Technical Article

High Expansion Foam Systems

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September, 2008

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INTRODUCTION

High Expansion foam systems are installed in many different hazards; high piled storage, liquefied natural gas, dike or bund protection, aircraft hangars, etc.

What is a high expansion foam system? A high expansion foam system is a foam deluge system that delivers the foam solution, (foam concentrate and water mixture), to a discharge device known as a high expansion foam generator.

Figure 1: Foam Deluge Riser – Photo Courtesy of S&L Mechanical

Most commercially available foam generators are water powered fans that force or “blow” the foam solution against a screen which results in a finished foam blanket that expands into a large fluffy cloud of foam bubbles. If you ever blew bubbles as a child, you submerged the circular ring dipping wand into a soapy solution, as you blew air through the circular end of the wand where the soapy film clung to, large bubbles would result on the discharge side of the dipping wand. High expansion foam generators work in essentially the same way, with the obvious exception being that the quantity of the soapy solution is greater, more air is provided, and the screen has thousands of more holes than the dipping wand.

Figure 2: High Expansion Foam Generators – Photo Courtesy of Chemguard

High expansion foam generators are “open discharge” devices, meaning there is not a fusible link, like in an automatic sprinkler head. The piping supplying the foam generator is empty, until a deluge valve is activated. When the deluge valve is activated, water passes through the riser past a proportioning device, which is located in line with the sprinkler piping. The proportioning device is where the foam concentrate is introduced into the water stream to form a foam solution. Foam solution leaves the proportioning device and travels down the empty piping until it enters the foam generator. Think of the foam generator as a water motor alarm, the foam solution pushes the fan in a circular motion, the foam solution discharges through a nozzle or series of nozzles, (depending upon the manufacturer), and the air current provided by the fan pushes or forces the foam solution against a screen, which in turn creates the large bubbles. I made the comparison to the water motor alarm, as they operate in a similar fashion and they both need to have strainers installed on the supply piping prior to connecting to the devices. Some manufacturers include this strainer, others do not, but in all cases, consult the manufacturer for the correct strainer, as the strainer mesh will vary depending upon the integral discharge nozzle(s) orifices of the foam generator.

SYSTEM DESIGN

We normally think of sprinkler systems in two dimensional terms, we look down from the ceiling on our drawings in the plan view, our system design water flow rate is generally referred to in terms density, which is gallons per minute per square foot.

High expansion foam system design is a three dimensional thought process. NFPA utilizes a foam submergence volume as a rate of application. Most designs are based upon 3 cubic feet per square foot per minute. High expansion foam fills a space with a puffy foam blanket. Care should be taken to note where wall openings may occur. If doors are present, they must be self closing doors as the effectiveness of the high expansion foam is based on the foam blanket staying in the hazard. If wall openings are present and un-avoidable, additional high expansion foam must be provided to account for the “leakage” of the medium from the hazard area.

Figure 3: High Expansion Foam Discharge – Photo Courtesy of Chemguard

A handful of NFPA standards discuss the use of high expansion foam as a protection option. Chapter 6 of NFPA 11, The Standard for Low, Medium, and High Expansion Foam lays out the basic guidelines for the installation of a high expansion foam system. Early in the chapter it explains what hazards it can be used for and what hazards it cannot be used for. High expansion foam can be used for ordinary combustibles (Class A Fires), Flammable and Combustible Liquids (Class B Fires), and a mixture of Class A materials and Class B materials, and liquefied natural gas. Caution should be exercised when protecting

combustible and flammable liquids, if the liquid is miscible, contact the high expansion foam manufacturer to determine if their high expansion foam is suitable for the miscible liquid. High expansion foam shouldn't be used where there are water reactive materials or metals, chemicals that release sufficient oxygen to sustain combustion, or liquefied flammable gas.

NFPA 11 also discusses personnel safety in the use of high expansion foam. Once the system activates, the area fills with a foam blanket, if personnel are located in the hazard at the time, they are essentially blinded by the foam blanket. Adequate pre-operation alarms must be present to prevent someone from being trapped in the hazard area. If you are to enter a space where a high expansion foam discharge has occurred, you are to use a hose stream to break down the foam or to cut your way through the foam. Generally a fire hose with a fog nozzle will do the job. One should never enter a high expansion foam blanket without some sort of life line and a breathing apparatus, the best way to enter a high expansion discharge is cutting your way through it with a hose stream.

NFPA also provides guidance regarding how deep the high expansion foam has to build to. The depth requirement is as follows: 1.1 times higher than the highest hazard but in no case less than 2 ft. over the hazard. A general question of how fast does the high expansion foam have to fill the space depends upon if the hazard has a sprinkler system or not and how the building is constructed. As an example, rubber tires have a maximum submergence rate of 7 minutes in a sprinklered building of light or un-protected steel construction. The same hazard in a sprinkler building with heavy or fire resistive construction has a maximum submergence of 8 minutes. If the same hazards are not sprinklered, the foam has to fill approximately 30 percent faster.

Figure 4

NFPA 11 makes an allowance for the submergence time to be timed 30 seconds after the automatic detection has activated the system, meaning high expansion foam must be discharging from the generators within 30 seconds of system activation. If a delay longer than 30 seconds occurs, some sort of system design change must occur. The most likely cause of foam not discharging from the high expansion foam generators in 30 seconds is transit time from the deluge valve to the generator or that adequately proportioned foam solution is not provided to the generator. In the case of transit time being too great, you try to shorten your distance to the generators, which may mean changing the supply piping to the generators. In the case of the proportioning not being correct for the foam solution, there are a variety of cause and effects, such as the wrong proportioning method chosen, foam concentrate not being present at the proportioning device at the same time the water is passing through it, foam concentrate supply piping has excess fittings, not enough straight piping on the supply or discharge of the proportioning device.

SYSTEM COMMISSIONING

A high expansion foam commissioning test is an event. The only way to prove that the system is designed and installed correctly is to activate the system. In the past 7 years, high expansion foam has grown in the protection of aircraft hangars. The largest single reason is that it will generally have a lower water requirement over other protection methods. For an example, we'll use a 50,000 sq. ft. Group 1 hangar that will not house aircraft with wing projections over 3000 sq. ft., you have (3) protection options:

1. Low expansion foam deluge systems at the ceiling
2. Low expansion foam system at the floor and over head sprinklers
3. High Expansion foam system covering the floor and overhead sprinklers

Option 1 will require a .16 gpm per sq. ft. (6.51 lpm per sq. m) of low expansion foam designed over the entire ceiling, having a minimum demand of 8,000 gpm (30,283 lpm). Option 2 would require a .10 gpm per sq. ft. (4.07 lpm per sq. m) of low expansion foam over the floor area and a design of .17 gpm per sq. ft. over 15,000 sq. ft. (6.92 lpm per sq. m over 4,572 sq. m) for water sprinklers at the ceiling, requiring a minimum water flow demand of 7,550 gpm (28,580 lpm). Option 3 would require a design of 3 cubic ft per square ft over the hangar floor and a design of .17 gpm per sq. ft. over 15,000 sq. ft. (6.92 lpm per sq. m over 4,572 sq. m) for water sprinklers at the ceiling, for a minimum water flow requirement of 5,550 gpm (20,820 lpm).

When you discharge a high expansion foam system in a hangar, you will generally operate the system for (4) minutes, the first minute is to ensure that you cover the floor and the additional (3) minutes are generally needed to ensure you have submergence. Once you have the hangar full of soapy bubbles, what do you do with it? One thing you don't want to do is just open the doors, otherwise you'll have big clouds of soapy bubbles blowing across the airport and disrupting take-off and landings. Prior to activating the system, ensure that you have some hose lines with fog nozzles to spray down the foam to break it down. Once you hit high expansion foam with water spray it readily breaks down and will go down the drain.

CONCLUSION

High expansion foam systems have been in use for many years and are gaining popularity for a variety of protection schemes. The equipment is specialized and the protection schemes are different than standard sprinkler protection. Before quoting, designing, or installing a high expansion foam system, one should consult the NFPA standard that governs the design and installation for the hazard and probably speak with a manufacturer/provider of the equipment for further guidance. Each manufacturer has specific high expansion foam concentrate that is tied to their high expansion foam generator's performance, and the manufacturer will generally lead a contractor through the steps required to install their equipment correctly.