Instructor Manual Module

6

Fire Fighting Foam Principles

Module Objective

Upon the completion of this module, participants should be able to develop firefighting strategies and foam-use tactics for controlling and fighting fires associated with flammable liquid hazards of ethanol-blended fuels.

Enabling Objectives

1. Describe the manner in which foam applications can be used to fight fuel fires.
2. List the ways in which foam applications suppress fire.
3. Predict when to fight fuel fires and when to simply protect surrounding areas.
4. State the generally accepted "rule of thumb" for the use of foam applications on ethanol-blended fuel fires.

Instructor Note:

Module Time: *40 minutes/ 55 minutes*

Materials:

- Emergency Response Considerations *video – (Show the video segment from 12:14 to 15:41)*

Instructor Note:

Show the video Emergency Response Considerations *(12:14 to 15:41).*

Introduction

As discussed previously, we have seen a tremendous growth of the ethanol industry and it will continue to expand. As always, emergency responders should be ready for emergencies associated with flammable liquids. Ethanol-blended fuels are similar to other flammable liquids and their hazards. The predominate danger from ethanol emergencies is not from incidents involving cars and trucks running on ethanol-blended fuel, but instead from cargo tank trucks and rail tank cars carrying large amounts of ethanol, manufacturing facilities, and storage facilities. Responders need to be prepared for large-scale emergencies and prepared with the most effective techniques and extinguishing media. This module will focus on foam basics and then foam applied specifically to ethanol-related emergencies.

Basic Foam Principles

Instructor Note:

Tell participants that this section covers basic principles of foam use. It is put here because not all participants will have this basic knowledge of foam. It also provides a bridge to the next section on specific foam use with ethanol and helps to broaden their understanding of why most foams are ineffective when used on ethanol emergencies.

The following section (from Basic Foam Principles through Rain-Down) is property of the Texas Engineering Extension Service (TEEX).

What is Foam?

As defined in National Fire Protection Association (NFPA) 11, low-expansion foam is: "…an aggregate of air-filled bubbles formed from aqueous solutions which are lower in density than flammable liquids. It is used principally to form a cohesive floating blanket on flammable and combustible liquids, and prevents or extinguishes fire by excluding air and cooling the fuel. It also prevents re-ignition by suppressing formation of flammable vapors. It has the property of adhering to surfaces, which provides a degree of exposure protection from adjacent fires."

What is Foam Concentrate?

"…a concentrated liquid foaming agent as received from the manufacturer." (NFPA 11 version 2016)

What is Alcohol Resistant Foam Concentrate?

"…a concentrate used for fighting fires on water soluble materials and other fuels destructive to regular….foams." (NFPA 11 version 2016)

Why Use Foam?

Ethanol will continue to burn at five parts water to one part ethanol (5:1 ratio/ 500% dilution). Many extinguishing agents are effective on flammable liquids. However, foam is the only agent capable of suppressing vapors and providing visible proof of security. Reasons to use foam include:

- Foam can provide protection from flammable liquids for fire and rescue personnel during emergency operations.
- A foam blanket on an unignited spill can prevent a fire.
- The suppression of vapors prevents them from finding an ignition source.
- Foam can provide post-fire security by protecting the hazard until it can be secured or removed.

How Foam Works

Foam can control and extinguish flammable liquid fires in a number of ways. Foam can:

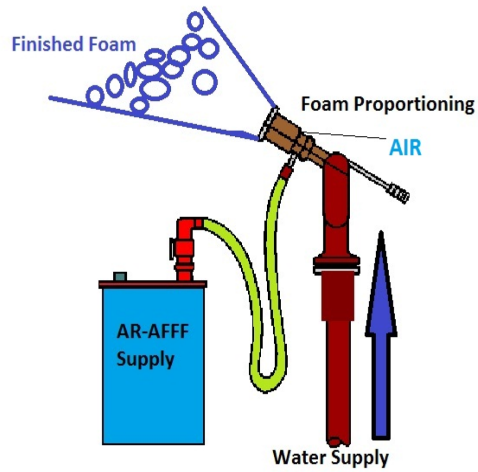
- Exclude oxygen from the fuel vapors and thus prevent a flammable mixture
- Cool the fuel surface with the water content of the foam
- Prevent the release of flammable vapors from the fuel surface
- Emulsify the fuel (some environmental foams)

Foam Tetrahedron

Foams used today are primarily of the mechanical type. This means that before being used, they must be proportioned (mixed with water) and aerated (mixed with air).

Four elements are necessary to produce a quality foam blanket. These elements include:

- Foam concentrate (AFFF, AR-AFFF, etc.)
- Water
- Air
- Aeration (mechanical agitation)



All of these elements must be combined properly to produce a quality foam blanket. If any of these elements are missing or are not properly proportioned, the result is a poor-quality foam or no foam at all. This training program is focused on ethanol-blended fuels and the foam of choice is AR-AFFF.

What is Foam Not Effective On?

Foam is not effective on all types of fires. It is important to know the type of fire and the fuel involved. Foam is not effective on:

- Class C (electrical) fires
- Three-dimensional fires
- Pressurized gases
- Class D (combustible metal) fires.

Foam is Not Effective on Class C Electrical Fires

Class C fires involve energized electrical equipment; water conducts electricity. Since foam contains 94-97% water, it is not safe for use on this type of fire. In some cases, foam concentrate is even more conductive than water. Class C fires can be extinguished using nonconductive extinguishing agents such as a dry chemical, carbon dioxide (CO_2), or halon. The safest procedure for this type of situation is to de-energize the equipment if possible and treat it as a Class A (ordinary combustible material) or Class B (flammable/ combustible liquids) fire.

Foam is Not Effective on Three-Dimensional Fires

A three-dimensional fire is a liquid-fuel fire in which the fuel is being discharged from an elevated or pressurized source, creating a pool of fuel on a lower surface. Foam is not effective at controlling three-dimensional flowing fires. It is recommended that firefighters control a three-dimensional flowing fire by first controlling the spill fire; then they may extinguish the flowing fire using a dry chemical agent.

Foam is Not Effective on Pressurized Gases

Foam is not effective on fires involving pressurized gases. These materials are usually stored as liquids, but are normally vapor at ambient temperature. The vapor pressure of these types of fuels is too high for foam to be effective. To be effective, foam must set up as a two-dimensional blanket on top of a pooled liquid. Examples of pressurized gases include:

- Acetylene
- Butane
- Liquefied Petroleum Gas (LPG)
- Propane
- Vinyl chloride

Foam is Not Effective on Combustible Metals

Class D fires involve combustible metals such as aluminum, magnesium, titanium, sodium, and potassium. Combustible metals usually react with water; therefore, foam is not an effective extinguishing agent. Fires involving combustible metals require specialized techniques and extinguishing agents that have been developed to deal with these types of fires. A Class D extinguisher or a Class D powder is the recommended choice for fires involving combustible metals.

What is Foam Effective On?

Foam is effective at suppressing vapors and extinguishing Class B fires. Class B fires are defined as fires involving flammable or combustible liquids. For the purposes of this discussion, Class B products are divided into two categories: hydrocarbons and polar solvents.

Hydrocarbons

Most hydrocarbons are byproducts of crude oil or have been extracted from vegetable fiber. Hydrocarbons for liquid fuels have a specific gravity of less than 1.0 and therefore float on water. Examples of these include:

- Gasoline
- Diesel
- Jet propellant (JP4)
- Heptane
- Kerosene
- Naphtha

Polar Solvents

Polar solvent fuels will mix with water with varying degrees of attraction for the water. For example, acetone has a stronger affinity for water than does rubbing alcohol. Polar solvent fuels are usually destructive to foams designed for use on hydrocarbons. Specially formulated foams have been developed for use on polar solvents. Some examples of polar solvent fuels include:

- Ketones
- Esters
- Alcohol including ethyl-alcohol (ethanol)

- Amine
- Methyl tertiary-butyl ether (MTBE)
- Acetone

NEVER mix AR-AFFF foam concentrates from different manufacturers. These concentrates are proprietary blends and may counteract each other when mixed in concentrate form. Finished foam (foam concentrate properly proportioned with water and aerated to allow expansion to manufacturer's recommendations) from different manufacturers being deployed into or adjacent to the same location is acceptable.

Foam Terminology

Before discussing the types of foam and the foam making process, it is important to understand the following terms:

- *Foam concentrate* is the liquid substance purchased from a manufacturer in a container, pail, drum, or tote
- *Foam solution* is the mixture obtained when foam concentrate is proportioned (mixed) with water prior to the addition of air
- *Finished foam* is obtained by adding air to foam solution through either entrainment or mechanical agitation

Types of Foam

Several foam types have been developed over the years, each with particular qualities:

- *Protein foam*, one of the earliest foams, is produced by the hydrolysis of protein material such as animal hoof and horn. Stabilizers and inhibitors are added to prevent corrosion, resist bacterial decomposition, and control viscosity.
- *Fluoroprotein* foams are formed by the addition to protein foam of special fluorochemical surfactants that reduce the surface tension of the protein-based concentrate and allow more fluid movement.
- *Aqueous Film-Forming Foam* (AFFF) replaces protein-based foams with synthetic foaming agents added to fluorochemical surfactants. Designed for rapid knockdown, AFFFs sacrifice heat resistance and long-term stability.
- *Film-Forming Fluoroprotein Foam* (FFFP) is a protein-based foam with the more advanced fluorochemical surfactants of AFFF. FFFPs combine the burnback resistance of fluoroprotein foam with the knockdown power of AFFF.
- *Alcohol-Resistant (AR) foam* is a combination of synthetic stabilizers, foaming agents, fluorochemicals, and synthetic polymers designed for use on polar solvents. The chemical makeup of these foams prevents the polar solvents from destroying them. Today's more modern AR foams can be used on both polar solvents and hydrocarbons.

This link is a visual explanation of the value of AR-AFFF foam concentrate - https://www.youtube.com/watch?v=LMFkwovkWH8

Foam will remove heat at a faster rate than it is released, separate the fuel from the oxidizing agent, dilute the vapor-phase concentration of the fuel and/ or oxidizing agent below that necessary for combustion, and terminate the chemical chain-reaction sequence.

AFFF type of foam lowers surface tension, will rapidly spread across the surface, has a high burn back resistance and has quick knockdown.

https://www.youtube.com/watch?v=F_HMe-aOp7A is a video emphasizing the positive attributes of AR-AFFF associated with the graphic in this slide.

Why Use Alcohol Resistant (AR) foam?

Alcohol Resistant (AR) foam is the only agent that is capable of extinguishing a fire, suppressing vapors and providing visible proof of security. The foam blanket on an un-ignited spill can prevent the spill from catching fire. The AR foam suppresses the vapors and prevents them from finding an ignition source. The foams polymeric membrane will prevent the ethanol from mixing with the water element of finished foam. AR foam also provides protection from flammable liquids for fire and rescue personnel during emergency operations.

https://www.youtube.com/watch?v=iYEzHfEaH98&t=4s is a video emphasizing what a polymeric membrane looks like.

Foam Characteristics

No single foam product performs the same for all classes of fires. Each foam type excels at different functions; however, performance in other areas is often diminished. Knockdown, heat resistance, fuel tolerance, vapor suppression, and alcohol tolerance are all characteristics of various foam types. Each property is explained in the text that follows.

- ***Knockdown*** is the speed at which foam spreads across the surface of a fuel. Quick knockdown is achieved by allowing the solution contained in the bubbles to spread rapidly across the fuel surface. Extremely quick knockdown sacrifices good post-fire security, which is required for a stable, long-lasting foam blanket.
- ***Heat Resistance*** Heat resistance is the ability of a foam bubble to withstand direct flame impingement or contact with elevated temperature surfaces, with little or no destruction to the foam bubble. The heat resistance of a foam blanket is often called “burnback resistance”.
- ***Fuel Tolerance*** is the ability of the foam to enter the fuel and resurface with little or no pick up of fuel within the structure of the bubble. A foam bubble which picks up fuel while submerged would simply carry the fuel to the surface and feed the fire.
- ***Vapor Suppression*** Vapor suppression is the ability of the foam blanket to suppress flammable vapors and prevent their release. Vapor suppression is necessary to extinguish fires involving flammable liquids and to prevent ignition of unignited flammable liquid spills.
- ***Alcohol Tolerance*** is the ability of the foam blanket to create a polymeric barrier between the fuel and the foam, thus preventing the absorption of the water from the foam bubbles. This absorption would result in the destruction of the foam blanket.

Property	Protein	Fluoroprotein	AFFF	FFFP	AR-AFFF
Knockdown	Fair	Good	Excellent	Good	Excellent
Heat Resistance	Excellent	Excellent	Fair	Good	Good
Fuel Tolerance	Fair	Excellent	Moderate	Good	Good
Vapor Suppression	Excellent	Excellent	Good	Good	Good
Alcohol Tolerance	**None**	**None**	**None**	**None**	**Excellent**
Source: National Foam					

Foam Proportioning and Delivery Systems

The effectiveness of foam depends on proper proportioning and the ability to deliver finished foam to the spill or fire.

Concentration Levels

Foams are applied at various concentration levels depending on the fuel involved and the concentrate being used. Typically for *hydrocarbons*, foam is proportioned at 3%: that is three parts foam concentrate to ninety-seven parts water. For *polar solvents*, foam is usually proportioned at 6%: that is six parts foam concentrate to ninety-four parts water. Some concentrates allow for proportioning at 1% on hydrocarbons.

Foam Proportioning Systems

A number of ways exist to proportion foam. These include:

- Line eductors
- Self-educting nozzles
- Pressure systems
- Pump proportioning systems

This section will discuss the most common proportioning systems: line eductors and foam nozzle proportioners (foam nozzles with pickup tubes).

Eductors

Eductors use the Venturi Principle to pull foam into the water stream. The flow of water past the Venturi opening creates a vacuum that draws the concentrate through the metering valve. The *metering valve* controls the amount of concentrate allowed to flow into the water stream. The *ball check* valve prevents water from flowing back into the pickup tube and the concentrate container. Major elements of the eductor setup include foam concentrate supply, water supply, eductor arrangement, metering valve, pickup tube, and foam solution discharge. Two common types of eductors are *in-line eductors* and *bypass eductors*.

In-Line Eductors

In-line eductors are some of the least expensive and simplest pieces of proportioning equipment available (see Figures 6.1 and 6.2 in Participant Guide). For this reason, they are perhaps the most common type of foam proportioner used in the fire service. Some advantages include:

- Low cost
- Minimal maintenance
- Simple operation

Figure 6.1: In-Line Eductor

Figure 6.2: In-Line Indicator

Bypass Eductors

Bypass eductors (see Figures 6.3 and 6.4 in the Participant Guide) differ in that they have a ball valve to divert flow from foam to just water, allowing time for cooling without wasting foam and with less flow restriction.

Figure 6.3: Bypass Eductor

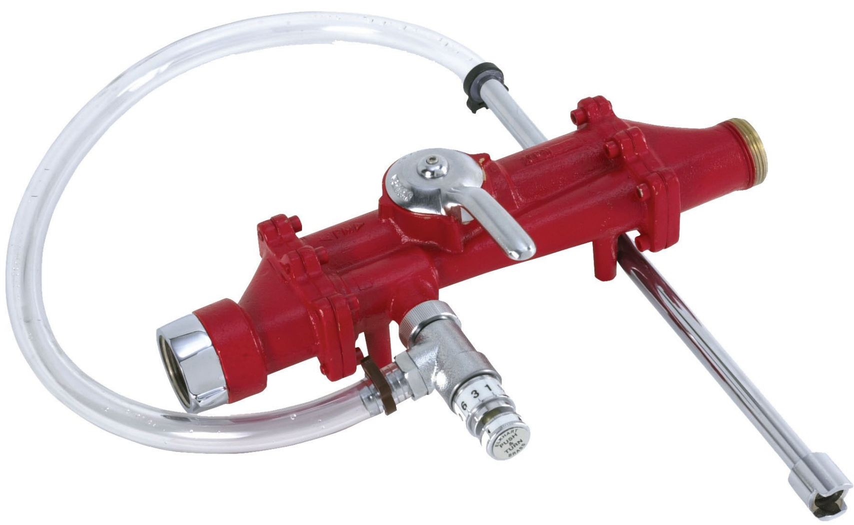
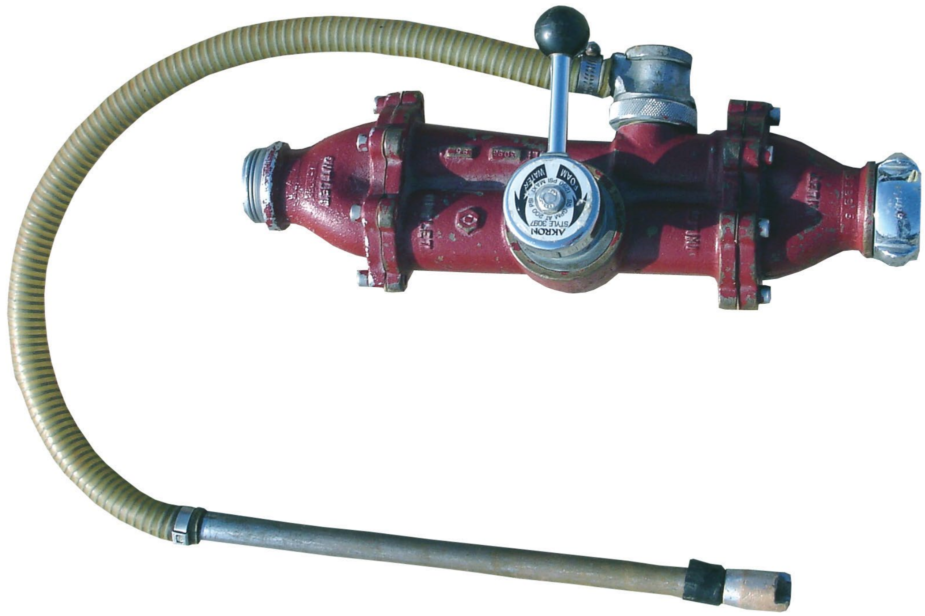


Figure 6.4: Bypass Indicator



Common Eductor Failures

The most common causes for eductor failure include:

- Mismatched eductor and nozzle
- Air leaks in the pickup tube
- Improper flushing after use
- Kinked discharge hoseline
- Improper nozzle elevation
- Too much hose between eductor and nozzle
- Incorrectly set nozzle flow

These may be eliminated by careful preparation, inspection, and use of the eductor, nozzle, and hose. Other eductor failures may be caused by:

- Incorrect inlet pressure to educator
- Partially closed nozzle shutoff
- Collapsed or obstructed pickup tube
- A pickup tube which is too long

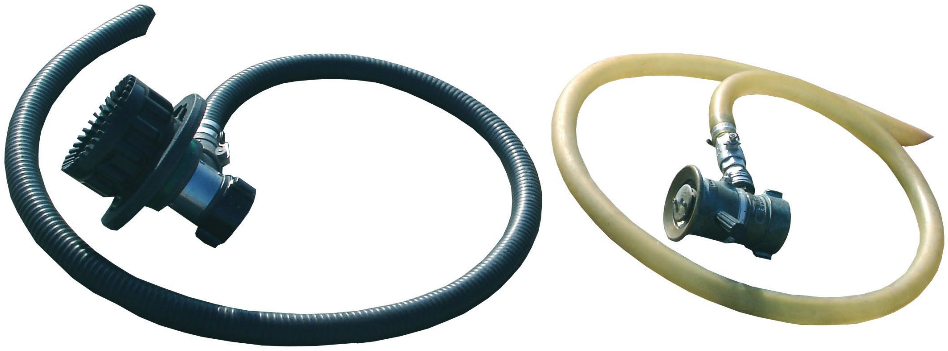
Foam Nozzles

Foam nozzles are either foam proportioning, air aspirating, or non-air aspirating.

Foam Proportioning Nozzles

Foam proportioning nozzles (see Figure 6.5 in the Participant Guide) have built-in orifice plates and utilize the Venturi Principle of operation, producing a very effective foam. These monitor nozzles have the ability to deliver significant volumes of finished foam. Due to the insignificant pressure drop across the eductor, they are able to project foam over long distances.

Figure 6.5: Foam Proportioning Nozzles with Air-Aspirator



Advantages of foam proportioning nozzles include:

- They are easy to operate
- They are easy to clean
- There are no moving parts
- There is no additional foam equipment needed

Hydrant with Foam Nozzle

The image shown in the PowerPoint presentation (Module 6, slide18) shows a fire hydrant with a foam nozzle attached to it.

Air Aspirating Nozzles

Air aspirating nozzles are foam generating nozzles that mix air and atmospheric pressure with foam solution (see Figure 6.6 in the Participant Guide). These nozzles produce an expansion ratio of between 8:1 and 10:1 and produce a good-quality, low-expansion foam.

Figure 6.6: Air Aspirating Nozzles

Non-Air Aspirating Nozzles

Fog nozzles are an example of non-air aspirating nozzles (see Figure 6.7 in the Participant Guide). Non-air aspirating nozzles produce an expansion ratio of between 3:1 and 5:1. This expansion ratio is not as good as that of air aspirating nozzles, but these nozzles often add some versatility which can be beneficial in various fire attack situations. Versatility includes the ability to switch from a foam solution to water in order to protect personnel and provide area cooling. Air aspirating nozzles do not offer this advantage.

Figure 6.7: Non-Air Aspirating Nozzles

A disadvantage of aspirating and non-air aspirating nozzles is that you must have additional equipment in order to generate foam. In addition, the gallonage setting on the nozzle must match the set flow for the eductor. It is important to understand the benefits of both types of nozzles in order to select the most appropriate one.

Foam Trailer

The image shown in the PowerPoint presentation (Module 6, slide 20) shows a portable foam trailers may be found at certain fire departments, local facilities for example airports and also stationed at major railroad facilities along principle routes. This specific trailer is equipped with 1,000 gpm self educting foam nozzle, an air aspirated and non –air aspirated nozzles and two totes of AR-AFFF.

Specialized Foam Nozzle

The images shown in the PowerPoint presentation (Module 6, slide 21) represent typical specialized foam firefighting equipment that may be in use by emergency service providers, bulk storage and/ or ethanol production facilities with their own fire brigades. In addition, private contractors who specialize in flammable and combustible liquid firefighting may have larger capacity and inventory available to them based on the scope and magnitude of any given ethanol-blended fuel incident.

Application Techniques

Proper application is critical for foam. The key to foam application is to apply the foam as gently as possible to minimize agitation of the fuel and creation of additional vapors. The most important thing to remember is to ***never plunge the foam directly into the fuel.***

- ***Bounce-off*** - The bounce-off method is effective if there is an object in or behind the spill area. The foam stream can be directed at the object, which will break the force of the stream, allowing the foam to gently flow onto the fuel surface.
- ***Bank-in*** - When no obstacles exist to bounce the foam off, firefighters should attempt to roll the foam onto the fire. By hitting the ground in front of the fire, the foam will pile up and roll into the spill area. This technique is particularly effective with non-air aspirating fog nozzles. The mechanical agitation of the foam hitting the ground will help to aerate the foam.
- ***Rain-down*** - An alternative application technique is the rain-down method. The nozzle is elevated and the foam is allowed to fall over the spill as gently as possible.

Remember! *Never* plunge a stream of foam *directly* into fuel!

This is the end of the section that is the property of TEEX.

The images shown in the PowerPoint presentation (Module 6, slide 23) are of actual application methods and approach as explained in previous slide. The first three images are showing the bank-in or roll-on method. The picture in the lower right corner is show the rain-down method of foam application. The most important factor to consider when using AR-AFFF finished foam on an ethanol-blended fuel incident is to apply the foam AS GENTLY AS POSSIBLE to your spill or fire. Proper application choice and technique will minimize AR-AFFF finished foam degradation, reduce risk to operational personnel and increase potential for successful management of the incident.

Foam for Ethanol and Ethanol-Fuel Blends

Some of the foams mentioned in the previous sections have been around for over fifty years and have proven to be very effective on hydrocarbon fuels. However, these foams were not developed for application on ethanol-blended fuels are simply ineffective. This is because the alcohol or ethanol content of the blended fuel literally attacks the foam solution, absorbing the foam solution into the ethanol-blended fuel. Foam that is designed to be alcohol resistant forms a non-permeable membrane between the foam blanket and the alcohol-type fuel. It is crucial that these AR foams are used in combating ethanol-blended fuel fires, including E10. This is an important point. Additionally, to be effective, these foams must be applied gently to the surface of the alcohol- or ethanol-blended fuels. Otherwise, the foam is absorbed into the fuel and will not resurface to form an encapsulating blanket. Extensive testing done at the Ansul Fire Technology Center indicated that even at low-level blends of ethanol with gasoline, as low as E10, there is a major effect on foam performance. The testing also indicated that with high-level blends of ethanol with gasoline, even AR foams required careful application methodology and techniques to control fires.

AR-type foams must be applied to ethanol fires using Type II gentle application techniques. For responding emergency services, this will mean directing the foam stream onto a vertical surface and allowing it to run down onto the fuel. Direct application to the fuel surface will likely be ineffective unless the fuel depth is very shallow (i.e., 0.25 inches or less). Type III application (fixed and handline nozzle application) is prone to failure in ethanol-blended fuels of any substantial depth. The only time it is effective is when it is deflected off surfaces, such as tank walls, to create a gentle style application. It has also been found that even with indirect application off surfaces, it may require substantial increases in flow rate to accomplish extinguishments. Therefore, in situations where AR foam cannot be applied indirectly by deflection of the foam off tank walls or other surfaces or there is no built-in application device to provide gentle application, the best option may be to protect surrounding exposures.

Foam Recommendations for Fire Departments

Departments that are subject to incidents involving the various blends of fuels found on highway incidents or at storage facilities should strongly consider converting to AR foam concentrates or develop a means of having a cache of AR foam readily available. When purchasing foam, ensure it is Underwriters Laboratory (UL) certified in order remain compliant with NFPA standards. Significant amounts of AR foam may be required. If your emergency response plan involves relaying on mutual aid, and mutual aid assets, be sure to confirm what type of aid will be provided and what firefighting resources are available. The mixing of different brands of foam can potentially hinder the desired outcome and efficiency in which to be performed, it is imperative that departments verify the compatibility of the foams with their mutual aid. Also be sure to train emergency responders to use these assets.

Foam Application Rates

AFFF-type foams require approximately 1 gallon per minute (gpm) foam solution flow for every 10 square feet of burning surface on a hydrocarbon-type fuel. Ethanol-blended fuels require approximately double that flow (2 gpm/ 10 square feet) of an AR-type foam solution. As with all types of foam, mixing percentage, application rate and flow rate are dependent upon the type and design of the foam concentrate. It is important to refer to the foam manufacturers recommendations.

Alcohol Resistant Foam Facts

There are quite a few new foam concentrates on the market that are challenging the fire protection standards for flammable and combustible liquids to include ethanol-blended fuels. As new testing and certification methods are adopted and approved by organizations such as NFPA (National Fire Protection Association) and UL (Underwriters Laboratories) it is absolutely critical that organizations and agencies purchase foam concentrates from reputable manufacturers. These globally recognized foam concentrate manufacturers have tested their foam products to these industry standards and the foam concentrates PASSED the tests. UL-162 is currently an industry standard relating to foam concentrate performance on ethanol and ethanol-blended fuels. All foam concentrates have a shelf life and will deteriorate over time. Shelf life can exceed 20 years if the foam concentrates are properly managed and maintained in an equitable storage environment according to manufacturers requirements to keep the particulates in the foam in suspension. Foam concentrate manufacturers typically require a concentrate sample on an annual basis to test, thus ensuring its integrity. Keep in mind that alcohol resistant (AR) foams are effective on both alcohol and hydrocarbon fires. AR foams have a special polymer that forms a protective membrane between the fuel and the foam as it contacts the polar fuel, making fire extinguishment possible. AR foams also make the foam more stable and heat tolerant, resulting in better burnback resistance when compared to conventional foams. As a matter of fact, some of the AR foams have quicker knockdown abilities and longer foam retention times than some of the traditional protein-based hydrocarbon foams. It is recommended that a thermal imaging camera be used to more accurately determine if a fire is completely extinguished, especially during sunlight hours. Also note, foam tanks and totes cannot be shaken and remixed easily, and contents can stratify. To avoid this, it is recommended that a maintenance program be in place to re-agitate the foam periodically. If a department has a specific hazard that only involves non-alcohol or non-ethanol-blended fuels, they may want to consider non-AR foam for that specific hazard. For ethanol production, transportation and retail fuel station related incidents emergency response agencies should have AR foam readily available.

Ethanol Scene Evaluation

Proper scene evaluation will assist in making the right choices for a successful incident mitigation. Benchmarks that need to be considered are:

- Size-up
- Situation report to include addressing life safety issues and/or
- Evacuate impacted areas
- Establish Unified Command
- Establish hot, warm and cold zones
- Protect exposures
- Deny entry
- Assemble resources to engage in mitigation activities in staging area
- Be sure to use the application rate recommended for ethanol

- AR-AFFF is the foam of choice

Keep in mind that AR foams are effective on both alcohol fires and hydrocarbon fires. Regardless of the type of incident, scope or magnitude, emergency responders adhere to the universal professional benchmarks of Life Safety, Incident Stabilization and Property Conservation (LIP) which ultimately lead to recovery activities. At every incident, some type of management process must be initiated to "organize the chaos." This incident management system (ICS) becomes even more important as a process when the nature of these incidents increases in complexity, geography and as mentioned before scope, magnitude and involving multiple response organizations with statutory responsibility and/or functional capabilities. Within the concept of the incident management system, standardized benchmarks need to be addressed at every single ethanol-blended fuel incident. This will ensure the health, safety and welfare of the emergency responders and impacted community. Additionally, the benchmarks noted above ensures that the incident management process is initiated and that objectives are developed. Strategies or solutions to achieve the objectives are identified, and resources (human and equipment) with the appropriate knowledge, skills and abilities are assigned to perform the work necessary to achieve the specific incident objectives and universal benchmarks of LIP. Finally, the intent of this information is to assist emergency responders following the ICS management process to arrive at an educated conclusion on whether their specific incident is going to become offensive or defensive in nature. *Please note that offensive operations involving the use AR-AFFF foam, specialized foam fire firefighting equipment and personnel may not always be the best strategy or solutions for every ethanol-blended fuel incident.

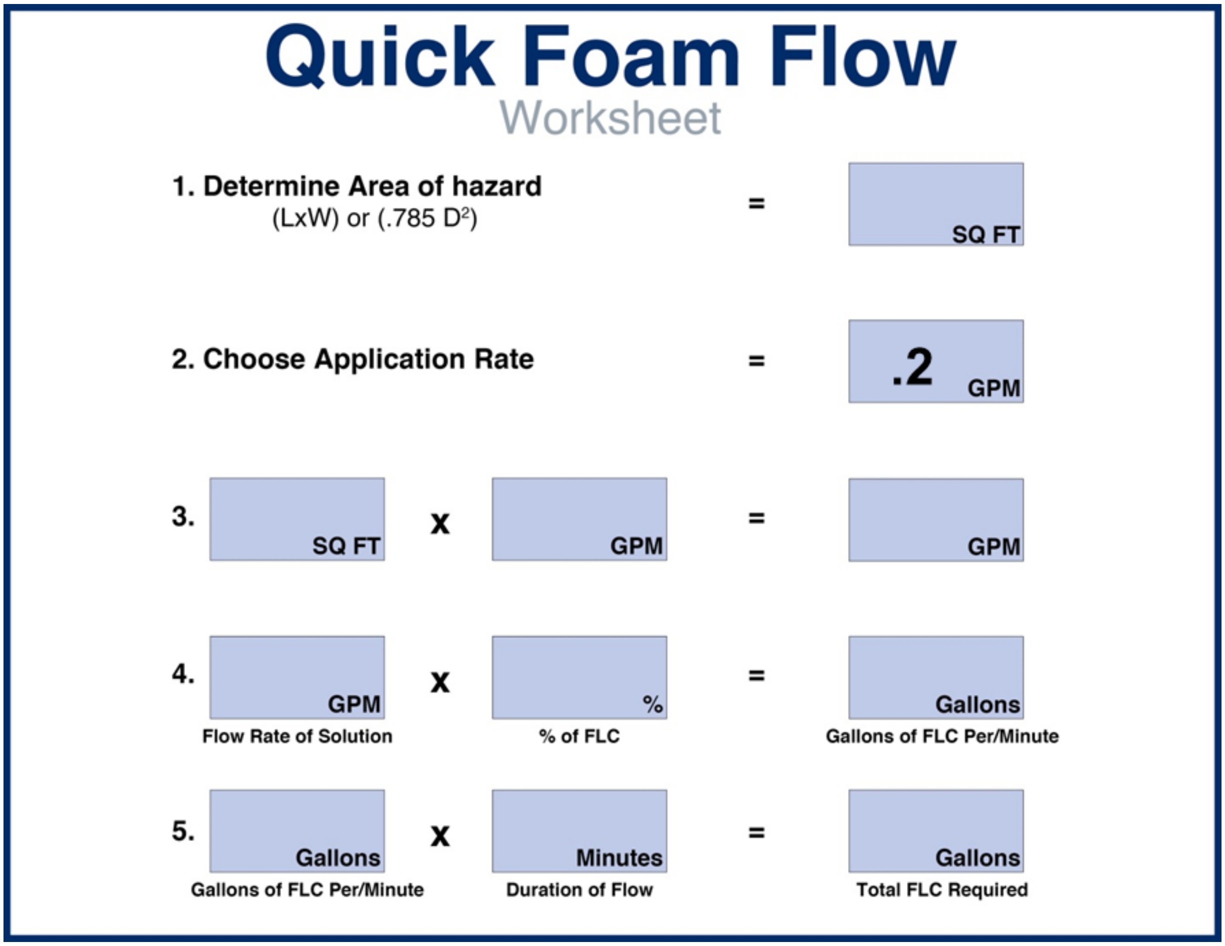
Application Formula

To determine the amount of foam concentrate required, you must find out the type of fuel and the area of involvement. The square footage multiplied by the application rate will give the recommended gpm. The whole formula will give the concentrate total, this includes the time duration for the attack and percentage rate for the concentrate to be used. As a note, double the amount of foam concentrate on hand prior to initiating fire attack (covers fire attack and maintaining foam blanket following knockdown). Time duration depends on the nature of the incident. Typical times are 60 minutes for tanks and 20 minutes for ground spills.

*Foam calculations courtesy of Williams Fire and Hazard Control.

Application Rates

Application rates recommended for ethanol spill fires of shallow depth follow NFPA 11. Increasing the foam application rate over the minimum recommendation will generally reduce the time required for extinguishment. NFPA recommended application rate for hydrocarbon only based incidents with film-forming type foams equals 0.1 gpm (foam solution) per square foot of fire with a minimum run time of 15 minutes. For ethanol-blended fuel incidents of any kind, flow times are based on specific manufacturer recommendations as well as the application rate which will be at least doubled to 0.2 gpm/ sqft of surface area identified within the incident.



Examples of application rates for ethanol-blended fuels:

For ethanol-blended fuel incidents the application time is based on the recommendations from the manufacturer of the foam and the type of foam that will be used.

An area of 2,000 square feet of ethanol-blended fuel is burning. You have universal plus 3%/ 6% foam available for securing the flame.

- 0.20 gpm/ sqft X 2,000 sqft = 400 gpm of foam solution required.
- 0.03 X 400 gpm = 12 gallons of 3% concentrate required per minute.
- 12 gallon X 30 minutes = 360 gallons of 3% AFFF concentrate required to control, extinguish and initially secure a 2,000 sqft ethanol-blended fuel fire.

Application rate calculations tell you more than just “How much foam do I need?”; they also tell you what hardware, tools, appliances and even possibly what application technique may prove most effective based on the incident specifics such as weather and terrain.

Application Rates

This chart shows the GPM requirements.

Area (Square Feet)	X	Minimum Application Rate	=	GPM Solution
	X	0.10 Hydrocarbon Liquid Spill/ Fire	=	
	X	0.16 Tank Dia.<150'	=	
	X	0.18 Tank Dia.<200'	=	
	X	0.20 Tank Dia.<250'	=	
	X	**0.20 Polar Solvent Spill/ Fire**	=	

This specific form provides resource need guidance as part of a detailed pre-plan for any flammable/combustible liquid bulk storage facility, ethanol or hydrocarbon production facility bulk storage and large scale above ground storage tanks at a retail facility. NOTE that the recommended application rates or densities indicated are for hydrocarbon fuels. The RED highlighted information is a starting point for ethanol blended fuels. Current methodology indicates that greater application rates or densities are required as tank diameter increases. Emergency response organizations and other with statutory responsibilities or functional capabilities should work closely with owners and operators of these facilities during pre-plan development. It is highly encouraged to tank advantage of fire protection engineers and other nationally recognized private contractors who engage in ethanol blended fuel incidents of scope and magnitude when calculating resource needs to include AR-AFFF foam concentrate needs, water supply and specialized foam firefighting equipment.

This chart shows the concentrate requirements.

GPM Solution	X	% of Foam Concentrate	=	Foam Concentrate GPM	X (Time)	Total Concentrate (Gal)
	X		=		20 Min. (Spill/Fire)	
	X		=		60 Min. (Tank Fire)	

Remember that due to the characteristics of ethanol and ethanol-blended fuels additional resources and time may be required to achieve incident objectives and manage the incident safely.

Total Concentrate (Gallons)	X 2	Incident Foam Needs Prior to Initiating Fire Attack
	X2	
	X2	

Incident foam needs rule of thumb is to double the amount of foam concentrate on hand prior to initiating fire attack (covers fire attack & maintaining foam blanket following knockdown).

Instructor Note:

Walk participants through Example: Spill Calculation, which shows the calculations to determine the appropriate amount of foam needed for a mock transportation incident involving ethanol.

Summary

AR foam is accepted as the best fire suppression/ firefighting agent for use in incidents involving hydrocarbons and ethanol-blended fuels. Because of its ability to maintain a protective layer on ethanol-blended fuels, AR-AFFF foam turned out to be the best choice for incidents involving these types of fuel. Because AR-AFFF foam also works well on gasoline fires, it is the recommended choice for all fuel fires involving either gasoline or ethanol-blended fuels. If it is unclear the chemical nature of the burning fuel, AR-AFFF is the preferred choice from a response standpoint. Refer to the foam manufacturer for the recommended application rate.

Instructor Note:

To reinforce what was discussed in this module, show the segment from 6:12 to 10:45 from the video Responding to Ethanol Incidents. This segment deals with the use of Type II and Type III foam application.

After the video ask and discuss the following:

- *What is the purpose of the burnback test?*
    - ***Answer**: To evaluate a foam's resistance to fire*
- *In Type II application with 95% ethanol, which foam was most effective?*
    - ***Answer**: AR-AFFF*
- *How did the AR-AFFF perform in the Type II test with 95% ethanol?*
    - ***Answer**: It extinguished the fire but failed the burnback test.*
- *Which was the only foam to pass the sprinkler test in a 95% ethanol fire?*
    - ***Answer**: AR-AFFF*
- *In the Type III test with 10% ethanol, did the AR-AFFF pass the test at the normal usage rate?*
    - ***Answer**: No, only at an increased usage rate*
- *Based on what we discussed in the module and what we saw in the video, what would be the best foam application method for Type III applications? Why?*
    - ***Answer**: Banking, because this method directs the foam stream toward a structure or object adjacent to the burning fuel to create a cascading effect that introduces the foam into the burning surface more gently then plunging or direct application.*
- *Why should direct application or plunging be avoided in ethanol or ethanol-fuel blend fires?*
    - ***Answer**: Plunging disturbs the polymers in the foam and prevent proper mixing with the polar solvent.*