JAMAICA FIRE BRIGADE

TRAINING DEPARTMENT

FOAM

Jamaica Fire Brigade

FOAM

Introduction

For years, foam has been used as a fire-extinguishing agent for flammable and combustible materials. Unlike other agents (water, dry chemicals, and CO_2), a stable foam "blanket" extinguishes a flammable or combustible liquid fire with the combined actions of cooling, separating flame or ignition sources from the fuel, suppressing vapours, and smothering. Slow drainage and long lasting foam provides extended burn back resistance and protection against reflash or reignition. Foams used as wetting agents enable water to penetrate and soak into Class A materials – extinguishing the fire up to 20 times faster than water alone.

Foam also absorbs more quickly than plain water. The result is more steam, more quickly and a greatly reduced fire temperature. The bottom line is you get faster extinguishment, use less water, and have less heat stress. In fact, the National Institute of Standards and Technology (NIST) rated foam 3-5 times more effective than untreated water.

Foam and Its Uses

Foam is used to combat fires in hydrocarbon fuels such as gasoline, kerosene, heavier oils, and others. Foam has lower specific gravity than the fuels; therefore, it floats on the fuel surface. Applying a blanket of foam to burning hydrocarbons cools the fuel and prevents flammable vapours from reaching the air. It should be noted that the used of foam is not confined to hydrocarbon fuels but it could be easily used for the extinguishments of CLASS A fires, e.g. Wood, paper, coal, etc. However, it is not frequently done because of the cost factor, and water being the cheapest and most readily available extinguishing agent.

A good-quality foam blanket should be a homogeneous mass of minute bubbles that will be minimally disrupted by wind, thermal updraft, or flame and hydrocarbon attack. It will reseal itself if the established foam blanket is disrupted, and it will flow around objects to gain access to and cover areas that are difficult to reach.

Fire-fighters must understand the characteristics of foam to maximize its application and effective-ness. As the foam is applied, it breaks down, and its water content vaporizes due to the heat and flames. Because of the loss of water through

evaporation, the foam must be applied to a burning surface in sufficient volume, at an adequate rate, and reapplied as necessary to be effective. Applying it in this manner ensures that there is a residual foam layer over the extinguished portion of the burning liquid.

The density and rate of foam application become even more critical when the fire control area is considered. This concept is based on the theory that around the fire ground there is a specifically defined area within which it is feasible to extinguish or control a fire long enough for Firefighters to rescue trapped or immobilized occupants. As indicated in this standard, the most serious problem that Firefighters face when using foam is that they must quickly apply large quantities of foam in a manner to form a fire-resistant blanket on the fire. This may be especially difficult on larger flammable liquid spills.

Foam Equipment and Systems

The proper understanding of foam and operation of foam fire fighting equipment is a primary responsibility of firefighting personnel. Although the technological advances in foam, its application, and equipment design have made the use of foam somewhat simpler than in the past, foam is not foolproof.

Firefighters must still understand the basic principles of foam, *proportioning*, and application if the operation is to be successful. The following sections examine some of the basic concepts with which firefighters should be familiar in respect to foam concentrates, portable foam proportioning equipment, and foam application equipment. Because there are many manufacturers of this type of equipment, it is impossible to provide specific operational guidelines for each type of system. However, the information in this handout provides the principles of each type of system. For more detailed information on foam fire fighting and equipment, see the IFSTA Principles of Foam Fire Fighting manual.

PRINCIPLES OF FOAM

There are two main types of foam

1. Chemical Foam
2. Mechanical Foam

Chemical Foam

Chemical Foam is formed from the chemical reaction of two agents, usually Sodium Bicarbonate and Aluminium Sulphate, to which a stabilizer is added. This stabilizer takes no active part in the chemical reaction, but its presence helps to strengthen the walls of the foam bubbles so as to prevent them from bursting easily. The main substances used as stabilizers are Liquorice (extract from the liquorice plant), Turkey Red Oil, Algumen, and Saponene. Chemical foam is usually found in extinguishers and fixed installations. Because this type of foam is not predominantly used today no more will be said on this type of foam.

Mechanical Foam

Foams in use today are of the mechanical type. These must be proportioned (mixed with water) and aerated (mixed with air) before they can be used. To produce quality fire fighting foam, foam concentrate, air, water, and mechanical agitation must be present and blended in the correct ratios, this is known as the *foam tetrahedron* {Figure 9.3}. Removing any element results in either no foam production or in poor quality foam.

To become familiar with types of foams and the foam-making process, it is important to understand the following terms:

1. *Foam concentrate*- The raw foam liquid as it rests in its storage container before the introduction of water and air

2. Foam Proportioner- The device that induces the foam concentrate into the water stream to make foam solution.

3. Foam Solution -The mixture of foam concentrate and water before the introduction of air.

4. Foam -The completed product after air is introduce into the foam solution (also known as finished foam)

To be effective foam concentrates must also match the fuel to which they are applied. Class A foams are not designed to extinguish Class B fires. Class B fuels are divided into two categories: **hydrocarbons** and **polar solvents**.

Hydrocarbon fuels, such as crude oil, fuel oil, gasoline, jet fuel and kerosene are petroleum based and float on water. Standard firefighting foam is effective as an extinguishing agent and vapour suppressant because it can float on the surface of these fuels.

Polar solvent fuels, such as alcohol, lacquer thinner, acetone, are flammable liquids that are miscible (capable of being mixed) in water. Fire fighting foam

can be effective on these fuels but only in special *alcohol-resistant* (polymeric) formulations. It should be noted that many modern automotive fuel blends, which include gasoline with 10 percent or more solvent additives, should be considered polar solvents and handled as such during emergency operations.

Class B foams designed solely for hydrocarbon fires will not extinguish polar solvent fires regardless of the concentration at which they are used. Many types of foam that are intended for polar solvents may be used on hydrocarbon fires, but such use should not be attempted unless the manufacturer of the particular concentrate being used specifically says this can be done. Additionally, polar solvent

foams cannot be used in crash apparatus because the foam concentrate is too viscous to proportion properly.

CAUTION: Failure to match the proper foam concentrate with the fuel results in an unsuccessful extinguishing attempt and could endanger firefighters.

How Foam Works

Foam extinguishes and/or prevents fire by the following methods (Figure 9.4):

- ***Separating*** - Creating a barrier between the fuel and the fire
- ***Cooling--*** Lowering the temperature of the fuel and adjacent surfaces
- ***Suppressing*** (sometimes referred to as smothering) - Preventing the release of flammable vapours and therefore reducing the possibility of ignition or re-ignition

In general, foam works by forming a blanket on the burning fuel. The foam blanket excludes oxygen and stops the burning process. The water in the foam is slowly released as the foam breaks down. This provides a cooling effect on the fuel and surrounding surfaces in contact with the fuel.

FOAM PROPORTIONING

The term ***proportioning is*** used to describe the mixing of water with foam concentrate to form a foam solution. Most foam concentrates are intended to
be mixed with either fresh water or saltwater. For maximum effectiveness, foam concentrates must be proportioned at the specific percentage for which

they are designed. This percentage rate for the intended fuel is clearly marked on the

outside of every foam container. Failure to proportion the foam at its designated percentage, such as trying to use 6% foam at a 3% concentration, results in poor-quality foam that may not perform as desired.

Most fire fighting foam concentrates are intended to be mixed with 94 to 99.9 percent water. For example, when using 3% foam concentrate, 97 parts water mixed with 3 parts foam concentrate equals 100 parts foam solution. For 6% foam concentrate, 94 parts water mixed with 6 parts foam concentrate equals 100 percent foam solution.

The selection of a proportioner depends on the foam solution flow requirements, available water pressure; cost, intended use (apparatus-mounted or portable), and agent to be used. Proportioners and delivery devices (foam nozzle, foam maker, etc.) are engineered to work together. Using a foam proportioner that is not compatible with the delivery device (even if the two are made by the same manufacturer) can result in unsatisfactory foam or no foam at all. For example, a proportioner that is designed to be used at 95 gpm (380 L/min) must be used with a 95 gpm (380 L/min) nozzle, or the foam will not proportion properly - if at all.

There are four basic methods by which foam may be proportioned.

- Induction
- Injection
- Batch mixing
- Premixing

Induction

The induction (eduction) method of proportioning foam uses the pressure energy in the stream of water to induct (draft) foam concentrate into the fire stream. This is achieved by passing the stream of water through a device called an inductor that has a restricted diameter (Figure 9.5). Within the restricted area is a separate orifice that is attached via a hose (pickup tube) to the foam concentrate container. The pressure differential created by the water going through the restricted area and over the orifice creates a suction that lifts the foam concentrate into the fire stream. In-line inductors and foam-nozzle inductors are examples of foam proportioners that work by this method.

Injection

The injection method of proportioning foam uses an external pump or head pressure to force foam concentrate into the fire stream at the correct ratio in comparison to the flow. These systems are commonly employed in apparatus-mounted or fixed fire protection system applications.

Batch Mixing

Batch mixing is the simplest method of mixing foam concentrate and water. With batch mixing, an appropriate amount of foam concentrate is poured directly into a tank of water. Batch mixing is commonly used to mix foam within a fire apparatus water tank or a portable water tank. It also allows for accurate proportioning of foam. Batch mixing may not be effective on large incidents because when the tank becomes empty, the foam attack lines must be shut down until the tank is completely filled with water and more foam concentrate is added. Another drawback of batch *mixing* is that Class B concentrates and tank water must be circulated for a period of time to ensure thorough mixing before being discharged. The time required for mixing depends on the viscosity and solubility of the foam concentrate.

Premixing

Premixing is one of the more commonly used methods of proportioning. With this method, premeasured portions of water and foam concentrate are mixed in a container. Typically, the premix method is used with portable extinguishers, wheeled extinguishers, skid mounted multiagent units, and vehicle-mounted tank systems.

Foam Expansion

Foam expansion refers to the increase in volume of a foam solution when it is aerated. This is a key characteristic to consider when choosing a foam concentrate for a specific application. The methods of aerating foam solution result in varying degrees of expansion, which depends on the following factors:

- Type of foam concentrate used
- Accurate proportioning of the foam concentrate in the solution
- Quality of the foam concentrate
- Method of aspiration

Depending on its purpose, foam can be described as:

1. Low-expansion
2. Medium-expansion
3. High-expansion.

NFPA 11, Standard for *Low-Expansion Foam* states that low-expansion foam has an air/solution ratio up to 20 parts finished foam for every part of foam solution (20:1 ratio). Medium-expansion foam is most commonly used at the rate of 20:1 to 200:1 through hydraulically operated nozzle-style delivery devices. In the high-expansion foams, the expansion rate is 200:1 to 1000:1.

$$\text{EXPANSION} = \frac{\text{weight of volume of foam solution}}{\text{weight of same volume of finished foam}}$$

The preferred application rate for foam is between 4 and 6 litres of foam solution per square meter per minute. Taking the average volumes of 5 litres of foam solution with an expansion ratio of 10:1, we obtain an application rate of 50 litres of finished foam per square metre of surface area.

When calculating the requirements for the use of foam at an incident, a factor of 20 minutes application should be taken to estimate the foam concentrate required. The formula for calculating the foam requirements is therefore 50 litres of finished foam per metre for a minimum of 20 minutes.

Specific Foam Concentrates

Numerous types of foams are selected for specific applications according to their properties and performance. Some foam are thick and viscous and form tough, heat-resistant blankets over burning liquid surfaces; other foams are thinner and spread more rapidly. Some foam produce a vapour-sealing film of surface-active water solution on a liquid surface. Others, such as medium- and high-expansion foams, are used in large volumes to flood surfaces and fill cavities. The following sections highlight each of the common types of foam concentrates.

Aqueous Film Forming Foam (AFFF)

AFFF (commonly pronounced "A triple F") is extremely effective in firefighting applications. It is the recommended extinguishing agent for hydrocarbon fuel fires and is the most commonly used foam today. Aqueous film forming foam (AFFF) is a synthetically produced material. AFFF consists of liquid concentrate that is made from fluorochemical and hydrocarbon surfactants combined with high-boiling-point solvents and water with suitable foam stabilizers. Because AFFF has a lower specific gravity *(the weight of a given volume of a substance as compared to an equal volume of water)* than hydrocarbon fuels, AFFF floats on the surface of these fuels and, because of its low viscosity, quickly spreads across the fuel surface to form a vapour-suppressing blanket (Figure 9.12). Furthermore, AFFF has a significant bleeding effect, so there is a cooling film floating on the surface of the fuel continually. Finally, this film is self sealing when disturbed.

It is available in 1%, 3%, or 6% concentrates to be mixed with water to form the foam solution. AFFF may be used with fresh water, salt-water, or brackish water (*water that is not appealing to the taste*). It resists breakdown by dry chemicals, making it suitable for use in combination with other agents.

How fast the fire is extinguished depends upon the manner in which AFFF is applied, its application rate, and its *density.* AFFF may be applied with an aspirating or non-aspirating nozzle.

Alcohol-resistant AFFF or (AR-AFFF) is available from most foam manufacturers. On most polar solvents, alcohol-resistant AFFF is used at 3% or 6% concentrations, depending on the particular brand used. Alcohol-resistant AFFF can also be used on hydrocarbon fires at a 1% or 3% proportion, depending on the manufacturer, but is not acceptable for use in Aircraft Rescue and Firefighting apparatus because it is too viscous.

Regular Protein Foam (PF)

Before the 1970s, protein foam (PF) was used widely for most all firefighting. However, due to its corrosiveness, the fact that it is not self sealing, and other limitations, PF is no longer widely used, except in some industrial setting.

Fluoroprotein Foam (FPF)

Fluoroprotein foam is not widely used in aircraft firefighting. However, it is widely used in protecting fuel tanks and petroleum processing facilities primarily because its unique fuel-shedding qualities make its highly desirable for sub-surface infection applications.

Film Forming Fluoroprotein Foam (FFFP)

Film Forming Fluoroprotein Foam (FFFP) is an effective agent on flammable liquid fires. Similar to AFFF, FFFP forms a self sealing film on the surface of the fuel, continuously suppressing fuel vapours. FFFP concentrates are available in 3% and 6% solutions that may be applied with a variety of water spray devices. Both salt and fresh water are suitable vehicles for the foam solution. As with AFFF, the effectiveness of FFFP depends upon the application rate, density, and blanketing of the fuel. However, FFFP is not as effective as AFFF in maintaining foam stability. After extinguishments, the foam blanket should be monitored and reapplied as necessary to avoid breakdown and possible reignition hazards.

FOAM MAKING EQUIPMENT

Inductor

To produce medium expansion foam, foam concentrate is induced by means of an inline inductor and Pick-up tube into the water steam. Induction of concentrate can be controlled by the regulating valve between 0-5% and to a great extent is independent of the water pressure. The Inductor regulating valve should normally be set at 2%. Air locks can be removed by turning the regulating valve to high setting for a few seconds and then returning to the normal setting.

Branch Pipe

Air is entrained at the branch pipe into the mixture of water and concentrate. This then passes through the conical shaped gauge, which produces the finished foam uniformly sized bubbles. In order to achieve maximum expansion ratio, care should be taken to ensure that the branch-man's clothes do not obstruct the intake of the branch. Where the branch in fitted with a pressure gauge, it is important that a pressure of five (5) bars (75 psi) be maintained in order that the maximum quality of foam and jet throw is obtained.

Generally, whenever possible the equipment should be used with one 25m length of 45mm (1 $^{3}/_{4''}$) hose between the Inductor and branch pipe. This enables the maximum amount of manoeuvrability with the branch.

CARE AND MAINTENANCE

Foam equipment is seldom used and may deteriorate through lack of use and maintenance. The following points should be examined periodically:

1. Washers have not rotted
2. Metering devices operate correctly
3. Valves operate freely and do not leak
4. Flexible connections are free from damage
5. Bulk storage tanks to not leak

Any deposits of concentrate, foam solution or produced foam, will leave sticky residue. It is therefore imperative that all equipment is thoroughly cleaned with water or vital equipment will be unserviceable when required. Drums of concentrate, which have been partially used but not resealed as the air contents, will cause oxidation.

USE OF BREATHING APPARATUS IN MEDIUM AND HIGH EXPANSION FOAM

Medium and High Expansion foam should never be entered without the use of Breathing Apparatus, guidelines and communication equipment. Even with the use of B.A., it should be only entered when the Officer in Charge of the incident thinks it is essential to do so.

The following points should be taken into account on all such occasions:

a. Because of the lubricating effects of the foam, the handgrip of the B.A. wearer is drastically reduced, thus making the operation of valves, lines hooks, etc, difficult.

b. The lubricating effect may also cause the straps of the facemask to become loose and allow foam to enter. If inhaled, foam is extremely irritating because of its detergent nature.

c. The foam drastically reduces the transmission of sound, creating difficulties i.e.:

    1. Evaluation signals cannot be heard.

2. Difficulty may be experienced in hearing other B.A. wearer who has facemasks fitted with speech diaphragm.

3. Difficulty mat be experienced in hearing the low cylinder pressure warning whistle

4. The D.S.U. may be difficult to hear or even fail to emit any sound due to foam entering the unit.

5. There is an adverse psychological effect similar to claustrophobia.