# A Firefighter's Guide to Foam

NATIONAL FOAM

Today's firefighter is faced with an increasing number of flammable liquid and hazardous vapor risks. Traffic accidents, rail disasters, industrial accidents, even a mishap at the local high school can result in a flammable liquid or hazardous vapor incident. Until recently, most of the training available to firefighters has focused on large volume industrial hazards. While these incidents are spectacular and devastating, their frequency is less common than the smaller incidents handled every day, by local municipal fire departments.

This guide outlines the basic characteristics and types of foam as well as application hardware and proper application techniques. Utilizing this handy reference, you will begin to recognize the advantages and limitations of the wide variety of foams and equipment available and, more importantly, make informed choices when responding to a particular situation.

National Foam has been on the cutting edge of the firefighting and fire protection industry developing innovative solutions to challenging problems for over 170 years. National Foam manufactures the most complete line of environmentally responsible foam concentrates, engineered foam systems and foam apparatus. Our Feecon division with over 30 years of experience has been the predominant leader in the development and manufacture of specialized airport foam firefighting equipment. Feecon products include turrets, nozzles, foam proportioning equipment and related accessories.

## Comprehensive Training Program Available

The only "TURNKEY" flammable liquids training program on the market.  Why develop your own program when the experts have done it for you?  Use it as a canned program or dovetail it with your existing program. For availability and pricing, contact your local National Foam distributor or call 610-363-1400.

## 24 HOUR RED ALERT SERVICE

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## FOAM CONCENTRATES

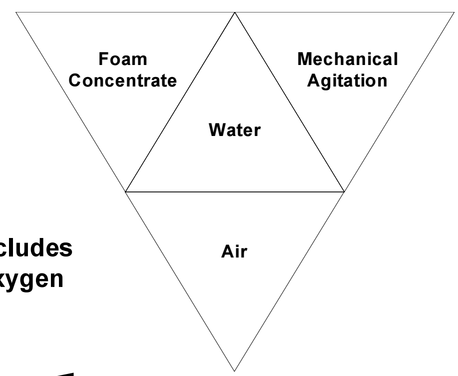
Fire-fighting foam is a stable mass of small bubbles of lower density than most flammable liquids and water. Foam is a blanketing and cooling agent that is produced by mixing air into a foam solution that contains water and foam concentrate.

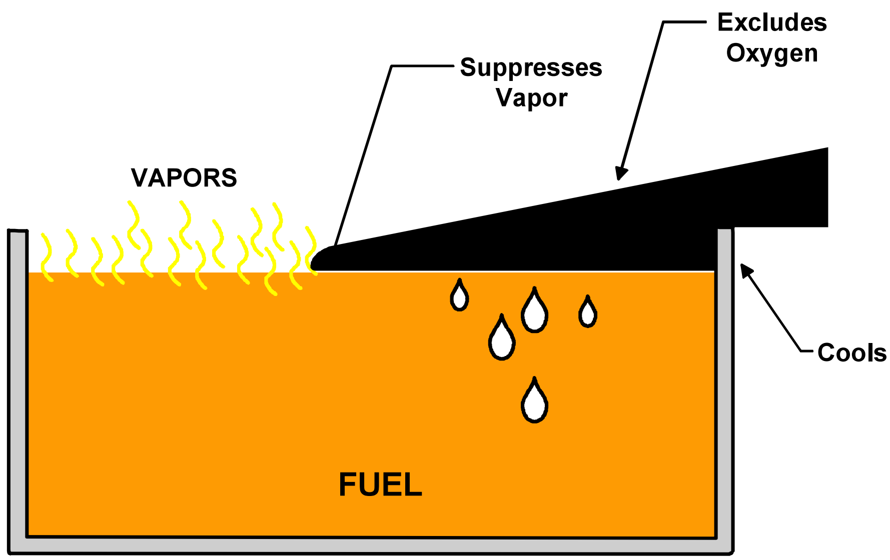
## FIREFIGHTING FOAMS • HOW THEY WORK

FOAM EXTINGUISHES FLAMMABLE OR COMBUSTIBLE LIQUID FIRES IN FOUR WAYS:

1. Excludes air from the flammable vapors.
2. Eliminates vapor release from fuel surface.
3. Separates the flames from the fuel surface.
4. Cools the fuel surface and surrounding metal surfaces.

## FOAM TETRAHEDRON




## EXPANSION RATES

Expansion rate is the ratio of finished foam produced from a volume of foam solution after being expanded from a foam making device.

NFPA categorizes foam concentrates into three expansion ranges, as follows:

1. LOW EXPANSION – Expansion ratio up to 20:1. Foams designed for flammable liquids. Low expansion foam has proven to be an effective means of controlling, extinguishing, and securing most flammable liquid (Class B) fires. Foam has also been used successfully on Class A fires where the cooling and penetrating effect of the foam solution is important.
2. MID-EXPANSION – Expansion ratio from 20:1 to 200:1. Medium expansion foams may be used to suppress the vaporization of hazardous chemicals. Foams with expansions between 30:1 and 55:1 have been found to produce the optimal foam blanket for vapor mitigation of highly water reactive chemicals and low boiling organics.
3. HIGH EXPANSION – Expansion ratio above 200:1. High Expansion foams are designed for confined space firefighting. High expansion foam concentrate is a synthetic, detergent-type foaming agent used in confined spaces such as basements, mines and ship board when used in combination with a High Expansion Foam Generator.

## FOAM TYPES

The following foam concentrates are the most commonly used today by firefighters.

- Protein Foam Concentrates
- Fluoroprotein Foam Concentrates
- Film Forming Fluoroprotein Foam Concentrates
- Aqueous Film Forming Foam Concentrates
- Alcohol-Resistant Foam Concentrates (AR-AFFF and AR-FFFP)
- Synthetic Detergent Foam (Mid and High Expansion)

### PROTEIN FOAM

Regular Protein foams (RP) 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 sea water. They MUST be properly aspirated and should not be used with non-aspirating structural fog nozzles.

Protein 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.

### FLUOROPROTEIN FOAM (FP)

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 sea water. They MUST be properly aspirated and should not be used with non-aspirating structural fog nozzles.

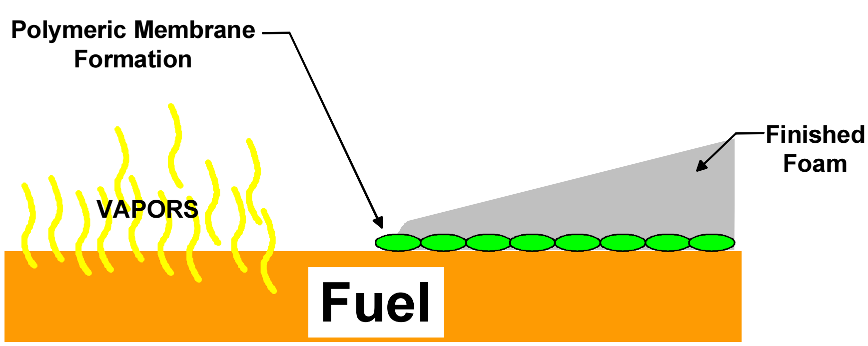
Fluoroprotein Foams are made by the addition of special fluorochemical surfactants to protein foam. This enhances the properties of protein foam by increasing foam fluidity and improves the properties of regular protein foam by providing faster knockdown and excellent fuel tolerance.

### FILM FORMING FLUOROPROTEIN FOAM (FFFP)

FFFP's are a combination of fluorochemical surfactants with protein foam. They are designed to combine the fuel tolerance and burnback resistance of a fluoroprotein foam with an increased knockdown power. FFFP foams release an aqueous film on the surface of the hydrocarbon fuel.

### AQUEOUS FILM FORMING FOAM (AFFF)

The National Foam AFFF family of foams are designed to provide the fastest possible knockdown on hydrocarbon fuels. Their fluidity allows them to quickly flow around obstacles, wreckage and debris. Different percentages may be selected depending on the users proportioning hardware. Standard AFFFs are premixable, dry powder compatible, and can be used with either fresh or sea water. AFFFs may be used through non-aspirating devices, however, for optimum performance aspirating nozzles should be used. Aer-O-Water® 3EM and 6EM conform to the fire performance and chemical formulation as defined by MILSPEC, MIL-F-24385-F.




Aer-O-Lite® cold foams have been specifically formulated for use in cold temperature environments. They have the same properties as regular AFFFs but have much lower usable temperatures as seen below in the storage and handling guide.

AFFF's are a combination of fluorochemical surfactants and synthetic foaming agents. AFFF's extinguish fires by forming a aqueous film. This film is a thin layer of foam solution that spreads rapidly across the surface of a hydrocarbon fuel causing dramatic fire knockdown. The aqueous film is produced by the action of the fluorochemical surfactant reducing the surface tension of the foam solution to a point where the solution can actually be supported on the surface of the hydrocarbon.

ALCOHOL RESISTANT AQUEOUS FILM FORMING FOAM (AR-AFFF)

Universal Plus is designed for use on Hydrocarbons @ 3% and Polar Solvents @ 6%. Universal® Plus has excellent performance characteristics under a wide variety of conditions. Universal® Plus is Dry Powder Compatible and may be used with fresh or sea water. When used at 6% on Polar Solvents Universal® Plus must be properly aspirated.

Universal Gold 1/3% is designed to be used on Hydrocarbons and Polar Solvents @ 3%. Universal® GOLD 3% allows you to minimize your foam inventory requirements while maximizing extinguishing capabilities. Universal ® GOLD 3% is Dry Powder Compatible and may be used with fresh or sea water. When used at 3% on Polar Solvents, Universal® GOLD 3% must be properly aspirated.

Alcohol resistant-AFFF foams are produced from a combination of synthetic detergents, fluorochemicals and polysaccharide polymer. Polar solvents (or water miscible) fuels such as alcohols are destructive to non-alcohol resistant type foams. Alcohol resistant-AFFF foams act as a conventional AFFF on hydrocarbon fuels, forming an aqueous film on the surface of the hydrocarbon fuel. When used on polar solvents (or water miscible fuels), the polysaccharide polymer forms a tough membrane which separates the foam from the fuel and prevents the destruction of the foam blanket. While some concentrates are designed for use on hydrocarbon fuels at 3% and polar solvents at 6% , today's newer formulations are designed to be used at 3% on both fuel groups. These newer formulations provide more cost effective protection of alcohol type fuels, using half the amount of concentrate as a 3% / 6% agent. The use of a 3 x 3 AR-AFFF also simplifies setting the proportioning percentage at an incident, since it is always 3%. Overall, AR-AFFF's are the most versatile type of foam available today, offering good burnback resistance, knockdown and high fuel tolerance on both hydrocarbon and polar solvent (or water miscible) fires.

ALCOHOL RESISTANT FILM FORMING FLUOROPROTEIN FOAM (AR-FFFP)

Alcohol resistant-FFFP foams are produced from a combination of protein foam, fluorochemical surfactants and polysaccharide polymer. Alcohol resistant-FFFP foams act as conventional FFFP's on hydrocarbon fuels forming an aqueous film on the surface of the hydrocarbon fuel. When used on polar solvents (or water miscible fuels), the polysaccharide polymer forms a tough membrane which separates the foam from the fuel and prevents the destruction of the foam blanket. AR-FFFP foams are available as 3% / 6% concentrates which are designed for use on hydrocarbon fuels at 3% and polar solvents at 6%. These formulations are also available for use at 3% on both hydrocarbons and polar solvent fuels.

Class A foams may be used as a firefighting agent or as a fire barrier. When used as a wetting agent, the concentrate lowers the surface tension of the water, allowing better penetration into deep seated fires. As a fire barrier, Class A foams increase moisture content in Class A combustibles, preventing the ignition of these type fuels. When used as a fire barrier, air aspiration of the foam solution is critical.

SYNTHETIC DETERGENT FOAM (MID AND HIGH EXPANSION)

Effective on Class A fires, High Expansion is very useful for confined space fire-fighting and as a wetting agent. High Expansion can be used on small scale Class B Hydrocarbon Fires.

Synthetic foams are a mixture of synthetic foaming agents and stabilizers. Mid-Expansion of Synthetic Detergent based foam is used for suppressing hazardous vapors. Specific foams are required depending on the chemicals involved. High expansion foams can be used on fixed installations to provide total flooding of warehouses or other enclosed rooms containing class A materials such as wood, paper, plastic and rubber. Care must be taken with regard to any electrical power source in the area. Fire extinguishment in these cases is rather different from low expansion foam. High expansion fire extinguishment really amounts to smothering the fire area, and cooling the fuel.

## FOAM CHARACTERISTICS

To be effective, a good foam must contain the right blend of physical characteristics:

1. KNOCKDOWN SPEED AND FLOW - This is time required for a foam blanket to spread across a fuel surface or around obstacles and wreckage in order to achieve complete extinguishment.

2. HEAT RESISTANCE - The foam must be able to resist the destructive effects of heat radiated from any remaining fire from the liquid's flammable vapor; and, any hot metal wreckage or other objects in the area.

3. FUEL RESISTANCE - An effective foam minimizes fuel pick-up so that the foam does not become saturated and burn.

4. VAPOR SUPPRESSION - The vapor-tight blanket produced must be capable of suppressing the flammable vapors and so minimize the risk of reignition.

5. ALCOHOL RESISTANCE - Due to alcohol's affinity to water and because a foam blanket is more than 90% water, foam blankets that are not alcohol-resistant will be destroyed.

THE FINISHED FOAM MUST FORM A COHESIVE BLANKET.

## PROPERTIES AND COMPARISONS OF FIRE FIGHTING FOAM TYPES

| Property | Protein | Fluoroprotein | AFFF | FFFP | AR-AFFF |
|---|---|---|---|---|---|
| 1. Knockdown | Fair | Good | Excellent | Good | Excellent |
| 2. Heat Resistance | Excellent | Excellent | Fair | Good | Good |
| 3. Fuel Resistance (Hydrocarbons) | Fair | Excellent | Moderate | Good | Good |
| 4. Vapor Suppression | Excellent | Excellent | Good | Good | Good |
| 5. Alcohol Resistance | None | None | None | None | Excellent |

## FOAM PERCENTAGES • WHAT THEY MEAN

Foam concentrates are designed to be mixed with water at specific ratios. Six percent (6%) concentrates are mixed with water at a ratio of 94 parts water to 6 parts foam concentrate. For example, if you were going to "premix" a batch of foam concentrate with water, to make one hundred gallons of foam solution, you would mix 6 gallons of foam concentrate with 94 gallons of water. When using a 3%foam you would mix 3 gallons of foam concentrate with 97 gallons of water. Once proportioned (mixed) with water, the resulting foam solutions of a 3% foam or a 6% foam are virtually the same with regard to performance characteristics. A 3% concentrate is more concentrated than a 6%, therefore requiring less product to produce the same end result.

The trend of the industry is to reduce the proportioning percentages of foam concentrates as low as possible. Lower proportioning rates allow the user to minimize the amount of space required to store the concentrate. By switching from a 6% foam to a 3% foam you can either double your firefighting capacity by carrying the same number of gallons, or cut your foam supply in half without compromising suppression capacity. Lower proportioning rates can also reduce the cost of foam system components and concentrate transportation.

Alcohol Resistant foam concentrates that have two percentages on the pail label are designed to be used at two different ratios. For example, a 3%/6% foam concentrate is designed to be used on Hydrocarbon fuels at 3% and Polar Solvent Fuels at 6%. This is due to the amount of active ingredient that provides the foam blanket with alcohol resistance. Newer formulations of AR-AFFF's have improved alcohol resistance so that they can be used at 3% on either hydrocarbons or polar solvents.

Wetting agents and Class A foam concentrates are less complicated mixtures of ingredients that can be proportioned at rates lower than 1%, typically 0.1% to 1.0%. A premix at .5%, is one half gallon of concentrate to 99.5 gallons of water.

## BASIC GUIDELINES FOR FOAM

### STORAGE
If manufacturer recommendations are followed, protein or synthetic foam concentrates should be ready for active service after many years of storage.

### WATER TEMPERATURE, CONTAMINANTS
Foams in general are more stable when generated with lower temperature water. Although all Foam liquids will work with water in excess of 100°F, preferred water temperatures are 35° to 80°F. Either fresh or sea water may be used. Water containing known foam contaminants such as detergents, oil residues, or certain corrosion inhibitors may adversely affect foam quality.

### COMBUSTIBLE PRODUCTS IN AIR
It is desirable to take clean air into the foam nozzle at all times, although the effect of contaminated air on foam quality is minor with low expansion foams.

### WATER PRESSURES
Nozzle pressures should be held between 50 and 200 psi. If a proportioner is used, proportioner pressure should not exceed 200 psi. Foam quality deteriorates at higher pressures. Range falls off at lower pressures.

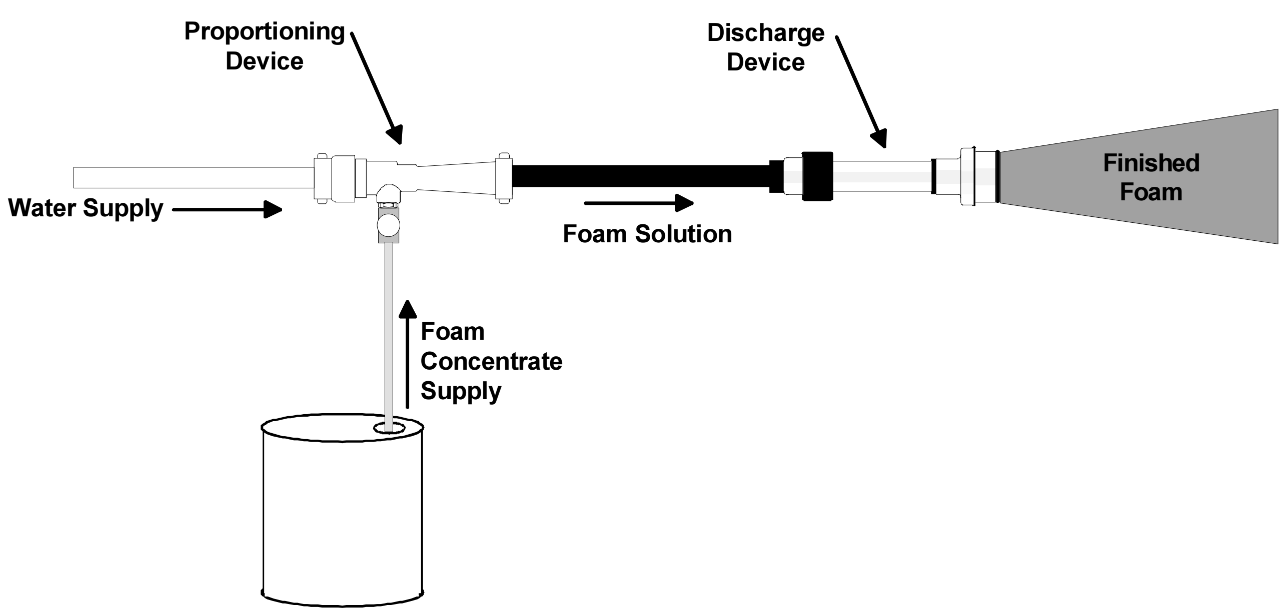
### UNIGNITED SPILLS
Where flammable liquids have spilled, fires can be prevented by prompt coverage of the spill with a foam blanket. Additional foam may be necessary from time to time, to maintain the blanket for ex-tended periods until the spill has been cleaned up.

### ELECTRICAL FIRES
Foam should be considered nearly the same as water when used on electrical fires, and is therefore not generally recommended. If it is used, a spray rather than a straight stream is safer, however, because foam is cohesive, even a dispersed (spray) foam stream is more conductive than a water fog. ***NOTE: Electrical systems should be de-energized via manual or automatic shut downs before applying water or foams.***

### VAPORIZED LIQUIDS
Foam is not recommended for use on materials which may be stored as liquids, but are normally vapor at ambient conditions, such as propane, butadiene, and vinylchloride. Firefighting foam is not recommended for use on materials which react with water such as magnesium, titanium, potassium, lithium, calcium, zirconium, sodium and zinc.

## HOW FOAM IS MADE

Finished foam is a combination of foam concentrate, water and air. When these components are brought together in proper proportions and thoroughly mixed, foam is produced. The following diagram shows how foam is made through typical proportioning equipment.



PROPORTIONERS

All foam proportioners are designed to introduce the proper percentage of foam concentrate into the water stream. There are several varieties of proportioning systems available to the fire service today. The choices range from the more commonly used and economical in-line eductors to Around-the-Pump systems to the sophisticated and more expensive Balanced Pressure systems. The following will offer a brief summary of the mechanics and capabilities of the different proportioning systems available.

EDUCTORS

Eductors are the most common form of proportioning equipment. They are used “in-line” in the hose lay or “hard piped” behind the pump panel for dedicated foam discharges and around the pump systems.

Eductors work on the Venturi principal. Water is introduced, under pressure, at the inlet of the eductor. The eductor reduces the orifice available for the water to pass through, so it must speed up to get through. This creates a pressure drop that, in turn, puts suction on the pick up tube. As the foam concentrate is pulled up the tube it passes through a metering valve that allows the correct percentage to be introduced into the water stream. In most cases, the metering valve can be adjusted to select a 1, 3, or 6% foam solution.

Eductors are extremely reliable and simple pieces of equipment... with some limitations...

1. Eductors Have A GPM Flow Rating.

   All eductors have a gallons per minute solution flow rating. Typically, 60, 95, 125, 250 gpm models are available. THE EDUCTOR MUST BE MATCHED WITH A NOZZLE THAT HAS THE SAME FLOW RATING! Eductor/Nozzle mismatches are the most common cause of Fire Service proportioning problems. Mismatches can result in a weak solution or a complete shut down of foam concentrate pick-up.

2. Eductors Require Adequate Inlet Pressure.

   Eductors establish their pressure drop at a fairly high energy cost. The loss between the inlet and outlet pressure of an eductor can be 40% or more! In order to accommodate this loss and still provide adequate nozzle pressure, relatively high eductor inlet pressures are necessary. Most manufacturers recommend inlet pressures AT THE EDUCTOR of between 180 - 200 psi.

   Most eductors will continue to pick-up at lower inlet pressures, however, at these lower pressures the solution flow drops. Under these conditions it becomes impossible to know how many gpm’s are being delivered to the fire.

3. Eductors Don’t Like Back Pressure.

   Too much back pressure on an eductor can shut down pick up. Therefore, it is important to follow these rules:

   - The nozzle and eductor must be matched.
   - The nozzle must be fully opened or fully closed... it can not be in-between.
   - Prevent kinks in the hose line between nozzle and eductor.
   - The nozzle should not be elevated above the eductor.
   - The hose lay can not exceed manufacturer’s recommendation. Following these simple rules helps to eliminate excessive back pressure on the eductor.

4. Eductors Must Be Kept Clean.

   Eductors must be thoroughly cleaned after each use. Failure to clean an eductor can result in clogging and blockage due to hardening foam concentrate residue. If this occurs, the eductor will not function properly, if at all. When eductors are properly understood and maintained they can accurately and reliably proportion foam at relative low cost.

AROUND-THE-PUMP SYSTEMS

Another method of proportioning is the Around-the-Pump type system. In this case an eductor is installed on the discharge side of the water pump. As before, water flow causes a vacuum which picks up and introduces the foam concentrate into the pump suction. An adjustable metering valve controls the flow of the foam concentrate.

Around-the-pump systems offer several advantages when compared to an inline eductor:

- Variable Flow Rate - The discharge rate can be adjusted for the specific application. The rate is infinitely variable up to the maximum flow of the unit.

- Variable Pressure - The system operates at any pressure above 125 PSI. The pump operation is the same with foam or water.

- No Back Pressure Restrictions - The unit is not affected by hose length or elevation loss.

- No Nozzle Restrictions - The unit operates with any size or type of nozzle.

However, Around-the-Pump systems have their own limitations:

- Pump Inlet Pressure is limited to ten PSI to prevent a back pressure condition that will shut the system down.
- There is no choice of simultaneous flow of foam solution and plain water.
- An operator must continually calculate, set and monitor the foam proportioning metering valve, to correspond with the GPM being flowed.
- Clean-up time can be long since **ALL** discharges must be flushed, whether or not they were opened during the operation.

BALANCED PRESSURE FOAM PROPORTIONING

Balanced pressure systems are extremely versatile and accurate. Most often these systems are associated with fixed systems and specialized mobile equipment. Their design and operations are complex. For additional details, please contact your National Foam representative.

The principle of operation is based on the use of a modified venturi proportioner commonly called a ratio controller. As water passes through a jet at the inlet of the ratio controller, it creates a reduced pressure area between the jet and a downstream section called a throat or receiver. This reduction in pressure causes foam liquid to flow through a foam liquid metering orifice and into the reduced pressure area.

As the water flow through the ratio controller jet increases so does the level of pressure reduction, thereby affecting a corresponding pressure drop across the foam liquid metering orifice. This corresponding pressure drop results in a foam liquid flow which is proportionate to the water flow through the ratio controller. As both the water and foam liquid flow into a common reduced pressure area, it is necessary only to maintain identical water and foam liquid pressures at the inlets of the ratio controller.

Pressure sensing lines lead from the foam liquid and water lines upstream of the ratio controller water and foam inlets to the diaphragm valve. This valve automatically adjusts the foam liquid pressure to correspond to the water pressure. A duplex gauge monitors balancing of foam liquid and water pressures on a single gauge.

For manual operation, the diaphragm valve is not required. The pressure of the foam liquid is adjusted to correspond to the water pressure by means of a manually operated valve in the foam liquid bypass piping.

The pressure loss across the proportioner is approximately 25-30 psi at maximum flow depending on the ratio controller size selected. The minimum flow for which this device will proportion correctly is approximately 15% of the maximum flow for which it is designed. Standard sizes of ratio controllers and performance data are available from National Foam.

Balanced proportioning allows for a wide range of flows and pressures without manual adjustments while placing no limitations on inlet pressure during foam operation.

FOAM NOZZLES

For the most effective and economical use of your foam, foam solution must be properly expanded. Standard fog nozzles generally do not provide optimum expansion and therefore do not provide for the best, most cost effective application of your foam supply. In the case of Polar Solvent fuels these standard fog nozzles may not deliver a foam quality that is able to extinguish the fire.

Foam nozzles are specifically designed to air aspirate (expand) the foam solution and form finished foam. There are three main types of foam nozzles.

1. LOW EXPANSION

   Low expansion nozzles expand foam solution up to 20:1. That is, for every gallon of solution that enters the base of the nozzle between 8 and 10 gallons of finished foam is produced. These nozzles draw air at the base of the nozzle; the air and the solution mix; travel up the foam tube (this is called residence time) and the properly expanded foam exits the nozzle.

2. MEDIUM EXPANSION

   Medium expansion nozzles can have expansion characteristics as high as 200:1, although expansions of 50:1 are more common. They operate in much the same way as low expansion nozzles, however, the diameter of the nozzle is much larger. Medium expansion nozzles can provide tremendous benefits when you really need to bury a risk! Medium expansion application when used with concentrates such as the National Universal Gold 1% / 3% can be very effective in suppressing vapors from chemicals.

3. HIGH EXPANSION FOAM NOZZLES

High expansion foam nozzles can expand foam in excess of 200:1, when high expansion foam concentrates are used. Because of their large size and limited effectiveness on flammable liquids, high expansion nozzles are not commonly carried on first response apparatus.

APPLICATION RATES (FOR CLASS B FIRES ONLY)

The application rates discussed in this section are for spill fires of shallow depth as recommended by NFPA 11. Increasing the foam application rate over the minimum recommended will generally reduce the time required for extinguishment. However, if the application rate is less than the minimum recommended, the time required to extinguish will be prolonged or, if too low, the fire may NOT be controlled.

Flammable liquids can be separated into two major categories... each having a different application rate.

1. **HYDROCARBONS** - Flammable liquids that FLOAT-ON and will NOT MIX WITH WATER.(eg. Gasoline, Diesel, JP4, Heptane, Kerosene)

   NFPA recommended application rate for Film Forming Type Foams equals 0.1 gpm (foam solution) per square foot of fire with a MINIMUM RUN TIME OF 15 MINUTES.

   Examples of application rates for Hydrocarbons:

   AN AREA OF 2000 SQUARE FEET OF REGULAR GASOLINE IS BURNING. YOU HAVE UNIVERSAL PLUS 3% / 6% FOAM AVAILABLE FOR SECURING THE FLAME.

   - .10 gpm/sq.ft. X 2000 sq.ft. = 200 gpm of FOAM SOLUTION REQUIRED.
   - .03 X 200 gpm = 6 gallons of 3% CONCENTRATE REQUIRED per minute.
   - 6 gal. X 15 minutes = 90 gallons of 3% AFFF CONCENTRATE REQUIRED to control, extinguish and initially secure a 2000 sq.ft. hydrocarbon fire.

   Application rate calculations tell you more than just "how much foam do I need?", they also tell you what hardware is required for a given size fire.

   Example: AN AREA OF APPROX. 10,000 SQUARE FEET IS BURNING. YOU'VE IDENTIFIED THE LIQUID AS DIESEL FUEL.

   - .10 gpm/sq.ft. X 10,000 sq.ft = 1000 gpm of FOAM SOLUTION REQUIRED. This means that 1000 gpm worth of EDUCTORS and NOZZLES will be needed. A single EDUCTOR/NOZZLE set rated at least 1000 gpm or several smaller sets could be used as long as they are operated simultaneously and the total flow adds up to a least 1000 gpm.
   - .03 X 1000 gpm = 30 GPM of 3% CONCENTRATE REQUIRED.
   - 30 gal X 15 minutes = 450 gallons of 3% CONCENTRATE REQUIRED to control, extinguish and initially secure a 10,000 sq.ft hydrocarbon fire.

2. **POLAR SOLVENTS** - Flammable liquids that are WATER MISCIBLE or WILL MIX WITH WATER. (eg. Ketones, Esters, Alcohol, MTBE, Amine)

   Fortunately the fire service can carry one type of foam that will handle both Hydrocarbon and Polar Solvent risks. NF's UNIVERSAL ® foams are designed for use on both. While Universal ® GOLD is used at 3% on both fuels, Universal ® Plus is used at 3% on Hydrocarbons and 6% on Polar Solvents.

   Examples of application rates for Polar Solvents:

   AN AREA OF 1000 SQUARE FEET OF A KNOWN POLAR SOLVENT IS ON FIRE. YOU HAVE UNIVERSAL ® PLUS 3% / 6% AR-AFFF AVAILABLE FOR SECURING THE FLAME.

   0.2gpm* FOAM SOLUTION per square foot of fire. Once again, NFPA recommends a minimum run time of 15 minutes on shallow spill fires.

   - .20 gpm/sq.ft. X 1000 sq.ft. = 200 gpm FOAM SOLUTION REQUIRED.
   - .06 x 200 gpm = 12 gallons of 6% FOAM CONCENTRATE REQUIRED per minute.
   - 12 gal X 15 minutes = 180 gallons of 6% AFFF CONCENTRATE REQUIRED to control, extinguish and initially secure a 1000 sq.ft. polar solvent fire.

* Note: Polar Solvent Application Rates can vary depending on the severity of the fuel. The .20 rate used in the example is the "middle of the road" rate. For fuel specific rates consult manufacturer or current UL Directory. For optimum performance on all fuel types FOAM should be properly air-aspirated (expanded). In the case of Polar Solvent risks, however, it is critical that the foam is expanded properly.

## PUTTING APPLICATION RATES TO WORK

After sizing up the incident and determining fuel type and square footage, you must apply the correct application rate formula. You must then MARSHAL YOUR RESOURCES BEFORE YOU ATTEMPT TO EXTINGUISH THE FIRE. Any applications of foam before all the indicated foam and foam hard-ware are available may serve to protect life or exposures... but can NOT be counted as part of the application when resources are gathered. Application rates provide an understanding of what re-sources will be necessary to be applied, without interruption in order to extinguish and secure the fire.

It is valuable to note that other information can be gathered with a good understanding of application rate formulas. Rather than wait for the fire, you can calculate the largest hydrocarbon/polar solvent fire that your department is equipped to handle. And, if you have a good accounting of your mutual aid district's foam and foam hardware inventory, you can calculate the largest hydrocarbon/polar solvent fire that the entire mutual aid network can handle.

In effect, YOU can do a PRE-PLAN for flammable liquid incidents!

It is also possible to calculate the water requirements for any given flammable liquid incident you may encounter by using application rates. In the above example of a 10,000 sq.ft. hydrocarbon fire, we established that we would need a flow of 1000 gpm of foam solution. Since we must operate for at least fifteen minutes, we will need 15,000 gallons of foam solution. Because we most commonly use a 3% Foam on hydrocarbons... .03 X 15,000 = 450 gallons of concentrate. 15,000 gallons of total foam solution minus 450 gallons of concentrate = 14,550 gallons of water required as a minimum.

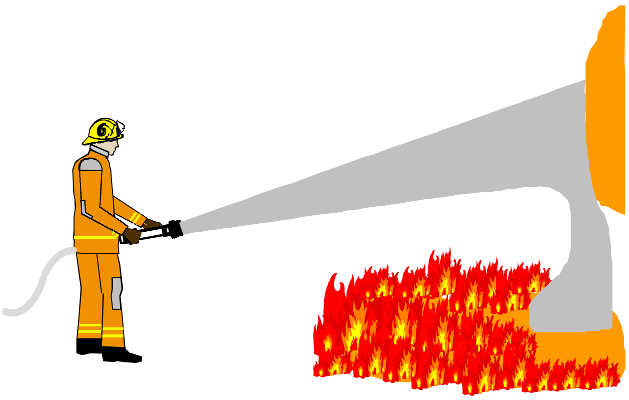
## POST FIRE SECURITY

While application rates will provide the necessary resources for control, extinguishment, and initial security they do NOT take into account the time a response team may have to maintain that security before a clean-up can be effected. Clean-up crews can have long response times (depending on the location... it may take several hours), and a single foam application may not adequately secure an incident when these long clean-up situations arise. A combustible gas indicator should be used to determine when reapplication is necessary and when a sufficient amount of foam has been applied to regain vapor control.

## FOAM FIREFIGHTING APPLICATION TECHNIQUES

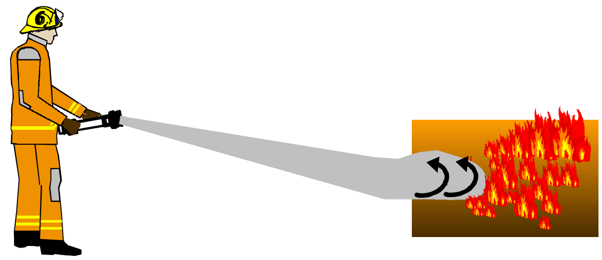
### BOUNCE OFF TECHNIQUE

When foam nozzles are used, particular care should be taken to apply the foam as gently as possible. For straight stream use, the foam should be banked off of a wall or other obstruction when available.



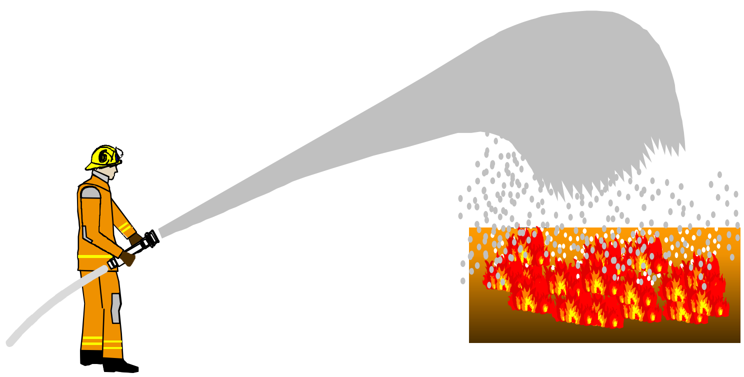
### BANK-IN TECHNIQUE

Foam can also be rolled onto the fuel surface by hitting the ground in front of the spill, and allowing the foam to "pile up" in front of the spill. The velocity of the stream will roll the foam onto the fuel.



### RAINDOWN TECHNIQUE

The foam nozzle is directed almost straight up and the foam stream is allowed to reach its maximum height and break into small droplets. The nozzle operator must adjust the altitude of the nozzle so the fallout pattern matches that of the spill area. This technique can provide a very fast and effective knockdown. How-ever, if the fuel has had a significant preburn and a thermal column has developed, or if the weather is severe (high winds), the Raindown method may not be practical or effective.



### NEVER PLUNGE

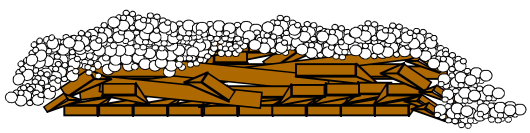
Plunging the stream directly into the fire can splash the fuel causing the fire to spread. If a foam blanket exists, plunging can break the existing blanket allowing vapors to escape. This usually results in spreading the fire, reignition, or flare ups. Usually, the fire will lessen in intensity or self extinguish once the plunging stream is removed.

If the foam nozzle is equipped with a spray stream attachment, it should be used to provide the most gentle application possible and reduce the mixing of foam and fuel. Only as a last resort should a straight stream be directed into the center of a pool or spill. Under this condition, the efficiency of the foam will be 1/3 or LESS than when applied by the recommended methods. Conventional AFFF's may be used effectively with standard water spray nozzles under some conditions, although a very unstable foam with relatively poor reignition resistance is formed from such devices.

Do not use water streams in such a way as to physically disrupt a foam blanket. Water streams may be used for cooling adjacent areas or as a fine spray to reduce flame radiant heat. HOWEVER, do not direct water streams where a foam blanket has been or is being applied.

## CLASS A FOAMS

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 EXTINGUISHING PROCESS

Class A foam extinguishes by isolating the fuel, reducing the fuel temperature and separating the supply of oxygen. The most common method of extinguishment is the use of water for cooling and heat absorption. Water is relatively abundant, easy to use and able to absorb great amounts of heat as it turns to a vapor. In order for water to absorb the maximum amount of heat, it is necessary that each drop of water turns to vapor.

- SPREADS WATER OVER THE CLASS A FUEL
- SLOWLY RELEASES ITS WATER
- ADHERES TO ITSELF
- PENETRATES THE FUEL

## CLASS A FOAM APPLICATIONS

***Class A foams may be used as a firefighting agent or as a fire barrier.***

As a wetting agent, Class A foams lower the surface tension of the water. The high surface tension of water causes untreated water to "bead up" on the surface of the burning fuel and roll off of the fuel surface without penetrating and absorbing heat or cooling the fire. This problem requires that more water be used to extinguish the fire. Class A foam solution, containing 0.1 to 1.0% foam, reduces the tendency of water to "bead up" by lowering its surface tension. This in turn allows the water to penetrate the burning surface, absorb the heat and cool the fire much more rapidly, with less water. Class A foams provide quicker control and increased penetrating power for deep seated fires.

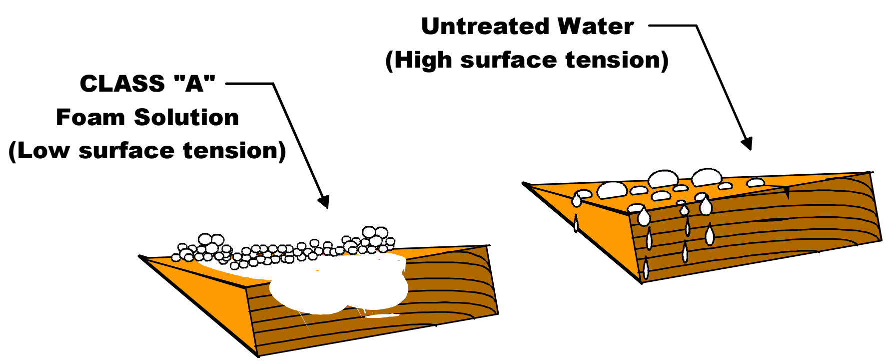
## ADVANTAGES OF CLASS A FOAM

- Increases effectiveness of water
- Reduces suppression and mop-up time
- Relatively easy to pre-mix
- Effective on all types of class "A" fires
- Can provide a short term fire barrier
- Proportioning and application rates are Not Critical as with class "B" foams
- Raises moisture content in material by 50%
- Absorbs 3 times more heat than plain water

Class A foams can also be used as fire barrier to pretreat Class A combustibles. When using Class A foams as a protective barrier, expansion of the solution is critical to the effectiveness of the foam. The foam's ability to "hold water" depends heavily on the integrity of the bubble. If the foam is not properly expanded, the water will drain quickly, providing little or no protection against the heat of the fire.

Proper aspiration of Class A foams is often achieved by using a compressed air foam system "CAFS". These systems use an air compressor to accomplish superior foam expansion. Better range is often accomplished by using a compressor driven system, and less water is used in the process. This method is widely used in wildland firefighting.

By "blanketing" a structure that is in the path of a fast moving wildland fire, the foam can actually act as a barrier to prevent the structure from reaching an ignition temperature. This blanket is also capable of preventing airborne embers from igniting the structure. Because of compressed air foam's ability to stick to inconsistent and vertical surfaces, this blanketing technique can also be used to create a firebreak by "blanketing" trees and brush on one or both sides of a road or other natural break in the foliage. By raising the moisture level in this dried out area, the rapid spread of the fire is halted.



## WETTING AGENTS

Many fire service professionals are not aware there is a difference between foam, and wetting agents or emulsifiers. Understanding the basic performance parameters and limitations of each will help the user determine the applicability of each agent for the intended use. Foam is generally intended for use on Class B fires only, although AFFF is an excellent Class A wetting agent. Wetting agents are applicable to Class A and non water soluble Class B combustibles.

Foam and wetting agents are not the same, as evidenced by development of separate NFPA standards within the same technical committee.

NFPA-11, Standard for Low Expansion Foam defines foam as 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 combustible vapors from access to air.

The basic mechanism foam utilizes for extinguishment is to separate the fuel from oxygen eliminating one leg of the fire tetrahedron, thus interrupting the combustion process. In situations where a fire has been extinguished or ignition has not occurred, foam also serves to provide a visual confirmation that the surface of the fuel has been covered.

NFPA-18 Standard on Wetting Agents defines them as, a chemical compound which, when added to water in proper quantities, materially reduces its surface tension, increases its penetrating and spreading abilities, and may also provide emulsification and foaming characteristics.

Wetting agents generally contain a surfactant or emulsifying ingredient which enables them to mix with hydrocarbon fuels (emulsify) similar to oil and water in salad dressing. This is sometimes referred to as “encapsulating” or “locking up” the fuel.

The basic mechanism dilutes the fuel which increases the flash point and reduces the fuel’s ability to vaporize at ambient temperatures or when heated. Over time, the fuel and wetting agent will eventually separate. This time frame is dependent on several variables, such as type of fuel, fuel temperature, amount of wetting agent, etc. Generally these agents require diluting the hydrocarbon fuel with about 6% of solution (emulsifying agent plus water) by volume.

This means a fire in a 10,000 gallon fuel oil storage tank would require about 600 gallons of wetting agent solution to effect extinguishment. The oil tank must have sufficient extra capacity to contain the fuel oil and emulsifying agent, since the two must mix.

As with many other pieces of fire fighting equipment, Underwriters Laboratories (U.L.) Listings are accepted as a reputable and dependable third party testing agency for the public good. Quite often U.L. Listings are a requirement of bid specifications. Just as the listing criteria for fire hose and ground ladders are different, so too are the listing criteria for foam and wetting agents. In considering the use of wetting agents as a primary agent to extinguish Class B fires, the U.L. test standards should be consulted as a comparison of each agent’s ability to perform.

There is a difference in the testing each undergoes to receive U.L. Listing for Class B applications. Foam is tested for five major areas of performance:

1. Rate of Application
2. Extinguishing Time
3. Sealability
4. Burnback Resistance
5. Foam Quality (Expansion and Drainage)

Wetting agents are tested for extinguishing only. There is no time limit, sealability test, burnback resistance test, or foam quality requirements.

## HIGH EXPANSION FOAMS

High expansion foam concentrate is a careful blend of premium grade surface active agents and synthetic, detergent type foaming agents. This concentrate is proportioned at about 1½% with water then expanded with air to form high expansion foam. When used in combination with a High Expansion Foam Generator, it makes a superior foam with an average expansion of 500 to 1, but can be used with generators producing foams from 200:1 to 1000:1. The foam liquid produces a foam with a smooth texture and uniform bubble which has excellent fluidity to flow around and over obstructions. Its tough adhesiveness provides a foam of superior stability. This foam liquid has a high expansion capability and good stability when used with either fresh or sea water.

In addition to being a superior foaming agent, it also has wetting ability to increase the penetrating effect of water on deep seated Class A fires. Its all-purpose use eliminates the need for stocking wetting agents.

### HOW IT WORKS

High expansion foam controls fires by cooling, smothering and reducing the oxygen content by steam dilution. A rapid draining foam such as produced by many detergents will lose most of its water and provide only a filmy network of bubbles. High expansion foam liquid is formulated to retard drainage and provide stability.

HOW IT IS MADE

High expansion foam is made by introducing a small amount (1½ %) of foam liquid into a foam generator where water and an immense quantity of air (up to 1000 times the quantity of water and liquid) are mixed in a turbulent state. The result is a tremendous blanket of foam. One five gallon can of NF High Expansion Foam Liquid can produce about one-third of a million gallons of foam. This would be enough to cover a football field twelve inches deep.

The temperature of the water and the quality of the air affect high expansion foam. Water should be less than 90°F and care must be taken to position the generator where smoke and combustion gases are not drawn into the air inlet.

If sprinklers are discharging into the area being filled, additional foam will be lost. A complex calculation of volumes which is found in NFPA-11A, is then required. Ventilation is an important phase of fire-fighting with high expansion foam. A vent must be provided at the opposite end of the confined space from the high expansion generator. Foam will not flow into non-ventilated spaces. In some cases where an odd shape building is encountered more than one vent must be provided.

## FOAM FIRE PROTECTION CONSIDERATIONS FOR OXYGENATES & GASOLINE / OXYGENATE BLENDS

### INTRODUCTION

Oxygenates are compounds blended into gasoline to enchance octane and to increase the oxygen content for cleaner burning. The most common additives are polar solvents or slightly polar solvents, which means they are destructive to foams other than Alcohol Resistant foam concentrates. The amount and type of additive has a direct bearing on the type of foam required for extinguishment. Many fire protection and fire suppression professionals are not aware of the impact oxygenates and gasoline/ oxygenate blends have on their foam requirements. NFPA-11 (1994 edition) recommends unleaded gasoline containing oxygenate additives at greater than 10% by volume be protected the same as polar solvents.

### HISTORY AND BACKGROUND

Oxygenates have been added to gasoline for many years, starting with ethanol in the 1920’s. However it is only in the past two decades that sufficient volumes of these materials have been used in the HPI (Hydrocarbon Processing Industry) to warrant much concern as to proper methods of protection for storage and loading facilities handling them. This increased usage has been the result of the ban on the use of leaded alkyls as octane enhancers, and the United States Environmental Protection Agency’s (USEPA) mandate to improve the air quality in severely congested areas by reducing carbon monoxide emissions from automobiles. In 1991, the EPA issued a mandate requiring gasoline sold in so called “carbon monoxide non-attainment areas” (39 mostly urban areas of the US) during the winter of 1992-93 and, presumably, during subsequent winters, to contain an oxygenate additive in an amount to raise the oxygen content of the gasoline to 2.0% on average by weight. In order to meet this requirement oxygenates must be added to gasoline at a level of about 15%. There is the possibility of blends as high as 30%.

There has been a great deal of interest in the use of methanol and ethanol in motor fuels, and extensive research has been done. These alcohols provide some octane enhancement and are high in oxygen content. In the U.S. and elsewhere, the use of fermentation ethanol as a motor fuel additive enjoys tax advantages or other government subsidies, without which, such use would not be economically feasible. Testing conducted by NF and others has shown that gasoline blends containing 10% or less methanol or ethanol can be adequately protected with foam concentrates at the same application rates used for the protection of gasoline or other hydrocarbon fuels. Blending higher alcohol contents requires the use of alcohol-resistant foams.

Drivability, corrosion and storage problems have prevented the widespread use of methanol and ethanol as gasoline additives. Many other oxygenated additives have been considered, and a few, such as tertiary butanol/methanol mixtures, have had some commercial success. However, it is now clear that ethers, especially methyl tertiary butyl ether (MTBE), are the most satisfactory materials to use, both as octane improvers and as oxygenates. They are cheaper and easy to make. They have good octane blending values. They contain oxygen and they do not seem to have adverse effect on drivability.

MTBE is made from isobutylene, a refinery waste product which is normally recycled or burned, and methanol which is produced from natural gas. It now has the largest share of the oxygenate market. There are three other ethers which may become commercially viable. These are tertiary amyl methyl ether (TAME), ethyl tertiary butyl ether (ETBE) and di-isopropyl ether (DIPE). TAME can be produced by refineries which have surplus isoamylene rather than isobutylene. ETBE will be economically viable only if governments extend the subsidies accorded to gasoline blended with fermentation ethanol, to gasoline blended with ETBE made from fermentation ethanol. This extension is likely to occur because of its political appeal to agricultural interests. DIPE, while more expensive than MTBE has some technical advantages, including a less offensive odor.

The initial use of MTBE was as an octane enhancer, replacing lead alkyls. For this purpose it is normally used at concentrations varying from 3% to about 10% by volume, the actual concentration depending upon the octane rating of the base gasoline and the desired octane of the finished blend. In order to meet USEPA's requirement for oxygen content of gasoline sold in the winter months, MTBE concentration of approximately 15% by volume may be required.

While alkyl ethers, the chemical class to which MTBE belongs, are generally referred to as polar solvents, they are much less polar than alcohols, ketones, esters and other chemicals which the fire protection industry normally classifies as polar solvents. Past research determined, that the dielectric constant of a fuel is a good measure of its polarity and, therefore, its tendency to be foam destructive. This study chose a dielectric constant value of 3.0 as the dividing line between polar and non-polar materials, although most common polar fuels have dielectric constants greater than 15. While no dielectric constant value has been reported for MTBE, the dielectric constants of other alkyl ethers are in the range of 2.8 to 3.9. Those of hydrocarbons are generally in the range of 1.8 to 2.8. This places alkyl ethers on the border line between polarity and non-polarity. It is this low degree of polarity that accounts for the success of fluoroprotein foam in extinguishing MTBE fires.

During testing, much was learned about the properties of MTBE and MTBE/gasoline blends. Among other things, it was learned that the grade of MTBE which is used as a gasoline additive may contain about 1-5% C 4 hydrocarbons. These are impurities from the isobutylene used as a raw material. Their presence is significant from a fire protection standpoint because they increase the Reid Vapor Pressure (RVP). Pure MTBE has a RVP of 4.65 psi at 77° F (25°C). Values reported by manufacturers of gasoline additive grade MTBE range from 7.8 to 10.5 psi at 77°F (25° C). As is the case with all high vapor pressure fuels, pure MTBE is a difficult fuel to extinguish, especially at high fuel temperatures. The high vapor pressure of gasoline additive grade MTBE makes it even more difficult to extinguish than pure material.

## THE PROBLEM

Simply put, gasoline is being formulated to burn cleaner and hotter for more complete combustion. While this is a positive step for the environment, it makes fire fighting more challenging. The use of MTBE or other oxygenates as gasoline additives present several problems:

Increasing the MTBE level in gasoline increases the volatility, which makes maintaining an acceptable foam blanket, and hence extinguishment difficult. The Reid Vapor Pressure of unleaded gasoline is normally fairly high, in the range of 8 or 9. The added volatility compounds the problem.

MTBE blended into gasoline reduces the surface tension of the fuel. AFFF film formation is dependent on a difference in surface tension between the fuel and the foam. As the fuel surface tension approaches that of the foam, film formation is inhibited, and hence the extinguishing speed of the AFFF is compromised. A good quality (aspirated) foam blanket is critical for extinguishment.

The amount of MTBE or other oxygenate additive is generally regarded as a trade secret by the manufacturer. It may be very difficult if not impossible, to determine the amount of additive. However, a check of local marketing terminals will probably confirm the level is greater than 10%.

MTBE is blended into gasoline at the refinery. Refiners will not generally blend different gasoline for different geographical areas. Therefore, all pipelines and marketing terminals serviced by a particular refinery will most likely contain MTBE/gasoline blends if the refinery is producing blended fuels. This means even if a particular geographical area does not require oxygenated fuels, and it is between the refinery and an area that does, you are likely dealing with oxygenated gasoline blends.

Alcohol based additives cannot be blended at the refinery. If the particular area utilizes this type of additive, the marketing terminals will have a separate tank of additive which is blended into gasoline at the tank truck loading rack.

RECOMMENDATIONS

Foam quality is a paramount consideration. The use of aspirating foam nozzles are a must to produce a foam blanket capable of resisting the increased vapor pressure. A good aspirated foam blanket is necessary to compensate for the loss in AFFF film formation.

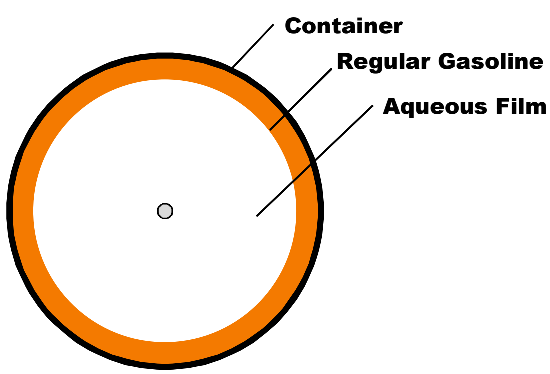
Exercise gentle application techniques to lessen foam submergence and fuel agitation. Because the MTBE is slightly polar, blends have a higher tendency to contaminate the foam blanket. Fuel pickup by the foam blanket is increased with foam submergence and fuel agitation.

Unless otherwise listed or approved, NFPA-11 (1994) recommends foam concentrate be utilized in accordance with polar solvent protection when the oxygenated additive content exceeds 10%.

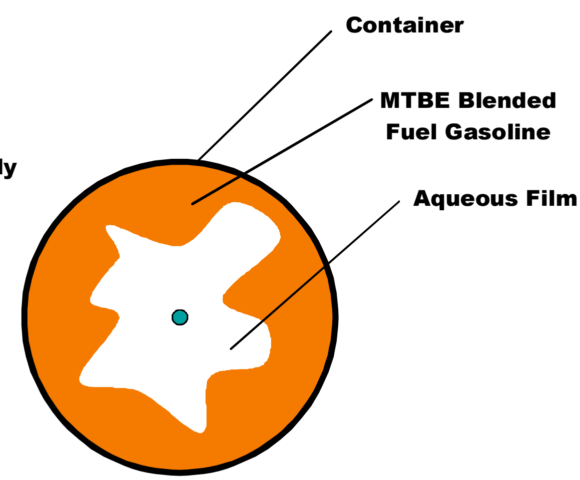
Safety personnel in the hydrocarbon processing industry (HPI) have recognized that these blends might present special fire protection problems. Caltex, for example, surveyed other HPI companies and the foam manufacturers during 1991 and 1992 to gather what knowledge then existed on the subject. Municipal fire departments which have gasoline marketing terminals located within their jurisdiction have also expressed concern. NF responded to this customer concern by initiating, in cooperation with a major HPI company, an extensive fire testing program during the summer and fall of 1992 and again in 1994. This was followed by a NF testing program, witnessed by UL. As a result of this latter program, UL listings for Type II and Type III application have been issued for the use of Aer-O-Foam XL-3 fluoroprotein and Universal Gold foam concentrates on MTBE and MTBE/gasoline blends.

Carbon monoxide pollution is an air quality problem in most of the urban areas of the world. If the U.S. strategy of requiring the use of oxygenated fuels succeeds in lowering CO levels, it is reasonable to expect that other countries will adopt the same requirement. When this occurs, virtually every major refinery, storage facility and distribution terminal in the world will be storing gasoline containing 15% or more MTBE or other oxygenate.

Traditional firefighting agents like Aqueous Film Forming Foams (AFFF) and their related application techniques may see an increase in difficulty in extinguishing or securing fires and unignited spills which involve gasoline treaded with the methl tertiary butyl ether (MTBE) additive.




**This graphic shows that aqueous film spreads rapidly across the surface of regular gasoline**




**This graphic shows that aqueous film struggling to spread across the surface of MTBE blended gasoline**

| | Protein | | | | AFFF | | | | | | AR-AFFF | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AOF 3% | AOF 3CF | AOF XL-3 | AOF XLX | AOW 1 | AOL 3 | AOL 3CF | AOL6 | AOW 3EM | AOW 6EM | Universal Plus | Universal Gold | Universal CG 6 | Knock Down | High Expansion | Training Foam |
| **Approvals** | **UL, U.S. Coast Guard, FM** | | **UL, U.S. Coast Guard, FM** | **UL** | **UL** | **UL, FM** | **UL, FM** | **UL** | **UL, Mil Spec MIL-F-24385-F, FM** | **UL, Mil Spec MIL-F-24385-F, FM** | **UL, FM** | **UL, FM** | **UL, U.S. Coast Guard** | **USDA Forest Service, UL - Wetting Agent 0.3%** | | |
| **Storage** | **20°F (-7°C) to 120°F (49°C)** | **-20°F (-29°C) to 120°F (49°C)** | **20°F (-7°C) to 120°F (49°C)** | **35°F (2°C) to 120°F (49°C)** | **20°F (-7°C) to 120°F (49°C)** | **20°F (-7°C) to 120°F (49°C)** | **-20°F (-29°C) to 120°F (49°C)** | **35°F (2°C) to 120°F (49°C)** | **35°F (2°C) to 120°F (49°C)** | **35°F (2°C) to 120°F (49°C)** | **35°F (2°C) to 120°F (49°C)** | **35°F (2°C) to 120°F (49°C)** | **35°F (2°C) to 120°F (49°C)** | **20°F (-7°C) to 120°F (49°C)** | **35°F (2°C) to 120°F (49°C)** | **35°F (2°C) to 120°F (49°C)** |
| **Applications** | | | | | | | | | | | | | | | | |
| **Storage Tanks** | • | • | • | • | • | • | • | • | • | • | • | • | • | **NA** | **NA** | **NA** |
| **Dike Protection** | • | • | • | • | • | • | • | • | • | • | • | • | • | **NA** | **NA** | **NA** |
| **Process Areas** | • | • | • | • | • | • | • | • | • | • | • | • | • | **NA** | **NA** | **NA** |
| **Warehouses** | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | **NA** |
| **Loading Racks** | • | • | • | • | • | • | • | • | • | • | • | • | • | **NA** | **NA** | **NA** |
| **Offshore Rigs** | • | • | • | • | • | • | • | • | • | • | • | • | • | **NA** | **NA** | **NA** |
| **Marine Tankers** | • | • | • | • | • | • | • | • | • | • | • | • | • | **NA** | **NA** | **NA** |
| **Aircraft Hangars** | • | • | • | • | • | • | • | • | • | • | • | • | • | **NA** | **NA** | **NA** |
| **ARFF** | • | • | • | • | • | • | • | • | • | • | • | • | • | **NA** | **NA** | **NA** |
| **LNG** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | • | **NA** |
| **Vapor Suppression** | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| **Hydrocarbons** | • | • | • | • | • | • | • | • | • | • | • | • | • | **NA** | **NA** | **NA** |
| **Polar Solvent** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | • | • | • | **NA** | **NA** | **NA** |
| **Acids** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | • | **NA** | **NA** | **NA** | **NA** |
| **Alkaline** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | • | **NA** | **NA** | **NA** | **NA** |
| **Class A Fires (Combustibles)** | **NA** | **NA** | **NA** | **NA** | • | • | • | • | • | • | • | • | • | • | • | **NA** |

**• = Applicable**
**NA = Not Applicable**

FOAM GLOSSARY

Adhesive Qualities - The ability to bind together substances of unlike composition. When a foam blanket clings to a vertical surface, it is said to have adhesive qualities. This is required to prevent vapor release from a tank shell, for example.

AFFF (Aqueous Film Forming Foam) - A foam liquid containing fluorocarbon surfactants that control the physical properties of water so that it is able to float and spread across the surface of a hydrocarbon fuel.

Airfoam - Foam produced by a physical agitation of a mixture of water, air and a foaming agent. Also called mechanical foam.

AR-AFFF (Alcohol Resistant-Aqueous Film Forming Foam) - A specially formulated foam concentrate for use on alcohols and other polar solvents.

Boilover - Violent ejection of flammable liquid from its container caused by the vaporization of water beneath the body of liquid. It may occur after a lengthy burning period of products such as crude oil when the heat wave has passed down through the liquid and reaches the water bottom in a storage tank. It will not occur to any significant extent with water-soluble liquids or light products such as gasoline.

Burnback Resistance - The ability of a foam blanket to resist direct flame impingement such as would be evident in a partially extinguished petroleum fire.

Class “A” Fire - A fire in combustible fuel such as wood and paper, where the cooling effect of water is of first importance in extinguishment.

Class “B” Fire - A fire involving a flammable liquid, where blanketing or smothering effect is of first importance.

Class “C” Fire - A fire in “live” electrical equipment, where use of a non-conducting fire extinguishing agent is of first importance.

Cohesive Qualities - The ability to bind together substances of like composition. A good foam blanket is held together by its cohesive qualities.

Combustible Liquid - Any liquid having a flash point at or above 100°F (37.8°C).

Concentration - The amount of foam liquid contained in a given volume of foam solution. The type of foam liquid being used determines the percentage of concentration required; i.e. 3% Aer-O-Foam Liquid is mixed in a 3% concentration (97 parts water, 3 parts Aer-o-Foam Liquid). 6% Aer-O-Foam is mixed as 94 parts water, 6 parts Aer-O-Foam Liquid.

Deflector - The device attached to most Type II fixed foam chamber discharge outlets which directs the flow of foam down and over a large area of the inside of the tank wall.

Discharge Device - A fixed or portable device which directs the flow of foam onto the hazard to be protected.

Downstream Device - In the direction to which the water is flowing.

Drainage Rate - The rate at which solution drains from a foam.

Expansion - The ratio of volume of foam formed to the volume of solution used to generate the foam; for example, an 8 expansion means 800 gallons of foam from 100 gallons of solution.

Flammable Liquid - A substance which is liquid at ordinary temperatures and pressures and has a flash point below 100°F (37.8°C).

Flash-Back - Reignition of flammable liquid caused by exposure of its vapors to a source of ignition such as a hot metal surface or a spark.

Fluoroprotein Foam Liquid - A foam based on natural protein and modified with a selected fluorinated surfactant which is loosely bonded to protein and gives the foam oleophobicity (ability to shed oil-like products).

Foam - The homogeneous blanket obtained by mixing water, foam liquid and air or a gas.

Foam Liquid or Concentrate - The foaming agent for mixing with the appropriate amounts of water and air to produce finished foam.

Foam Maker - A device designed to introduce air into a pressurized foam solution stream.

Foam Solution - A homogeneous mixture of water and foam liquid.

Foam Stability - The relative ability of a foam to withstand spontaneous collapse or breakdown from external causes, such as heat or chemical reaction.

Friction Loss - The loss of pressure in a flowing stream resulting from resistance to flow imposed by the inside of the pipe or hose and by changes in flow direction such as elbows and tees.

Head Loss - Pressure necessary to force water up a pipe or hose to a given vertical height above the source of water pressure. To convert feet of water head to pounds per square inch, divide by 2.31.

Heat Resistance - The ability of a foam to withstand exposure to heat.

Hydrophobic - Water hating; having the property of not mixing with water.

Hydrophilic - Water liking; mixes readily with water.

Mechanical Foam - See Airfoam.

Minimum Operating Temperature - The lowest temperature at which a foam liquid will proportion with venturi devices.

NFPA-Requirements or Recommendations –Standards established for Foam Extinguishing Systems as set forth in the National Fire Protection Association Standard No. 11.

Oleophobic - Oil hating; have the ability to shed gasoline, oil and similar products.

Pickup - The induction of foam liquid into a water stream by venturi.

Polar Solvent - A liquid whose molecules possess a permanent electric moment. Examples are amines, ethers, alcohols, esters, aldehydes, and ketones. In fire fighting, any flammable liquid which destroys regular foam is generally referred to as a polar solvent (or is water miscible).

Polymeric Membrane - A thin, durable, cohesive skin formed on a polar solvent fuel surface, protecting the foam bubbles from destruction by the fuel; a precipitation which occurs when a polar solvent foam comes in contact with hydrophilic fuels such as isopropanol, ethanol and other polar solvents.

Pour Point - The lowest temperature at which a foam liquid is fluid enough to pour, generally about 5°F above the freezing point.

Pressure Drop - The net loss in flowing water pressure between any two points in a hydraulic system. It is the sum of friction loss, head loss, or other losses due to the insertion of an orifice plate, venturi, or other restriction into a section of pipe or hose.

Product - Another name that can be applied to a flammable liquid, such as polar solvent (alcohol) or hydrocarbon (gasoline, oil, etc.).

Proportioner - The device where foam liquid and water are mixed to form foam solution.

Protein - Complex nitrogen containing organic compounds derived from natural vegetable or animal sources. Hydrolysis products of protein provide exceptionally stable, cohesive, adhesive, and heat-resistant properties to foam.

Protein Foam Liquid - Concentrated solution of hydrolyzed protein to which chemicals are added to obtain fire resistance, freezing point depression and other desirable characteristics.

Quarter-Life - The time required in minutes for one-fourth of the total liquid solution to drain from the foam. Also referred to as 25% drainage time.

Residual Pressure - The pressure existing in a line at a specified flow. (As opposed to static pressure).

Skin Fire - A flammable liquid fire, such as a spill on a solid surface where the liquid is not present in a depth exceeding 1 inch.

Solution - Same as Foam Solution.

Spray Pattern - The pattern produced by a widely divergent flow of fully formed subdivided foam, the pattern varying with the nozzle pressure and the adjustment of the spray-creating device.

Static Pressure - The pressure existing in a line at no-flow. This can be considerably higher than the residual pressure.

Submergence - Plunging of foam beneath the surface of burning liquid resulting in a partial breakdown of the foam structure and coating of the foam with the burning liquid.

Surfactant or Surface Active Agent - A chemical that lowers the surface tension of a liquid.

Syndet - Synthetic detergent or cleaning agent.

Type II Applicator - The NFPA term for a discharge outlet not supplemented with means for delivering foam on the surface of the burning liquid without undue submergence or agitation of the surface of the liquid.

Universal® -Type Foam - A synthetically compounded foam concentrate designed for Type II and Type III applications on water miscible fuels and hydrocarbons.

Upstream - In the direction from which the water is flowing.

Venturi - A constricted portion of a pipe or tube which increases water velocity, thus momentarily reducing its pressure. It is in this reduced pressure area that Foam Liquid is introduced in many types of proportioning equipment.