum conditions for prolonged storage.

A carbon steel or stainless steel foam concentrate storage tank, should be constructed with an expansion dome capacity of at least 2% of the tank volume. The tank should be closed to the atmosphere with a pressure-vacuum vent mounted on the expansion dome. The foam concentrate level in the tank should be maintained at a point halfway into the expansion dome.

Interior surfaces of a foam storage tank should not be painted or coated. All foam concentrates are very fluid materials. Any lesion in the surface of a coating will be penetrated by the foam concentrate, thereby lifting the coating away from the tank shell in sheets or flakes. Most foam concentrates can be stored safely in tanks of mild steel construction. Consult the description labels on the foam concentrate container for each foam concentrate for acceptable tank construction materials and recommended ambient storage temperatures.

Maximum recommended storage temperatures should not be exceeded. Excessive temperature may cause deterioration in any foam concentrate.

The minimum usable temperature of a foam concentrate is not its freezing point. This minimum temperature is the point at which the foam concentrate will proportion properly through venturi-type devices such as line proportioners and portable nozzle pickup tubes.

Positive displacement type foam proportioning systems, such as balanced pressure proportioning, in-line balanced pressure proportioning, bladder tanks and pressure proportioners, allow foam concentrates to be used at temperatures considerably lower than those listed. Quality foam concentrates are not adversely affected by excessively low temperatures, but they may become too viscous to proportion properly. Freeze-thaw cycling is not detrimental to National Foam products.

The following are some basic guidelines for improving foam concentrate storage life:

1. Keep foam concentrate tank filled into expansion dome.

2. Storage tanks should be fitted with a pressure-vacuum vent. A pressure-vacuum vent reduces condensation and evaporation, which are harmful to the foam concentrate. This vent requires periodic inspection and cleaning.

3. Avoid long-term storage at temperatures above the maximum recommended.

4. Never mix different foam concentrates in common storage tanks.

5. Avoid dilution of foam concentrates with water.

6. Avoid contamination with foreign ingredients, chemicals or oils.

7. Valves, couplings or piping that will be in continual contact with the foam concentrate should not be constructed of dissimilar metals. The use of dissimilar metals may cause galvanic corrosion.

8. Utilize National Foam's Technical Service Department for periodic analysis of your foam concentrate supplies.

TESTS AND APPROVALS

All NF products undergo extensive testing from their conception in the research laboratory through rigid quality control standards prior to reaching the market. NF's foam concentrate products are approved and listed by independent testing agencies such as Underwriters Laboratories. Also, certain foam concentrates are approved by the US Coast Guard and other federal agencies. These approvals are the customer's assurance that NF has demonstrated through extensive fire testing and evaluations that the product complies with the rigid requirements and specifications of the testing authority.

In special cases, fire tests are conducted to determine foam effectiveness on a particular flammable liquid and to determine the minimal application rates the hazard requires. Application rates for polar solvent or alcohol-type fuels are determined by the foam concentrate manufacturer through actual fire testing. The approvals for each particular foam concentrate are provided in their respective data sheets.

Foam Concentrate Evaluation

Periodic testing of foam concentrate supplies through a good maintenance program can help sustain the integrity of the foam concentrate. NF's Technical Service Program offers analytical evaluations of foam concentrates to ensure the integrity of the foam concentrate. The Technical Service Report includes the results of at least four laboratory tests.

Technical Service Laboratory Tests

1. pH - determine if a pH value of the foam concentrate lies within its original specified limits.

2. Specific Gravity - determines if the foam concentrate is diluted, or if it is concentrated due to evaporation.

3. Sediment - measures the undissolved solids or particles in a foam concentrate. Problems with dispersion occur with sediments in excess of 0.5%.

   Note: Ensure that the foam sample represents the overall foam supply.

4. Foam Quality - the quality of a good foam is the sum total of its expansion, its 25% drainage time, and ultimately, its fire performance. Procedures for these tests are outlined in NFPA Standard 11.

Note: Synthetic foam concentrates may require additional tests to evaluate surface tension, viscosity and the effectiveness of the aqueous film or polymeric membrane.

If the Technical Service Report for the foam concentrate sample reveals results consistent with its original specifications, it is considered satisfactory and suitable for fire service. Significant deviation from the original specifications in any of the test results may indicate one of the following problems:

1. Contamination
2. Improper storage conditions
3. Chemical change
4. Any combination of the above

At this point, fire tests are recommended. Fire tests on foam samples are conducted within specially designed fire modeling equipment using a protocol developed to simulate full scale UL Standard (UL 162, 6th Edition) fires. Hydrocarbon and/or polar fuels are used as appropriate.

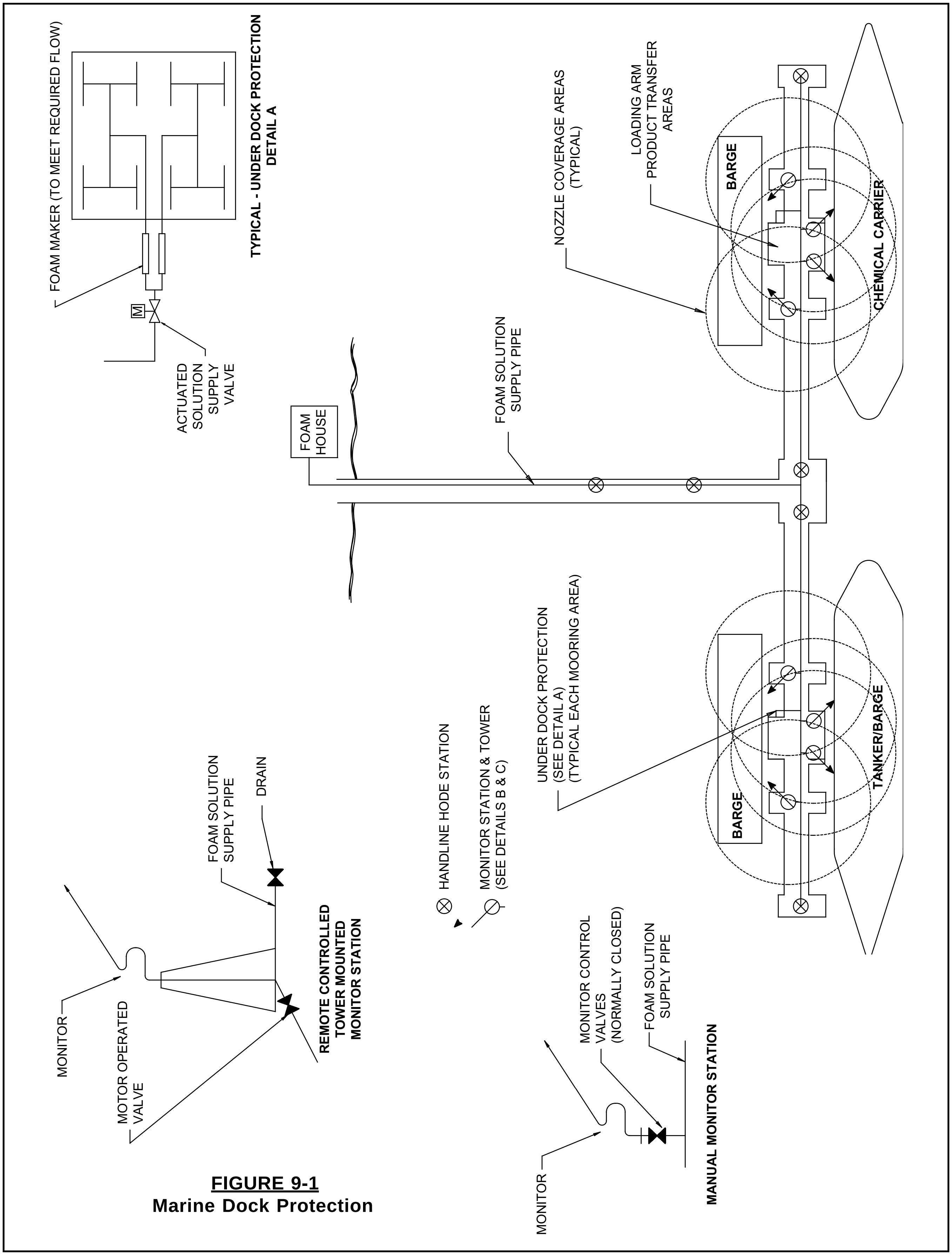


FIGURE 9-1
Marine Dock Protection

APPENDIX

PROPOSAL REQUEST DATA REQUIRED

MARINE DOCK

Owner / Builder: ____

Location: ____

Overall Dock Area: __________________ ft. length x ___________ ft. beam ______________

Product / Area(s) to be considered: ____

Hydrocarbons - ____

Polar Solvents and / or Alcohols (list names / describe) ____

Other (describe/list) ____

Approx. Size of Largest Vessel to Dock: ft. length x _____________ ft. beam

Foam Proportioning System Location:

On Dock _________On Land ______ Other (explain) ____

Approx. Distance From Farthest Hazard ___________ ft.

Approx. Height of Monitor Tower _________________ ft.

Approx. Height of Loading Arms _________________ ft.

Foam Concentrate (_____ % of injection)

_____ Protein/Fluoroprotein _____AFFF_____ AR-AFFF

Electrical voltage and enclosure requirements at site:

Phase, Hertz, volt _____ / _____/ ____ /

Motor enclosure type _____________________________

Starter enclosure type_____________________________

Water Pump (s): (available for foam system):__________ GPM / ________ PSI

MARINE EQUIPMENT LIST

Some National Foam equipment listed is commonly used in marine applications with specific foam proportioning systems and foam making devices. Listed foam equipment combinations should be reviewed by National Foam before releasing a purchase order.

Some National Foam equipment listed on the data sheets may not have a specific marine approval, but are suitable for marine application and environment. NF should be contacted to review the foam equipment selection and to provide any clarification before finalizing a design plan or issuing a purchase order.

Data Sheet Name		Data Sheet Number
Aer-O-Foam 3% Regular		NFC100
Aer-O-Foam 3% Cold Foam		NFC110
Aer-O-Foam XL-3		NFC120
Aer-O-Water 3EM		NFC210
Aer-O-Water 6EM		NFC220
Aer-O-Lite 3%		NFC300
Aer-O-Lite 3% Cold Foam		NFC310
Aer-O-Lite 6% Cold Foam		NFC320
Universal Plus 3% X 6%		NFC410
Universal Gold 3%		NFC420
Universal CG6%		NFC430
Sampling and Testing Procedure		NFC960
Ratio Controller - Model RCT	(2” threaded)	NPR080
Ratio Controller - Model RCF	(3” thru 8” flanged)	NPR090
Ratio Controller - Model RCW	(3” thru 8” wafer)	NPR100
Balanced Pressure Proportioning Systems		NPR130
Diaphragm Valve - Back Pressure Service		NPR140
Water Powered Ball Valve - Model WPBV-M2 & M2S		NPR110