INTRODUCTION

GENERAL FOAM INFORMATION

Since the late 1800's foam has been used as a fire extinguishing medium for flammable and combustible liquids. Unlike other extinguishing agents such as water, dry chemical or C02, a stable foam blanket can extinguish a flammable or combustible liquid fire by physically separating the flame/ignition source from the fuel surface. It can also secure the fuel surface against reflash or reignition. Water only, if used on a standard hydrocarbon fuel,is heavier than most of those liquids and if applied directly to the fuel surface, will sink to the bottom having little or no effect on extinguishment or vapor suppression. Should the submerged water reach it's boiling point of 212°F,the water may boil below the fuel surface, throwing the fuel out of the contained area and spreading the fire, referred to as a boil-over.

Prior to reviewing the characteristics of each foam concentrate, there is a suggested terminology associated with each foam concentrate that should be understood.

FOAM: A fire fighting foam is a stable mass of small air-filled bubbles which have a lower density than oil, gasoline or water. Foam is made up of three ingredients - water, foam concentrate and air. When mixed in the correct proportions, these three ingredients form a homogeneous foam blanket used to suppress fuel fires.

FOAM SOLUTION: This is a mixture of water and foam concentrate after they have been mixed together in the correct proportions.

FOAM CONCENTRATE: This is the liquid concentrate that is supplied from the manufacturer which when mixed with water in the correct proportion forms a foam solution.

DRAINAGE RATE: This is the rate at which the foam solution will drain from the expanded foam mass or how long it will take for 25% of the solution to drain from the foam over a given period of time. This is often called the "quarter life" or 25% drain time. A foam that has a fast drain time is normally very fluid and mobile, spreading across the fuel surface very quickly, while foams with longer drain times are normally less mobile, moving across the fuel surface slowly.

EXPANSION RATIO: This is the amount of expansion the foam develops after it has been vigorously agitated with air to a given quantity of foam solution; i.e.,a ratio of 5 to 1would mean that one gallon of foam solution after aeration would fill an empty 5 gallon container with the expanded mass of foam bubbles.

- LOW EXPANSION FOAM: According to NFPA 11, after being aerated, a foam that has an expansion ratio of between 2 to 1 and 20 to 1.
- MEDIUM EXPANSION FOAM: Between 20 to 1 and 200 to 1.
- HIGH EXPANSION FOAM : Above 200 to 1.

PROPER AMOUNT OF FOAM CONCENTRATE TO BE MIXED WITH WATER: The foam shipping container will usually display a number or combination of numbers. Normal numbers shown are either 1%, 3% or 6% or a combination of the 3% and 6% when intended for use with water soluble fuels. For the water soluble fuels, the first number is the proportioning rate for hydrocarbon fuels, and the second number is the proportioning rate for water soluble fuels. If the container of foam concentrate has 3% shown, it means that for every 100 gallons of foam solution required, 3 gallons of the foam concentrate must be used in the solution with the balance being 97 gallons of water. If 6% is displayed, this would mean that 6 gallons of the foam concentrate will be required to be mixed with 94 gallons of water to form the 100 gallons of foam solution. From this explanation it becomes obvious that a 3% foam concentrate is twice as concentrated as a 6% foam concentrate. On the same size and type of flammable liquid fire, half as much 3% foam concentrate would be required than if the 6% foam concentrate had been used.

CAN FOAM CONCENTRATES BE USED WITH SEA WATER AS WELL AS FRESH WATER?

The foam concentrates of today can be used successfully with either sea, fresh or brackish water.

HOW FOAM EXTINGUISHES A FLAMMABLE LIQUID FIRE: Fire burns because there are four elements present. These elements are heat, fuel, air(oxygen) and a chemical chain reaction. Under normal circumstances if any one of the elements is removed or interfered with, the fire is extinguished. Fire fighting foam does not interfere with the chemical reaction. Foam works in the following ways:

- The foam blankets the fuel surface smothering the fire.
- The foam blanket separates the ignition source from the fuel surface.
- The foam cools the fuel and any adjacent metal surfaces.
- The foam blanket suppresses the release of flammable vapors that can mix with air.
- The foam blanket suppresses the vapors from a fuel spill reducing the risk of ignition.

Before reviewing the different types of foam concentrates, it is necessary to understand that there are two different basic flammable or combustible fuel groups.

- Standard hydrocarbon fuels such as gasoline, diesel, kerosene and jet fuel. These products do not mix with water or are not miscible in water, i.e. these products all float on top of water and for the most part, they do not intermix.
- Polar solvent or alcohol type fuels are fuels that mix readily with water or are miscible in water.

It·is imperative that when firefighters prepare to fight a flammable liquid fire, they identify which of the particular fuel groups are involved, This is necessary as some foam concentrates are not suitable for use on the polar solvent/alcohol type fuel spills or fires.

By understanding this, it is now possible to review the different types of foam concentrates.

The following list of foam concentrates are the most common types currently used by firefighters today.

- Protein
- Fluoroprotein
- Film Forming Fluoroprotein (FFFP)
- Aqueous Film Forming Foam (AFFF)
- Synthetic - Medium/High ExpansionType (detergent)
- Alcohol Resistant (AR-AFFF)
- Wetting agent
- Class A Foam Concentrate

PROTEIN FOAM CONCENTRATE: Available in either a 3% or 6% type concentrate. This type of concentrate is based on hydrolyzed protein, foam stabilizers and preservatives. It will produce a highly stabilized air foam. Protein foam must always be used with an air aspirating type discharge device.

Protein foam can become contaminated with fuel if plunged directly onto the fuel surface; therefore, the application technique for Protein foam is quite critical. The foam should be applied as gently as possible to the flammable liquid surface. The application rate for Protein foam solution on a hydrocarbon spill fire is 0.16 gpm/sq.ft.

Protein foam, because of its stability, is relatively slow moving when used to cover the surface of a flammable liquid.

FLUOROPROTEIN FOAM CONCENTRATE: Available in either a 3% or 6% type of concentrate. This product is manufactured using the same method as Protein but with the addition of fluorochemical surfactants. The addition of these surfactants in the concentrate improves the performance of a fluoroprotein foam over a protein foam in two areas.

First, it makes the Fluoroprotein foam more resistant to fuel contamination/pickup and second, it makes the foam blanket more mobile when discharged onto the flammable liquid. Because the Fluoroprotein foam is more resistant to fuel contamination, it allows the discharging foam to be applied directly to the fuel surface and the foam blanket will then resist saturation by fuel vapor. This type of foam can also be used with a High Back Pressure Foam Maker by using the subsurface method of forcing expanded foam into the base of a cone roof storage tank containing a hydrocarbon fuel. The expanded foam enters the base of the storage tank then floats up through the flammable liquid to the surface where it covers the surface with a foam blanket. Fluoroprotein foam is sometimes used in the hydrocarbon processing industry for storage tank fire fighting. It is recommended for use with air-aspirating discharge devices. The recommended foam solution application rate on hydrocarbon spills is 0.16 gpm/sq. ft.

AQUEOUS FILM FORMING FOAM CONCENTRATE (AFFF): Available in either a 1%, 3% or 6% type concentrate. These types of concentrates are manufactured from all synthetic materials such as:

- Synthetic foaming agents
- Solvents (i.e.,viscosity leveler, freezing point depressant, foam booster)
- Fluorochemical surfactants
- Small amounts of salts
- Foam stabilizers (slow drainage, increases fire resistance)

AFFF Foam extinguishes flammable liquid fires by separation, and by forming an aqueous film on the surface of the flammable liquid by the foam solution as it drains from the foam blanket. This film is very fluid and floats on the surface of most hydrocarbon fuels. This gives the AFFF greater speed in fire control and knockdown when used on a typical hydrocarbon spill fire. In certain circumstances, it is possible to notice the fire being extinguished by the "invisible" film before there is a complete foam blanket coverage over the surface of the fuel.

The AFFF solutions can be applied to a flammable liquid fire using either aspirating or non-aspirating discharge devices. The difference between the two is that the air-aspirating device entrains air and causes it to mix with the foam solution within the device. The non air-aspirating device is incapable of this process.

- The AFFF/Water solution requires relatively low energy input to expand the foam solution into an expanded foam mass.
- AFFF solutions are quite unique in that in addition to forming an expanded foam mass, the liquid that drains from the foam blanket has a low surface tension which gives it the ability to form an aqueous film that floats on the fuel surface.

When flow rates and pressures are similar, AFFF solutions used with a non air-aspirating discharge device will generally discharge/throw the foam a greater distance than the foam that is discharged from the air-aspirating discharge device. A non-aspirating AFFF will generally extinguish a low vapor pressure fuel spill fire slightly faster than the foam discharged from an air-aspirating device. This is because the non-aspirated nozzle generated foam has a lower expansion and will be more fluid; therefore, it will move more quickly across the fuel surface.

AFFF is similar to a Fluoroprotein foam in that the application technique is not as critical as with the Protein generated foams. An AFFF can also be used successfully with the sub-surface injection method.

NOTE:The sub-surface method of discharging foam into a storage tank can only be used with tanks that contain standard hydrocarbon fuels, NOT polar solvent/alcohol type fuels.

The recommended application rate for AR/AFFF 3x6% generated foam solution on a hydrocarbon spill fire with low water solubility is 0.10 gpm/sq. ft.

AFFF is suitable for use in a pre-mix state and is suitable for simultaneous use with some dry chemical extinguishing agents.

SYNTHETIC/DETERGENT (HIGH EXPANSION) FOAM CONCENTRATE: Normally used at a concentrate rate of between 1.5% to 2.75%, this type of foam concentrate is manufactured from a combination of hydrocarbon surfactants and solvents. Hi-Ex foam solution is normally used through devices that give high expansion ratios such as the medium or high expansion type foam generators.

In areas where volume fire control is required, a high expansion foam generator can be used to fill an entire room with large amounts of very light expanded foam bubbles. Depending on the generator being used, high expansion ratios of 500 to 1 up to 1,000 to 1 can be achieved.

Fire control and extinguishment is achieved by rapid smothering and cooling. Fires involving solid material as well as flammable liquids can be controlled and extinguished using high expansion foam. It also has a special value for dealing with a spill of liquefied natural gas (LNG.) A deep layer of a 500 to 1 expanded foam will provide a thermal insulation barrier around the LNG spill which reduces the heat intake, therefore the rate of evaporation is decreased. Because of the high expansion ratios being achieved, there is less water used; even with large discharges of the high expansion foam. Medium expansion foam normally has an expansion of around 50 - 60 to 1.This foam is more dense and can be used outdoors but is still affected by weather conditions.

ALCOHOL RESISTANT-AQUEOUS FILM-FORMING FOAM (AR-AFFF): Available in a 1x3%, 3x3%, and 3x6% type of concentrate. Flammable liquids that readily mix with water are more difficult to extinguish when compared to a hydrocarbon fire. The polar solvent/alcohol liquids destroy any foam blanket that has been generated using the standard AFFF or Fluoroprotein type concentrates. The water in the generated foam blanket mixes with the alcohol causing the foam blanket to collapse and disappear until the fuel surface is completely exposed again. To overcome this problem, the AR-AFFF type concentrates were developed. Using the standard AFFF concentrate as a base material, a high molecular weight polymer is added during the manufacturing process. When AR-AFFF is used on a polar solvent fuel fire, the polar solvent fuel tries to absorb the water from the foam blanket. A polymer precipitates, thus forming a physical membrane/barrier between the fuel surface and the foam blanket. This barrier now acting like a raft, protects the generated foam blanket from destruction by the alcohol fuel.

AR-AFFF concentrates are viscous, although current modem AR-AFFF concentrates are designed to work through standard proportioning equipment such as in-line eductors, bladder tanks and balanced pressure pump systems.

It has become common to use the AR-AFFF concentrates for emergency response firefighting, even when used for hydrocarbon fires, due to this type of foam having longer drain times and better vapor suppression characteristics than AFFF foams.

When the AR-AFFF is used at the correct proportioning rate on a hydrocarbon fuel,the fire fighting performance and application rate are the same as for the standard AFFF agents. The "invisible" film is formed, the speed of covering a fuel spill with the foam blanket is similar and the application technique using either air-aspirating or non air-aspirating nozzles can be used. When used on an alcohol fire, an air-aspirating nozzle will give better performance than the non air-aspirating nozzle. The intensity of the fire, the distance the foam must be thrown, and the application rate also play an important role in determining the type of nozzle and method of extinguishment. The application technique and performance factors are the same for the 1x3%, 3x3%, and 3x6% AR·AFFF concentrates.

FILM FORMING FLUOROPROTEIN (FFFP): FFFP is a derivative of AFFF and Fluoroprotein. These concentrates are based on protein formulations to which an increased quantity of fluorochemical surfactants have been added. FFFP concentrates were developed to obtain the quick knockdown of AFFF with the added burn back resistance of standard Fluoroprotein foam. The FFFP concentrate performance factor lies somewhere between the AFFF and the Fluoroprotein. The FFFP concentrates do not have the quick knockdown of the AFFF's when used on a spill fire such as an aircraft crash or a highway spill. When used on fuel in depth fires they do not have the burnback resistance of Fluoroprotein. FFFP foam can be generated with either the air-aspirating or the non air-aspirating nozzle. When used through a non air-aspirated nozzle they do not provide expansion ratios as good as AFFF when used through the same type of nozzle. The application rate is 0.10 gpm/sq. ft. when used on a hydrocarbon spill fire.

CLASS A FOAM CONCENTRATE: This is a biodegradable mixture of foaming and wetting agents. When mixed in the correct proportions with water, it can change two properties of the water. Class A foam will reduce the surface tension which allows for greater penetration into Class A fuels. It also gives water a foaming ability which allows water to remain and cling to vertical and horizontal surfaces, reducing runoff. This allows the water to absorb more heat. By adding a small quantity of a Class A foam concentrate into the water stream, the effectiveness of the water can be increased up to 5 times.

WETTING AGENT: This type of agent is very similar to Class A Foam with regard to reducing the surface tension of the water but does not have tremendous foaming abilities.

SHELF LIFE: Shelf life is the term used to describe the length of time which foam concentrates remain stable and usable without a significant change in their performance characteristics. The shelf life depends upon the composition of the concentrate, the ambient storage temperature, the container materials and if the concentrate is stored in its original container. A shelf life of 30 - 35 years is possible for synthetic type agents when stored within the manufacturers guidelines, temperature limits and in the original shipping container.

Protein based foam concentrates are not considered synthetic and have a naturally occurring product in their formulations. If these products are stored within the manufacturers' guidelines including temperature limits and in their original shipping container, a shelf life of 7-10 years or more can be expected.

COMPATIBILITY: Compatibility is the ability of one foam concentrate to be mixed with another concentrate of the same type and proportioning ratio without altering the chemical, physical or performance characteristics of the ad-mixed foam concentrates. All foams are compatible when applied on a fire simultaneously. Buckeye foam concentrates have been found to be compatible with most other foam concentrates of like quality and type. Buckeye recommends that a proper compatibility study be made to determine the quality of the concentrate with which the Buckeye concentrate is to be mixed.

Any AFFF that is manufactured to the latest revision of MIL-PRF-24385F (SH) AMD2 specification must be compatible with products from any other manufacturer that appear on the Qualified Products List (QPL.)