Technical Article

Foam Systems - Low Expansion, Medium Expansion, High Expansion

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March, 2006

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FOAM EXPANSION DEFINITION

Foams are defined by their expansion ratios. Low-expansion foams expand 1 to 20 times greater than their original volume, medium-expansion foams expand 20 to 200 times greater than their original volume, and high-expansion foams expand 200 to 2000 times greater than their original volume.

Each foam type is specifically suited for different protection schemes. Low-expansion foams are designed for their ability to spread over a liquid surface. Medium-expansion foams are utilized for poisonous vapor or fume suppression. High-expansion foams are best suited for three-dimensional fires, but are also utilized to suppress liquid spill fires.

FUELS OR CHEMICALS

NFPA 30, *Combustible and Flammable and Combustible Liquids Code*, breaks fuels or chemicals into different categories based on their vapors willingness to form an ignitable mixture with air. Flammable liquids are designated as Class 1A, 1B, or 1C. Combustible liquids are designated as Class ll, Class lllA, or Class lllB. The protection of Class 1A flammable liquids are outside of the scope of NFPA 30, as the code does not consider a 1A flammable liquid to be able to be protected with a fixed system.

Beyond the classification of the fuel or chemical being flammable or combustible, the fuel or chemicals ability to mix with water, (miscibility), is a prime consideration. Non-miscible liquids do not mix with water and are generally referred to as hydrocarbons. If the fuel or chemical is non-miscible, a standard AFFF can be utilized to extinguish it. If the fuel or chemical is miscible, an alcohol resistant AFFF must be used. If you have mixed storage, some non-miscible liquids and some miscible liquids, an alcohol resistant AFFF must be used.

Where a high-expansion foam system is being considered, only non-miscible liquids or Class A fires can be protected with high-expansion foam.

FOAM CONCENTRATES

Foam concentrates are mixed with water to form a foam solution. Foam concentrates are either specific to the fuel or chemical that they are to protect or are specific to the type of discharge device through which the solution will be discharged.

Synthetic low-expansion foam concentrates are available in two types: standard AFFF’s (Aqueous Film Forming Foam), and AR-AFFF (Alcohol Resistant Aqueous Film Forming Foam). Standard AFFF’s are listed for their percentage to be added to water to extinguish hydrocarbon or non-miscible fuels. Listed percentages for standard AFFF’s are 1%, 3% and 6%. The percentage indicates how much foam concentrate is added to the water to make a solution. For a 1% AFFF, 1 part foam concentrate, 99 parts water. For a 3% AFFF, 3 parts foam concentrate, 97 parts water. For a 6% AFFF, 6 parts foam concentrate, 94 parts water.

1% AFFF's are the most concentrated foam concentrates and are generally utilized where storage space is a concern or if there is a cost advantage over 3% AFFF foams. 3% AFFF foams are the industry standard for fixed systems and come in two types, a commercial grade and a Mil-spec grade. A 3% Mil-spec grade is a superior foam concentrate and must be utilized on U.S. Military projects. Mil-spec foam concentrates are unique because they are subjected to additional tests by the military and must be blended so they will be compatible with other manufacturers Mil-spec foam concentrate. 6% AFFF foams are not generally found in fixed systems due to the lack of hardware and discharge devices listed with them. 6% AFFF foams are typically used by municipalities and are carried on fire trucks to be discharged through fire hoses.

AR-AFFF foams are unique because they are designed not only to extinguish hydrocarbon or non-miscible fuels or chemicals but also miscible fuels or chemicals. AR-AFFF foams go by many different descriptions, such as; ARC's, ATC's, 1 x 3's, 1 x 6's, 3 x 3's, 3 x 6's, and Universal foams. Each description is to identify the concentrates ability to be utilized on non-miscible and miscible fuels or chemicals. The acronyms stand for the following:

ARC – Alcohol Resistant Concentrate
ATC – Alcohol Type Concentrate
1 x 3 – 1% on non-miscible liquids, 3% on miscible liquids
1 x 6 – 1% on non-miscible liquids, 6% on miscible liquids
3 x 3 – 3% on non-miscible liquids, 3% on miscible liquids
3 x 6 – 3% on non-miscible liquids, 6% on miscible liquids

Figure 1: *Pre-Piped Foam System with Bladder Tank and Deluge Valve.*

For fixed systems, the 3% AR-AFFF (3 x 3), has the most extensive listings with fixed proportioning devices, sprinkler heads, and other fixed discharge devices.

Medium-expansion foam uses an alcohol resistant low expansion foam concentrate and discharges it through a medium-expansion discharge device to create the higher volume of foam.

High-expansion foam concentrates are specific to each manufacturer and are designed to be discharged through the manufacturer's specific high expansion foam generator. High-expansion foam concentrates are available in 1.5%, 2%, 2.5%, and 2.75%. Each concentrate is specific to a manufacturer and to the manufacturers high-expansion foam generator. High-expansion foam concentrates should not be mixed. The high-expansion foam concentrate must be matched with the high-expansion foam generators utilized in the hazard area.

NFPA STANDARDS

Foam systems are covered in a number of NFPA standards. Many times these NFPA standards will refer to each other to provide additional information. The most confusing part of these system designs is what standard to use and which one takes precedent. Some NFPA standards are quite obvious, such as NFPA 409, which is the *Standard on Aircraft Hangars*. Others, such as NFPA 30, the *Flammable and Combustible Liquids Code*, seem quite general, but its protection schemes are for storage of these liquids in warehouses. NFPA 11 is the most inclusive foam standard, as it is the *Standard for Low-, Medium-, and High-Expansion Foam*.

In brief, the following will discuss various foam standards and where they are used.

NFPA 11, *STANDARD FOR LOW-, MEDIUM-, AND HIGH EXPANSION FOAM*

In past editions of NFPA 11, the standard only concerned itself with low-expansion foam. NFPA 11A covered medium- and high-expansion foam. The 2002 edition of NFPA 11 became the standard for low-, medium-, and high-expansion foam. The different foams have similar system requirements, so it makes sense that they are covered under one inclusive document.

NFPA 11 does not assume that all systems installed are fixed or are automatic. Within the definitions of NFPA 11, a description for a fixed system is as follows: "A complete installation in which foam is piped from a central foam station, discharging through fixed delivery outlets to the hazard to be protected with permanently installed pumps where required". This is the foam system that most of us think of when we say or hear foam system, where a sprinkler riser supplies discharges devices in a hazard area.

Figure 2: *Example of a Mobile Foam System. Photo Credit: Kidde Fire Fighting - National Foam*

Figure 3: *Example of a Mobile Foam System. Photo Credit: Kidde Fire Fighting - National Foam*

A mobile system is described as: "Any type of foam-producing unit that is mounted on wheels and is self-propelled or towed by a vehicle and can be connected to a water supply or can utilize a pre-mixed foam solution." In general, this type of system would normally describe a fire truck. NFPA 11 also recognizes specialized devices that are mounted on trailers and are either discharging foam solution provided to it or can produce and discharge foam solution when connected to a water supply. Typical units are trailers with foam monitors mounted to the trailer that may or may not have a foam proportioning device as part of the trailer.

Figure 4: *Example of a Mobile Foam System. Photo Credit: Kidde Fire Fighting - National Foam*

Figure 5: *Example of a Portable Foam System. Photo Credit: Kidde Fire Fighting - National Foam*

A portable system is defined as: “Foam-producing equipment, materials, hose, and so forth, that are transported by hand”: These are typically devices such as hoses, eductors (portable proportioning devices), and discharge nozzles.

Semi-fixed systems are identified as: “A system in which the hazard is equipped with fixed discharge outlets connected to piping that terminates at a safe distance.” These systems combine the fixed system and the mobile system. The discharge devices are mounted or are located in a fixed position supplied by piping that is supplied outside the hazard area by a fire truck or hose supply from a hydrant. The supply is not permanently in a fixed location, although the discharge devices are piped and mounted in permanent fashion.

Figure 6: *Manual Discharge of Low-Expansion Foam Through a Hose Line. Photo Credit: Kidde Fire Fighting - National Foam*

The systems may be manually or automatically operated. Where a portable, mobile, or semi-fixed system is present, manual activation is required. Where a fixed system is present, the option for manual or automatic activation is available. When a system is automatically operated, there must be a manual means of operation provided as well. Manual operated systems are subject to the approval of the authority having jurisdiction.

The system description types and the activation means outlined in NFPA 11 are for any foam type present, such as low-, medium-, or high-expansion foam.

NFPA 11 – LOW-EXPANSION FOAM SYSTEM DESIGN

Prescriptive design requirements provided in Chapter 5 of NFPA 11 for low-expansion foam are concerned with the bulk storage of fuels and chemicals and the vessels they are contained in, as well as the spill or spread area of these fuels or chemicals. Large storage tanks with surface areas greater than 400 sq. ft., such as fixed cone roof tanks and floating roof tanks are addressed in NFPA 11.

Protection options for bulk storage tanks may include the application of foam troughs, foam chambers, monitors, or fixed nozzles. The design densities provided in NFPA 11 are for hydrocarbon or non-miscible fuels and are specific to the discharge device utilized. Where miscible liquids are present, the specific listing of the foam concentrate for the fuel or chemical and discharge device must be utilized. A foam trough is referred to as a type 1 discharge device, a foam chamber is referred to as a type 2 discharge device. A foam trough is essentially an internal trough or slide that the expanded foam is discharged upon and slides down to the liquid surface level. A foam chamber is mounted to the exterior of the tank with a deflector located on the interior of the tank. The expanded foam discharges against the deflector, which directs the foam solution to the interior tank wall, where it falls to the liquid surface and spreads across it.

Bunded or diked areas are linear obstructions built around bulk storage tanks to inhibit the free flow of fuels or chemicals from a tank that has ruptured or may otherwise be leaking. Dikes or bunded areas provide a wall of protection from the fuel spreading outside a manageable fire area. A spreading fuel fire in a diked area creates a greater hazard, as there may be more than one tank located in a diked area. Diked areas are typically protected with foam makers, monitors, or hand-lines. Where foam makers are utilized, the distance they can be placed apart at the dike wall is determined by their flow rate. The densities provided in NFPA 11 for dike areas again are for hydrocarbon or non-miscible liquids, where miscible liquids are present, the specific listing of the foam concentrate for the fuel or chemical and discharge device must be utilized.

Figure 7: *Foam Blanket Spreading in a Diked Area.*

NFPA 11 also provides protection information for loading racks, meaning either rail or truck type. The two methods of protection offered are either foam-water sprinklers or foam monitors. If foam water sprinklers are utilized, NFPA 11 refers to the design criteria set forth in NFPA 16. Where monitors are used, the application area is to include the canopy, pumps, meters, vehicles, and any other equipment associated with the loading and unloading operation. Essentially the entire ground area of the loading rack is to be protected. In the case of loading racks, the densities provided in either NFPA 11 or NFPA 16 are for hydrocarbon or non-miscible fuels, where miscible liquids are present, the specific listing of the foam concentrate for the fuel or chemical and discharge device must be utilized.

The duration of low expansion foam concentrate is measured in minutes required application. This duration varies depending upon the hazard and miscibility of fuel in Chapter 5 of NFPA 11. Duration times in Chapter 5 of NFPA 11 range from 10 minutes through 65 minutes.

NFPA 11 – MEDIUM- AND HIGH-EXPANSION FOAM DESIGN

Where chapter 5 of NFPA 11 discussed protection of specific hazards with low-expansion foam, Chapter 6 of NFPA 11 addresses the protection criteria and/or the use of medium- and high-expansion foam for various hazards.

Low-expansion foam solution is very liquid and is meant to spread over 2 dimensional liquid surfaces. Medium- and high-expansion foam is designed to fill a volume, or 3 dimensional cubic area.

Medium-expansion foam does not have specific protection criteria outlined in Chapter 6 of NFPA 11. Any system or design with medium-expansion foam is strictly in accordance with the foam concentrate manufacturers proof tests.

High-expansion foam is an aggregate of dry, air-filled bubbles. The bubble structure of high-expansion foam is easily reduced in volume with fog water spray or water discharge from overhead sprinklers. When determining the amount of foam volume needed for a high-expansion foam system, it must be known if the area is to have sprinklers installed or not. When sprinklers are located in an area with high-expansion foam, additional high-expansion foam must be calculated due to the breakdown of the bubble structure if the sprinklers were to operate. This is typically referred to as the Rs value utilized in the calculation utilized to determine the rate of discharge in cubic feet or cubic meters per minute.

In determining the amount of expanded foam for an area, the total submergence volume is divided by the submergence time in minutes. The sprinkler breakdown is added to this volume per minute, then the sum is multiplied by a shrinkage factor, then that sum is multiplied by a room leakage factor for a total cubic discharge per minute.

R = (V/T + Rs) x Cn x CL

Where:

R = rate of discharge in m^3/min (ft^3/min)

V = submergence volume in m^3 (ft^3)

T = submergence time in minutes

Rs = rate of foam breakdown by sprinkler in m^3/min (ft^3/min)

Cn = compensation for normal foam shrinkage

CL = compensation for leakage

The Rs or sprinkler breakdown is the design flow rate of the sprinkler system multiplied by 10 cubic feet per minute. The Cn or factor utilized for foam shrinkage per NFPA 11 is 1.15. The actual shrinkage factor may be higher or lower based on the specific manufacturer, so consulting with the manufacturer would be prudent. The CL or leakage factor is a compensating factor for the high-expansion foam that will leak out of the room upon discharge. NFPA 11 indicates that the factor cannot be less than 1.0, meaning 1.0 is a completely tight structure. Wall or floor openings have to be considered to determine the leakage factor.

High-expansion foam will fill the entire volume of a room. Entering the area after a high-expansion foam system discharge must be approached with care. The burning hazard is buried with expanded foam, but may still be burning; entering a space too early can have adverse effects, such as providing an in-rush of oxygen to the fire and re-igniting the material. Other safety issues that surround high-expansion foam is that the person entering the expanded foam is essentially blind to any mounted or suspended objects. NFPA 11 instructs any person entering an area where high-expansion foam has been discharged to utilize a fog spray from a hose line to cut a path through the foam.

Figure 8: *High-Expansion Foam System Discharge. Photo Credit: Kidde Fire Fighting - National Foam*

Chapter 6 of NFPA 11 requires the use of clean-air or fresh-air intake to the high-expansion foam generator. The heated air and products of combustion do not promote quality foam expansion. This clean-air or fresh-air intake is supplied outside of the hazard area. Normal supplies of clean or fresh air is through the roof or inlets located high on the walls of an area.

The high-expansion foam generator is the discharge device that produces the highly expanded foam. The high-expansion foam generators currently manufactured in the U.S. utilize a fan motor behind one or a series of nozzles discharging high expansion foam solution against a screen. The air current provided by the fan pushes the solution through the screen and aerates the solution into a highly expanded bubble structure. Most of the high-expansion foam generators have water-powered fans, such as a water motor gong is water powered, although very large high expansion foam generators are electrically powered. High-expansion foam generators are open discharge devices and are part of a deluge system.

NFPA 13

NFPA 13, *Standard for the Installation of Sprinkler Systems* makes references to high-expansion foam systems in the storage section of the standard. With the addition of a high-expansion foam system, the sprinkler system density for a commodity can be greatly reduced. In the case of rubber tire storage, there are a couple of storage arrangements that can only be protected with sprinklers in combination with a high-expansion foam system. The installation and design requirements for the high-expansion foam system must adhere to NFPA 11.

NFPA 16

NFPA 16 is the *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*. In simpler terms, it is the standard for closed head and deluge foam/water sprinkler systems. NFPA 16 has general requirements regarding the foam sprinkler riser components, such as where system isolation valves and foam solution test connections are located. The location of these valves is dependent upon where the foam proportioning device is installed. If the proportioning device is located upstream of the sprinkler riser valve, the system isolation and solution test valve are located upstream of the sprinkler riser valve. If the proportioning device is located downstream of the sprinkler riser valve, the system isolation and solution test valve are located downstream of the sprinkler riser valve.

NFPA 16 provides specific wording required on the placard of the fire department connection installed on the system. There are to be pumping pressure instructions to the fire department so the foam concentrate is not exhausted prematurely in the event of a fire.

NFPA 16 prescribes the minimum design area for a closed head foam water sprinkler system is 5000 sq. ft. The minimum density indicated in NFPA 16, regardless if it is closed head or deluge is .16 gpm per sq. ft. It should be noted that, again, this density is for hydrocarbon or non-miscible liquids, where miscible liquids are present (alcohol resistant foam concentrates must be used), the foam concentrate manufacturer must be consulted for the minimum required density for the specific fuel and specific sprinkler head utilized with the specific alcohol resistant foam concentrate.

NFPA 16 provides information regarding the calculation method utilized for foam concentrate lines. Where a standard AFFF foam concentrate is utilized, the Darcy or Fanning formula of determining pressure loss in the concentrate piping must be used. The piping discharging foam solution does not require a special formula, other than Hazen-Williams. Alcohol resistant foam concentrates are pseudo plastic and have different viscosities and varying shear rates. Where alcohol resistant foam concentrates are utilized, the specific manufacturer of the foam concentrate must provide pressure loss values for different concentrate pipe sizes.

NFPA 16 limits the area of coverage of a sprinkler to 100 sq. ft. on a foam/water sprinkler system. Other standards that utilize sprinklers on foam systems will take precedence over this requirement, so it is important to research the specific standard.

NFPA 16 requires a minimum duration of foam concentrate of 10 minutes. Again, other standards specific to a hazard or storage arrangement will take precedence, so specific standard research is required.

NFPA 30

NFPA 30 is the *Flammable and Combustible Liquids Code*. NFPA 30 covers a tremendous amount of information regarding the storage and handling of flammable and combustible liquids. NFPA 30 indicates protection schemes for the storage of flammable and combustible liquids. The section of the code that addresses protection criteria separates protection with water only sprinklers in one table and protection with foam/water sprinklers in another. The protection tables break the storage down by liquid class, container size, maximum storage height, and maximum ceiling height. The container will also be segregated from non-relieving style and relieving style containers, as well as metal and non-metallic type containers. Non-relieving style containers are generally metal containers with threaded metal caps that will are not easily removed with low or moderate pressure increase of the container. Relieving style containers are containers whose threaded covers, friction tops, or other sealing device will be displaced with low or moderate pressure, or simply melt and vent the container or vessel. Where low-expansion foam is added to the water, lower densities are provided, or in some cases, the storage arrangement can only be protected foam/water sprinklers.

NFPA 30 has a minimum proportioning requirement of within (4) sprinklers operating. This means that the foam proportioning device must have the ability to proportion foam into the water stream within the flow rate of (4) fused sprinklers. Combustible and flammable liquid fires have very high heat releases. If foam water solution cannot be delivered to fire in a short period of time, the design area could be overcome resulting in a system failure.

NFPA 30 provides minimum density requirements based on storage arrangements, not miscibility or minimum listed densities. Where the minimum listed density for a sprinkler head and specific foam concentrate protecting a given fuel is higher than the density prescribed in NFPA 30, the listed density shall take precedent.

NFPA 30 has a minimum foam concentrate duration of 15 minutes. This duration requirement takes precedence over NFPA 16. NFPA 30 references NFPA 16 for the sprinkler system riser requirements as well as system commissioning and testing.

NFPA 409

NFPA 409 is the *Standard on Aircraft Hangars*. Important changes for the protection of very large aircraft hangars, referred to as Group 1 aircraft hangars occurred in the 2001 Edition of NFPA 409. Group 1 aircraft hangars either have door heights in excess of 28'-0" or storage and servicing areas greater than 40,000 sq. ft.

Figure 9: *Example of a Group I Aircraft Hangar.*

In past editions of NFPA 409, only one protection design option was available for Group 1 aircraft hangars, which was overhead foam deluge systems. The operating area of the foam deluge systems was determined based on the maximum ceiling height. For ceiling heights of 25 ft. or less, all the foam deluge sprinkler systems that wholly or partially fell into a 100 ft. circle must be calculated. For ceiling heights greater than 25 ft. but less than 75 feet, all the foam deluge sprinkler systems that wholly or partially fell into a 150 ft. circle must be calculated. For ceilings in excess of 75 ft., all the foam deluge systems that wholly or partially fell into a 200 ft. circle must be calculated. These circles were to be moved around the hangar ceiling area to capture the greatest number of systems to operate. In addition to the overhead foam deluge system, where a hangar was housing an aircraft with wing areas in excess of 3000 sq. ft., supplemental protection was to be provided directly under the wing projection of the aircraft. Where overhead and supplemental protection existed, the design flow rates were combined.

Figure 10: *Discharge of Low-Level Underwing Foam System.*

The 2001 Edition of NFPA 409 offered (3) protection options for Group 1 aircraft hangars:

Option 1) Foam deluge systems at the ceiling, the standard now prescribes that all foam deluge system that wholly or partially fall into a 200 ft. circle must be calculated, regardless of ceiling height. If the hangar houses an aircraft with wing areas in excess of 3000 sq. ft., supplemental protection is to be provided directly under the wing projection of the aircraft.

Option 2) A combination of overhead automatic sprinklers, designed to provide .17 gpm per sq. ft. over 15,000 sq. ft and an automatic low-level low expansion foam system designed to provide .10 gpm per sq. ft. over the entire aircraft floor area.

Option 3) A combination of overhead automatic sprinklers, designed to provide .17 gpm per sq. ft. over 15,000 sq. ft. and an automatic low-level high-expansion foam system designed to provide 3 cubic feet per minute per sq. ft. over the entire aircraft floor area.

Figure 11: *Trench Drains in an Aircraft Hangar.*

The design options added in the 2001 Edition of NFPA 409 were brought forth by the U.S. Military. Option 2 addressed a system developed by the U.S. Navy, where foam solution would be discharged through fixed discharge nozzles located in drain trenches. Option 3 addressed a system preference by the U.S. Air Force that reduced the amount of surfactants in the foam solution to be discharged in a fire and a reduction in required water supply.

Although each branch of the military refers to NFPA 409 in their technical design guides, they both have design requirements that are specific to their needs. Currently for U.S. Navy or Marine Corps hangars, refer to Interim Technical Guidance FY05-01 (ITG FY05-01). Currently for U.S. Air Force or Air National Guard hangars, refer to Engineering Technical Letter 2002-15 (ETL 02-15). Each document can be printed from each branch's respective web site.

Figure 12: *Supplemental Protection for a Group I Aircraft Hangar.*

The greatest cost for fire protection in a Group 1 aircraft hangar is the water supply. If we assume a 60,000 sq. ft. hangar, 200’ x 300’, not housing an aircraft with a wing span in excess of 3000 sq. ft., the water supply requirements for each option are as follows:

Option 1) 16 gpm per sq. ft. x 60,000 sq. ft. x *1.15 = 11,040 gpm

Option 2) .10 gpm per sq. ft. x 60,000 sq. ft. x *1.15 = 6,900 gpm
.17 gpm per sq. ft. x 15,000 sq. ft. x *1.15 = 2,933 gpm
Total Water Requirement for Option #2 = 9,833 gpm

Option 3) 3 cubic ft per minute per sq. ft. of high expansion foam (The total required volume differs depending upon manufacturers; for this exercise a flow rate of 3484 gpm is assumed.)

.17 gpm per sq. ft. x 15,000 sq. ft. x *1.15 = 2,933
Total Water Requirement for Option #3 = 6,417 gpm

<u>1.15 is an over-discharge factor applied to the sprinkler systems</u>

Group II hangars are smaller hangars than Group 1 hangars. The description of a Group II hangar is a hangar with a maintenance and storage area not greater than 40,000 sq. ft. and a door height no greater than 28’-0”.

The protection of Group II hangars is somewhat similar to Group 1 hangars. There are (4) design options available for Group II hangars:

Option 1) A foam deluge sprinkler system designed to provide .16 gpm per sq. ft. over the entire floor area.

Option 2) A combination of automatic sprinklers at the ceiling designed to provide .17 gpm per sq. ft. over 5,000 sq. ft. and a low level low expansion foam system designed to provide .10 gpm per sq. ft. over the entire floor area.

Option 3) A combination of automatic sprinkler at the ceiling designed to provide .17 gpm per sq. ft. over 5,000 sq. ft. and an automatic high expansion foam system designed to provide 3 cubic ft per minute per sq. ft.

Option 4) A closed head foam/water sprinkler system designed to provide .16 gpm per sq. ft. over the entire floor area.

NFPA 409 limits the area of coverage of a foam deluge sprinkler system and a closed head foam/water sprinkler system to 15,000 sq. ft. per system.

Another important addition to the 2001 edition of NFPA 409 was the designation of Class IV hangars, which are membrane covered, rigid, steel frame structures that are used as aircraft hangars. These structures generally use light tube steel and have a relatively thin skin or membrane covering the tube steel. Due to their construction type, the options for foam systems are limited as the structure may not support sprinkler piping. Typical discharge devices for Class IV hangars are oscillating monitors, fixed discharge devices in drain trenches, or high-expansion foam generators mounted in the perimeter walls.

Figure 13: *Example of a Class IV Hangar. Photo Credit: Public Domain --from Google*

NFPA 418

NFPA 418 is the *Standard for Heliports*. Heliports are landing spaces for helicopters and could be located on grade, on top of a structure, or a suspended platform. Foam system design is required for heliports that are greater than an H-1 heliport or where the heliport is located above an occupied structure, such as a roof top. The foam system design for heliports is a .10 gpm per sq. ft. over the entire area. A 5-minute duration is required. Where a roof-top hangar is present, the foam fire protection requirement is a design in accordance with NFPA 16, where a minimum design area of .16 gpm per sq. ft. over an area of 5,000 sq. ft. is required. The foam duration for roof-top hangars is in accordance with NFPA 16 where 10 minutes is required.

FOAM QUALITY

Foam quality is a measurement of the expansion of the foam and the drain time of the water from the bubble structure. Foam blankets are created by aeration or agitation. Low-expansion foam solution can be discharged through variety of devices, some aerate the solution to expand it and create a longer drain time, other devices create a foam blanket by agitating the solution.

Discharge Device	Aeration	Agitation
Standard Spray Sprinkler		Yes
Foam Maker	Yes	
Foam Chamber	Yes	
Hand Line Nozzle		Yes
Aerating Hand Line Nozzle	Yes	
Monitor and Nozzle		Yes
Monitor with Aerating Nozzle	Yes	
Grate Nozzle		Yes
Medium Expansion Nozzle	Yes	

Table 1.

Aeration of the synthetic low-expansion foam solution creates better foam qualities. In most cases, a discharge device that aerates the foam solution will provide better fire fighting capabilities than one that does not. Aerating discharge devices will typically extinguish a fire at a lower density than a non-aerating discharge device. Most of the densities indicated in the NFPA Standards mentioned above are provided based on the discharge devices ability to aerate the foam solution. Once synthetic low-expansion foam solutions are aerated the blanket becomes quite persistent and long lasting.

COMPRESSED AIR FOAM

Compressed air foam creates a foam blanket with air injected into a foam/water solution stream. Until recently, compressed air foam used in fire fighting applications was discharged from handheld hose lines. Many airports and heliports have portable compressed air foam assemblies where a tank with foam solution and high to moderately high air pressure is utilized to form a very thick high quality foam to be discharged from a hose nozzle. The difference between compressed air foam and the previous foam types discussed is the foam quality of the foam blanket. Compressed air foam has a very stable consistent bubble structure. The foam quality of compressed air foam allows it to combat liquid spill fires and three-dimensional fires, as the foam is so thick it will stick to horizontal and vertical surfaces.

Compressed air foam was developed approximately 65 years ago. The major advantage of compressed air foam is that it requires less product to extinguish the same fire. The challenge in its application was how to discharge it through a fixed system piping network. In 1999, serious work and study started with compressed air foam to establish how and if it could be discharged from a fixed piping network. Some of the obstacles that had to be overcome were what to discharge it out of, how to calculate adequate supply pipe size, and what are adequate discharge densities on fuel fires. A rotating nozzle was developed to broadcast the enhanced foam blanket. A computer calculation program was developed for the hydro/pneumatic flow through the piping.

Figure 14: *Compressed Air Foam Discharging From Fixed System. Photo Credit: Fireflex Systems Inc.*

Comparative fire tests with compressed air foam with foam/water sprinklers were conducted and as was always known, the compressed air foam performed as well or better in the fire tests conducted. Approval tests at Factory Mutual have also been conducted on the specialized compressed air foam system. The next edition of NFPA 11 will add a section recognizing fixed systems that discharge compressed air foam.

The compressed air foam system that is approved is a proprietary system and has only one manufacturer. The piping calculations are currently restricted to balanced system calculations and can only be performed by the manufacturer. The compressed air foam system is only offered as an integrated system. Currently, the integrated compressed air foam system is limited to hydrocarbon fuel fires, transformer fires, and Class A fires. Additional testing for the protection of miscible liquids is on going and results are forthcoming.

Figure 15: *Integrated Compressed Air Foam System. Photo Credit: Fireflex Systems Inc.*

CONCLUSION

Prior to designing any type of foam system, it is prudent to study the different standards that may govern its design and installation. Each foam concentrate or foam hardware manufacturer have designed proportioning devices and discharge devices that are unique and specific to a given foam concentrate, so it is important to consult with your choice of vendor prior to quoting or designing a project. Most foam concentrate vendors have a design data book or a technical assistance service to help a contractor from making mistakes in the application of a system. There are many applications and opportunities for foam systems today, so it is important to utilize the resources available to you to take the “scary” out of special hazards.