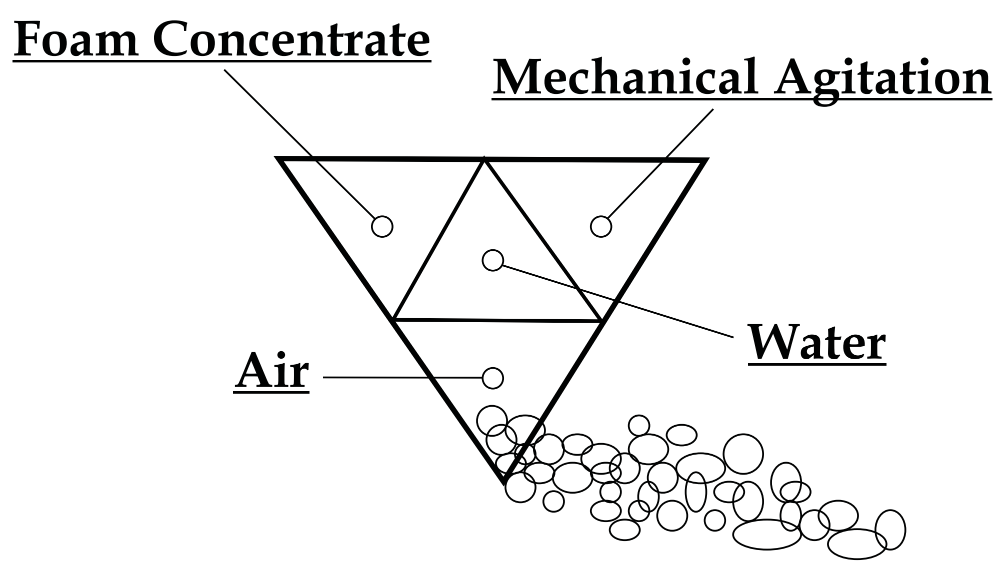
Class A Foam

Awareness and Operations Level Workbook and Glossary



The Foam Tetrahedron

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Class A Foam Course Outline

Course Objectives

1) Explain the concept and chemistry of foam as an enhancement to fire suppression.
2) Identify the types of mechanical foams and explain benefits and limitations of each.
3) Define proportional and non-proportional concentrate injection systems, batch mixing, eductors, and discharge side injection systems.
4) Understand operational characteristics using foam, critical application rates, and initial attack strategies.
5) Understand operations and performance of fog/combination nozzles, low and medium expansion foam tubes (Low Energy Foam Delivery Systems), and CAFS (High Energy Foam Delivery Systems).
6) Present application techniques and strategies for structural and wildfire suppression responsibilities.
7) Provide current research and reports on the use of Class A foaming agents for wildfire and structural suppression.

Classroom Activities

1) Overview of surface activate agents (surfactants) in the fire environment. Class A and Class B foaming agents.
2) Evaluation of mechanical foam generating systems and concentrate delivery systems.
3) Discuss operational techniques and strategies for successful applications.
4) Study of safety and environmental concerns when using foam agents.
5) Understanding of application rates and critical flow rates for Class A and Class B fuels.
6) Demonstrations and hands-on evaluations of systems and equipment used in fireground applications.

Live Fire Demonstration Exercise (if appropriate)

In order to conduct any live fire or demonstration fire training exercise, a burn location should be determined by the local agency having jurisdiction in advance and be in close proximity to the classroom activities. For wildfire fuels, the location should be representative of the problems encountered by the local agency. If an acquired structure or debris is to be burned, the agency having jurisdiction and the instructor should inspect the site well in advance of the demonstration burn.

All fire training and demonstrations shall be in complete compliance with all applicable local, state, federal, and jurisdiction policies. ***The NFPA standard 1403 for conducting live fire training exercises shall be followed.***

All participating members in either demonstration or live fire operations will wear complete NFPA approved protective clothing, including, but not limited to, full bunker clothing (coat and pants), gloves, boots, helmets, and hoods. ***Any attendee participating in live structural training shall be in compliance with the local use of SCBA and be under the direction of Fire Ground Command.***

The demonstration/training exercise will focus on the use of foaming agents on structural attack, exposure protection, and application techniques and tactics for the range of foaming agents.

Awareness and Operations Level

Class A Foam Applications

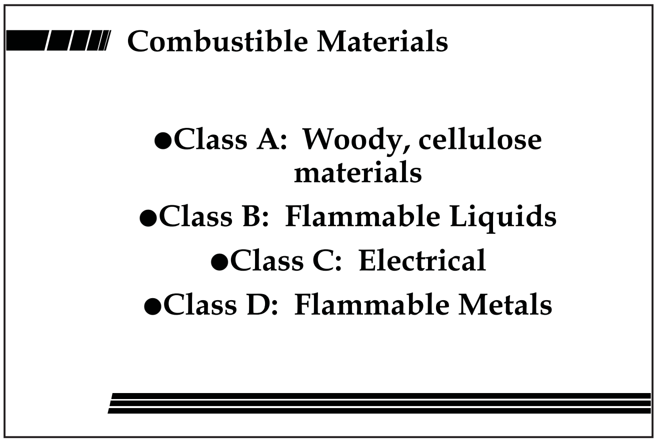
- Review of Course Content
- Course Objectives
- Classroom Activities...
  Slides, Demonstrations, and
  Video Presentations
- Glossary of Common Terms
- Foam vs Fire, CAFS, Proportioners
- Live Fire Exercise (Operations Level)
- Review of NFPA 1403
- Summary and Review
- Test
- Course Evaluation

Class A Foam Applications

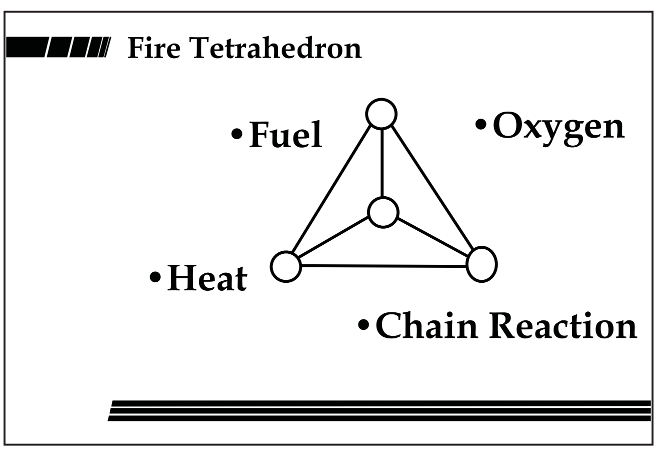
Course Objectives

- The Concept and Chemistry of Foams
- Proportional and Non-Proportional Injection
- Low Energy Foam Delivery Systems
- High Energy Foam Delivery Systems
- Application Tactics and Strategies
- Current Research

- Explain the concept and chemistry of foam for fire suppression.
- Define proportional and non-proportional injection systems, batch mixing, eductors and the benefits and limitations of each.
- Understand the operations and performance of nozzles, aspirating nozzles and foam tubes (Low Engery Systems).
- Understand the operations and performance of CAFS (High Energy Systems).
- Present tactical and strategic considerations of foam applications.
- Provide current research and reports on the use of Class A foam agents for Forestry/Rural and Intermix responsibilities.



- Class A combustibles include wood, paper, fabrics, and other deep-seated fuels that leave an ember.
- Class B flammable liquids include both hydrocarbon and alcohol-based fuels.
- Class C fires are Class A or Class B fires with energized electricity involved.
- Class D flammable metals like magnesium and others require specialty agents for effective extinguishment.
- **NOTE:** Tires can be Class A until they melt into a liquid state and become Class B flammable liquid hydrocarbon.



- The basic Fire Tetrahedron and how it interacts.
- Fuel, anything flammable that, when heated, will produce a vapor that will burn when contacting a source of ignition.
- Oxygen, necessary for combustion, will vary on enclosed fires, providing different stages to a structure fire. Smoldering or free burning, it can also be an indicator of life safety within a confined space.
- Heat, a source of ignition and the preheating of the fuels to provide vapors that will ignite.
- Remove or modify any side of the tetrahedron and complete combustion will cease to exist, including the interruption of the chemical chain reaction (i.e. the use of Halons, Shock waves and Ion separation).

Methods of Fire Extinguishment

Primary

- Remove Heat
- Remove Fuel
- Remove Oxygen

Secondary

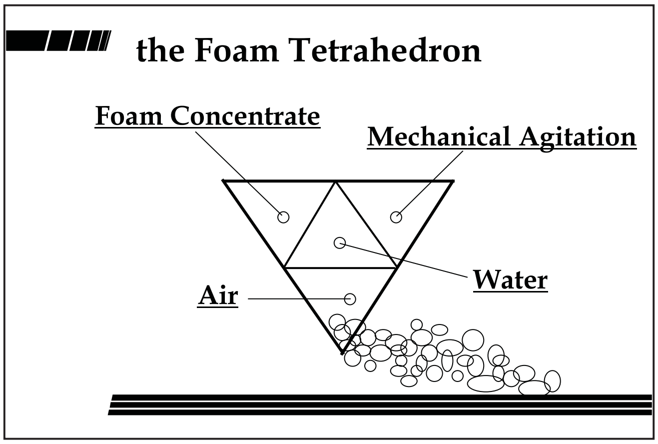
- Interrupt Chemical Chain Reaction

- Typically, initial structural attack concentrates on the removal of heat with the application of water spray.
- Structurally, removal of fuel is not appropriate, but in wildfire suppression removal of fuel in advance of a fire is common. This is known as indirect attack.
- Removal of oxygen happens in the later stages of the compartment-type unvented fire, but is not practical for initial attack, unless a door can be closed on a room of involvement.
- Interruption of the chemical chain reaction of fire is accomplished by the use of shock waves, critical vibrations or ion separation in some combination. A good example is how Halon works on a fire.

The Concept of Foam Applications

- The Properties of Foam in the Fire Environment
- Differences in Mechanical Foams
- The Reduction of the Surface Tension of Water
- Class A Foam's Role in Initial Attack

- Discuss the objectives of the awareness and operational level of foam applications.
- Understand the limitations of foam. Foam is not a good tool for three dimensional Class B fires, or fires involving pressurized flammable liquids or gases. For Class B fires, the use of chemical powder is best for three dimensional fires and foam for fires on pooled liquids.
- Provide an overview of the most commonly used mechanical foams.
- Offer discussion and present demonstrations of the reduction in the surface tension of water and how this enhancement will relate to initial fireground attack and suppression activities.
- Overview the main benefits of using not only Class B foam but Class A foam for structural initial attack, pretreatment and exposure protection.
- As a water enhancement, Class A foam has many variables from a tactical standpoint. Discussion will be provided to offer strategies and tactics to fit most needs, whether structural or wildfire.



There are four separate qualities that make a good foam blanket. Each must be in the proper proportion to generate a quality finished foam.

Water as supplied by the pumper (or water flow + pressure) is not only the transfer of the water, but the supplier of the energy to make a finished foam as well. The energy that is put into the line in the form of flow (gpm) and pressure (psi) is used at the nozzle tip to help generate a finished foam. This is true of "low" energy systems only.

The **foam concentrate** must be added into the water stream to create a foam solution. This can be done in a number of ways. As simple as batch mixing in a tank to as complex as an around-the-pump proportioning system. There are eductors, automatic discharge side injection systems, suction side injectors, and balanced pressure systems. But, they all do one thing, mix foam concentrate into the water in a controlled accurate manner. This finished foam solution is used to make a final foam blanket.

Air, or some other inert gases, when made available for mixing, will provide one part of this tetrahedron. The **mechanical agitation** that is created by the nozzle tips, foam attachments, or foam tubes draws the air into the foam solution, and tumbles and mixes the solution with air. The final outcome, if all items are added properly to the tetrahedron, is a finished foam of some quality and quantity.

How a Foam Acts on a Fire

In some form, a foam blanket will do the following:

✓ **Smothers**

✓ **Suppresses**

✓ **Separates**

✓ **Cools**

Smothering - The use of a foam blanket will provide an excellent covering that can be used to surround a fuel thereby breaking a side of the tetrahedron. This smothering ability will act to isolate the fuel from other sides of the tetrahedron.

Suppressing - Foams, especially Class A, are extremely effective at allowing water to penetrate into the fuel upon which it is applied either absorbing heat or generating a film.

Separates - A layer of foam in blanket form will accomplish several things. A key factor of both Class A and B fuels is the ability to separate the fuel from the air and heat. Again, this will break the tetrahedron.

Cools - Still 99% or more water, a foam blanket will have all the cooling characteristics of plain water applications. In exposure protection the holding benefits will be extended when using a foam blanket.

Types of Mechanical Foams

- Protein
- Syndet, High Expansion
- Aqueous Film Forming Foam (AFFF)
- Fluoroprotein
- Film Forming Fluoroprotein (FFFP)
- Alcohol Resistant Concentrates (ARC)
- Polar Solvents and HazMat Foams
- Syndet, Class A

Protein has been used extensively since WWII and its base composition is hydrolyzed waste protein materials.

Syndet, High Expansion is a combination of synthetic foaming agents and stabilizers used to provide vast quantities of finished foam to fill cavities (i.e. coal mines, shipboard and enclosed areas) and locations of potential firefighter life safety. A drawback can be lightness of the finished product.

Aqueous Film Forming Foam is a combination of fluorochemical surfactants and synthetic foaming agents that form a thin film layer for vapor suppression.

Fluoroprotein is a combination of fluorochemical surfactants and protein foam. It has increased fluidity and better fuel tolerance.

Film Forming Fluoroprotein, a combination of fluorochemical surfactants and protein that combines the burn-back resistance of protein with film forming capability.

ARC and **Polar Solvent Foams** consist of synthetic stabilizers, foaming agents, fluorochemicals, and alcohol resistant membrane forming additives that combine to provide the most versatile foam available today. Individual HazMat foams are designed for specific chemicals and their vapor suppression.

Syndet, Class A combines surfactants, stabilizers, and corrosion inhibitors to provide a biodegradable, high bubble producing, concentrated product for Class A combustible products.

Protein Foam

PROS

- Long Lasting
- Excellent Heat Resistance
- Stable and Relatively Inexpensive

CONS

- Messy and Poor Flowing
- Slow Knockdown and Low Fuel Tolerance
- High Concentrations 3% and 6%

- 3% or 6% concentration ratios.
- Effective on hydrocarbon fires, but ineffective on polar solvent (alcohol).
- Typical usable temp. is 20 degrees F. up to 120 degrees F. Cold protected foams will go as low as -20 degrees F.
- Protein foams will produce a homogenous, stable foam blanket that has excellent burn-back resistance.
- Protein foams have low knockdown, but relatively inexpensive post fire security.
- May be used with either fresh or saltwater.
- Mechanical aspiration is mandatory for application.

Syndet, High Expansion Foam

PROS

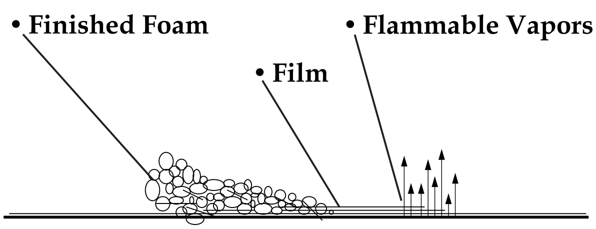
- **Good Wetting Capability**
- **Excellent Bubble Producer for Filling Cavities**

CONS

- **Low Tactical Stability**
- **High Concentration Ratio 3% and 6%**

- These foams are composed of synthetic foaming agents and additional stabilizers.
- High expansion is designed to produce a stable foam blanket and is resistant to flammable product pickup.
- Some drawbacks include its high expansion ratio and light weight. In unconfined spaces, wind renders it useless.
- It is ideally suited for compartment-type fires and areas of concern for firefighter safety, i.e. mine shafts, shipboard fires, and, as taught many years ago, for basement fires in structural attack.
- Avoid the use of this type of application if there is any consideration the source of the fire may be an electrical problem. The foam is still 94% to 97% water.
- Some Hazmat foams fall into this category.

Film Forming Process



- As a finished foam covers and works to smother the fire, the unique film-forming ability works to provide a thin layer of solution that prevents vaporization of the flammable liquid.
- The surfactants and films are stored in the shell of the bubble. When the bubble breaks, the solution drains out to become this layer.
- An increase in 1/4 drain time means a slowing of the amount of solution draining out of the finished bubble blanket.
- The finished foam also works to exclude air from the flammable vapors, separate the flames from the fuel surface, and cool the fuel surface and surrounding metal surfaces.

Aqueous Film Forming Foam (AFFF)

PROS

- **Low Surface Tension (16 dynes cm/2)**
- **Rapidly Spreads Across Surface**
- **High Burn Back Resistance / Quick Knockdown**

CONS

- **High Concentration Ratio (3%, 6%)**
- **High Cost (Flourine)**
- **Does Not Biodegrade**

- A combination of fluorochemical surfactants and synthetic foaming agents create a unique characteristic, an aqueous film.
- The thin layer spreads rapidly across the surface blocking flammable vapors.
- Most effective on hydrocarbon fuels with higher surface tensions such as kerosene, diesel and jet fuels and less effective on fuels with lower surface tensions like hexane and gasolines.
- Concentration ratios of 1, 3, 6% are common and must be understood when mixing or using an eductor.
- 1% = 1 gal. + 99 gal. of water to make 100 gal. 1% solution.
- 3% = 3 gal. + 97 gal. of water to make 100 gal. 3% solution.
- 6% = 6 gal. + 94 gal. of water to make 100 gal. 6% solution.
- The reason for not training more often with department application equipment is usually cost, but the fact that it doesn't biodegrade is becoming more and more important as departments are legally being held responsible for the products they put on the ground.

Fluoroprotein Foams (FP, FFFP)

- **Fluoroprotein Foam (FP)**
  - **Fluorochemical Surfactants + Protein**
  - **Increased Concentrate Fluidity**
  - **Faster Knockdown**
- **Film Forming Fluoroprotein Foam (FFFP)**
  - **Fluoroprotein + Aqueous Film Forming**

- FP Fluoroprotein foams are a combination of protein foam and the addition of special fluorochemical surfactants to provide increased fluidity to the concentrate and increases the foam's ability to produce faster knockdowns and improved fuel tolerances.
- FFFP Film Forming Fluoroprotein foams have all of the properties of fluoroprotein and also provide the vapor suppression characteristics of an aqueous film.

Alcohol Resistant AFF Foams

- Extremely Versatile 3X3 % and 3X6 %
- Excellent Burn-back Resistance
- Fast Knockdown
- Excellent Fuel Tolerance on both Hydrocarbon and Alcohol Based Fires

- Alcohol Resistant Concentrates (ARC) and AFFF-AR all are terms for a foam that combines synthetic stabilizers, foaming agents, fluorochemicals, and alcohol resistant membrane forming additives.
- Since polar solvents and alcohols are destructive to non-alcohol resistant foams, an ARC foam must be used for vapor suppression and extinguishment. The alcohol aggressively mixes with the water in the foam bubble, destroying it.
- Typically, these foams will have a dual percent rate, i.e. 3X3% or 3X6%. The lower ratio is used on a standard hydrocarbon based fire and the higher ratio is used for the alcohol based fire.
- The film formed when alcohol is present is a tough polymeric membrane, occasionally called mucouloid, which separates the alcohol from the foam blanket.
- The higher the alcoholic level of the fuel the better the creation of the membrane.
- When a polar solvent foam is used, and the polymeric membrane has been created for suppression, care must be taken to not disturb the foam blanket in any way. This type of foam, unlike most AFFF concentrates, does not heal itself when disturbed. If the foam blanket is somehow broken, a reapplication will be necessary.

Fuel and Heat Tolerance of Finished Foams

Fuel Tolerance

The ability of the finished foam bubble to shed the fuel it is applied to.

Heat Tolerance

The ability of the finished foam bubble to withstand radiant and direct flame impingement without degradation.

When a foam blanket is applied to a fuel spill, either burning or as a vapor suppression operation, fuel tolerance is a big concern. It is the foam blanket's job to prevent vaporization. Foams that have very low fuel tolerance will pick up the fuel and carry it on the outer shell of the bubble structure. This will allow for little or no vapor or fire suppression.

When the finished foam is plunged into the fuel, its ability to drop off or shed the fuel as it rises to the surface is a key factor in the suppression effort. This is how sub-surface injection systems work. Expanded foam is injected under pressure into the bottom of a storage tank, rises to the surface, and covers the top providing suppression. The choice of foams is based on fuel tolerance of the

Another term that is used is HEAT TOLERANCE. This refers to a finished foam’s ability to resist and not degrade when placed in contact with either direct flame impingement or radiant heat. The finished foam blanket must be of a slow draining nature to hold up to high temperatures. The more rigid and stable the finished foam blanket, the better its heat resistance. This is important for all foams. Flammable liquids spills and fires being attacked with Class B foams, and pretreatment of exposures with Class A foams both need the blanket for resistance to the high radiant heat or direct flame impingement.

Class B Flammable Liquids

- **Hydrocarbon Fire**
  - **0.1 GPM of Foam Solution Per Square Foot of Burning Liquid for a Minimum of 15 Minutes**
- **Polar Solvent Fire (Alcohol Base)**
  - **0.2 GPM of Foam Solution Per Square Foot of Burning Liquid for a Minimum of 15 Minutes**

These rates come from NFPA 11 for spill fires of shallow depth. More application rate will reduce suppression time, but too little application rate and the potential for the fire not to go out is possible.

Remember, your limits of application rate (i.e. a 95 gpm eductor will limit your application to only 95 gpm of solution).

Hydrocarbon fires require 0.1gpm per sq ft of burning liquid for a minimum of 15 minutes.

EXAMPLE 2000 square feet of gasoline
.1 x 2000 sq. ft. = 200 gpm of solution (not expanded foam)
.03 x 200 gpm = 6 gallons of 3% foam concentrate per minute
6 gal. x 15 minutes = 90 gallons of 3% concentrate to control, extinguish, and initially secure 2000 sq. ft. of hydrocarbons burning.

Polar Solvent fires require 0.2 gpm per sq ft of burning liquid for a minimum of 15 minutes.

EXAMPLE 1000 square feet of alcohol based fire
.2 x 1000 sq. ft. = 200 gpm of solution (not expanded foam)
.06 x 200 gpm = 12 gallons of 6% foam concentrate per minute
12 gal. x 15 minutes = 180 gallons of 6% concentrate to control, extinguish, and initially secure 1000 sq. ft. of polar solvents burning.

Gasoline Additives May Change Intial Attack Procedures

- ✓ **M.T.B.E. (methyl tertiary butyl ether) added to Allow Fuels to Burn Cleaner**
- **Future Use of Methyl Tertiary Amyl Ether, Ethyl Tertiary Butyl Ether, and Di-isopropyl Ether Will Present Special Dangers**

MTBE and other Additives

The U.S. EPA in its attempt at helping to provide cleaner burning fuels throughout the United Sates has mandated the use of alcohol based additives to make the fuel burn cleaner and reach even stricter emission standards.

MTBE or methyl tertiary butyl ether, in the past a by-product of the fuel processing industry, is now present in fuels in levels above 15% of total volume. The challenge to the fire service surfaces as these chemicals are more understood. They are polar solvents, and as such must be treated in a different way. As we have learned in the past, foams must be designed to work on alcohol. Because of its tremendous affinity for water, alcohol tends to destroy the foam

The level of MTBE in a fuel may require the initial attack strategy to deal with vapor suppression or mitigation of a fire as a polar solvent. This is done when using the higher % number on the dual purpose foam concentrates. Typically, we have used universal 3/6% foams, and now more 3/3% foams are available.

Unlike traditional AFFF applications, putting a finished foam down on this type of fire requires a higher level of aeration. For fire fighting efforts normally a 7 to 10 : 1 expansion ratio is necessary and for vapor suppression a 10 to 30 : 1 ratio is preferred. This higher expansion will provide a greater level of post fire security.

Pre-planning for this type of fire is necessary. A survey of local distributors and terminals within your jurisdiction will provide additional information on the extent of these additives in use in your area of response.

Hazardous Material Foams

A specialty Foam or Stabilizer used to deal specifically with fuming chemicals in a vapor suppression operation.

HAZMAT foams are designed to deal with those chemicals that produce fuming vapors. These foams are not designed in any way to neutralize the chemical, but to provide an immediate suppression of the potential hazardous vapors being given off by the spill. They aren't designed for fire suppression and many times will degrade other finished foams.

A finished foam blanket on fuming chemicals will not only suppress vapors being given off, but protect the chemical from the outside atmospheric changes as well.

To be effective HAZMAT foams need to be well expanded. Typically, 30:1 + expansion ratios with extended quarter drain times work the best for these operations. Since no real standards exist for these types of foams, your local supplier of concentrates would be your best resource for information on their use.

Foam Stabilizers are additives used to make an existing blanket much more resistant to some chemicals. Normally, the stabilizer is added to the finished foam blanket with special equipment. The finished product exhibits a rubbery plastic type coating that protects the foam from degradation.

Again, consult the manufacturer in the use of these additives.

Syndet, Class A Foam

PROS

- **Excellent at Reducing Surface Tension**
- **Low Concentrate Mix Ratio 0.1 to 1%**
- **Tremendous Bubble Producer**
- **Biodegrades Quickly**

CONS

- **Detergent Base Will Attack Lubricants**

- Class A foam does some things very well. Reduction of the surface tension of water has a tremendous effect on the ability of water to soak into deep-seated Class A fuels.
- Class A foam will increase the effectiveness of water. In certain instances from three to five times more.
- It will extend the useful life of water as it resists quick evaporation in a hot environment.
- Will provide a short term fire barrier.
- This foam will operate effectively on all Class A fuels.
- Easy to use and mix, the foam is visible upon application.

Some drawbacks involved include:

- Eye and skin irritation
- Corrosion on some metals and may speed up deterioration of some gasket materials.
- High concentrations (outside the envelope of testing) can be environmentally harmful.
- Reduced life expectancy of leather goods and possible increase in pump lubrication requirements.

Foam Mix Ratios

- **Class B Foam Concentrates**

1% = 1 Gallon Concentrate + 99 Gallons Water

3% = 3 Gallons Concentrate + 97 Gallons Water

6% = 6 Gallons Concentrate + 94 Gallons Water

- **Class A Foam Concentrates**

0.1% = 1 Gallon Concentrate + 999 Gallons Water Up To

1% = 1 Gallon Concentrate + 99 Gallons Water

Mix Ratios for Flammable Liquid Foams (Class B)

Protein Foams - 3% or 6% listings for Underwriters Laboratories, U. S. Coast Guard, Factory Mutual, and the New York Board of Standards

Fluoroprotein Foams - 3% or 6% listings for Underwriters Laboratories, U.S. Coast Guard, Factory Mutual, FAA, and New York Board of Standards

Standard AFFF - 1%, 3% or 6% listings for Underwriters Laboratories (1%, 3% & 6%), Factory Mutual (3% & 6%), N.Y. Board of Standards (6%)

Universal AFFF - 3% by 3% and 3% by 6% listings

Mix Ratios for Class A Foam Concentrates - Mix Ratios on Class A foam can vary greatly on the type of application, outside weather and temperature conditions, and necessary longevity of the foam blanket. The use of High Energy Delivery Systems will require a lower concentration to make a quality foam blanket.

Typical Application Rates:

0.1% up to 0.3% will provide a wet foam through low expansion nozzles, moderately wet foam through a medium expansion nozzle, and dry foam through a High Energy Delivery System.

0.3% up to 0.6% will provide a much dryer foam through low and medium expansion nozzles, and extremely dry foam with High Energy Systems.

0.6% up to 1% will offer only minimally more foam quantity, but will provide more surfactant in the bubble shell for a longer lasting foam blanket in low and medium expansion nozzles.

Important Foam Properties

Performance

- **Surface Tension**
- **Expansion Ratio**
- **Drain Time**
- **Foam Viscosity**

Handling

- **Concentrate Viscosity**
- **Toxicity & Biodegradability**

Foam Performance issues

Surface Tension is the elastic force of a liquid which tends to minimize the surface area thus causing droplets to form. The demonstrated high surface tension of water is a hindrance in firefighting.

Expansion Ratio is the ratio of the volume of finished foam to the original volume of non-aspirated solution. The Quantity of bubbles.

Drain Time is the rate at which the foam solution is released from the bubble structure of a finished foam. The Quality of bubbles.

Finished Foam Viscosity is the fluidity of foam. An indication of foam's ability to cling and stick to a surface. This attribute is important in pre-treatment and exposure protection.

Handling Characteristics

The concentrate viscosity is important especially during cold weather when foam concentrate can become too thick to proportion properly.

Toxicity is measured on plant, fish and animals to ensure a safe usable product that can be applied in the environment and can come into contact with users without the need for special equipment.

Biodegradation has become more of an issue than ever before with the renewed environmental interests. A fire department is responsible for the products it puts on the ground.

Surface Tension

- **The Elastic-like Force at the Surface of a Liquid which Tends to Minimize the Surface Area.**
- **Indicates the Ability to Penetrate and Spread Regardless of Drain Time and Expansion Ratio.**

Water, long used in fire suppression due to its readily available nature, inherently has "high surface tension" characteristics that hinder its ability to soak and penetrate into deep-seated Class A combustibles.

A Surface Active Agent, when added to the water, will reduce the surface tension to a level that will allow faster penetration.

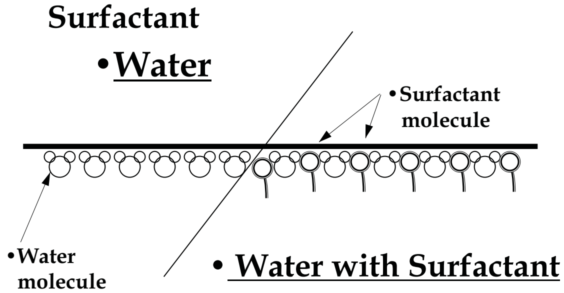
Typical surface tension of water (measured in dynes) is about 70 dynes per centimeter. When just 0.1% of Class A foam (surfactant) is added, it will reduce the tension to as little as 30 dynes. A dyne is the amount of force required to move one gram of weight the distance of one centimeter. This measurement is calculated using a tensiometer. (A sphere has the least amount of surface area.)

The reduced surface tension will allow water to spread and form a film which will coat and cling to hot fuels and convert to steam more quickly.

Smaller water droplets will also convert to steam more quickly than larger drops = Faster Absorption of BTUs.

Reduction of Surface Tension = Reduction of Rekindles.

Water & Water with Surfactant



Hydrocarbon surfactant molecules tend to be water shedding and oil loving.

Oil loving allows it to be good at spreading and excellent at wetting.

Fluorocarbon surfactant molecules tend to be water shedding and oil indifferent.

Oil shedding allows it to be excellent at spreading, but poor at wetting.

Other names include "wet" water, "slippery" water, but it will always have the same extinguishing characteristics as plain water.

High specific latent heat of vaporization of water will not be affected by the addition of surfactants.

Decrease in the surface tension of water increases the amount of free surface of water available for absorption of heat.

Expansion Ratio

Volume of Finished Foam
-------divided by-------- = Expansion Ratio
Volume of Foam Solution

- LOW 1:1 up to 20:1
- MEDIUM 20:1 up to 200:1
- HIGH above 200:1

Since it takes energy to produce a finished foam, it follows that, the more energy used to aspirate foam solution, the higher the volume of finished foam.

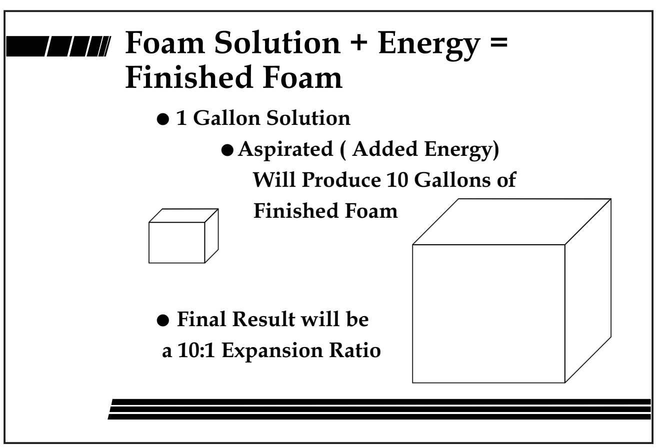
A law of Mother Nature dictates that in Low Energy Delivery Systems (nozzle aspirated), you can have reach or expansion. The same energy that is taken from the velocity of the fire stream for reach is also used to draw air into the stream and produce expanded foam.

NFPA 11 calls out the ranges of specific equipment.

Low expansion, up to 20:1, commonly will refer to common combination nozzles. Most typical selectable or automatic nozzles will do 5 or 6 to 1 expansion.

Medium expansion, up to 200:1, can be produced with the use of larger aspirating tubes or attachments to nozzles. Increased expansion, but reduced reach.

High expansion, over 200:1, is only produced with fan-type attachments and netting. The resulting foam is very light and has little reach. These foams, created from Hi X foam concentrates, will fill large cavities with highly expanded foam.



Expansion ratios and applications

Foam Solution - no bubble structure, wet water, immediately runs off a vertical surface. Used for immediate penetration into dry fuels, on deep-seated fires, and mop up. Conventional nozzles, with limited expansion. (1:1 to 3:1 expansion)

Wet Foam - watery foam, runny on vertical surfaces, fast draining, no “body”, great variations in bubble size. Direct initial attack on fine fuels, deep-seated fires, mop up. Low expansion nozzles, CAFS with “stripping” nozzle. (3:1 to 5:1 expansion)

Fluid Foam - watery shaving cream consistency, flows over vertical surface, medium to small consistency bubble size, medium to fast drain rate. Exposure protections, wet line, (less than 30 minutes). CAFS and low expansion nozzles. (6:1 up to 10:1 expansion)

Dry Foam - shaving cream and medium to small bubble structure. Clings readily to vertical surfaces, makes foam barriers for exposure and wet lines that will hold over 30 minutes. Mostly air, slow drain time, CAFS and low expansion nozzles. (over 10:1 expansion ratios)

Drain Time

Indicates Foam's

- **Durability**
- **Longevity**
- **Rate of Solution Release from the Bubble Structure**

The QUALITY of the foam blanket.

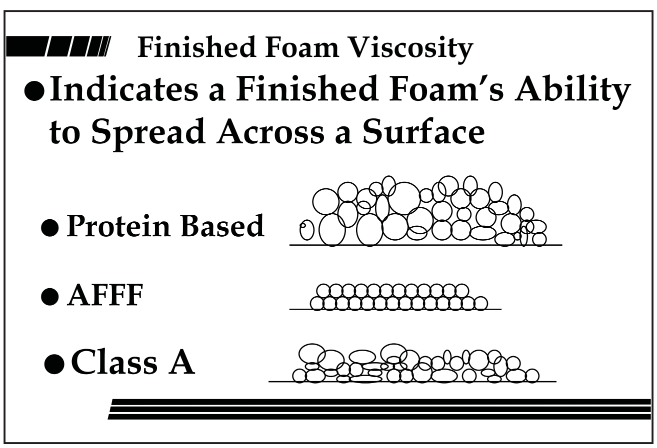
Measured in 1/4 drain time typically with foams for flammable liquids. The amount time it takes for 25% of the solution to drain out of the finished foam blanket. EXAMPLE: A finished foam has a 3 minute 1/4 drain time. If that is accurate, for safety purposes, when a foam blanket is drained down by 50%, a reapplication will be necessary. Therefore, within 6 minutes, for maximum vapor suppression, there should be an additional application.

Drain time with Class A foams shows the stability of the foam blanket. The rate that the solution drains down and soaks into the Class A fuels upon which it was applied. Cold water tends to decrease the drain time, and salt water will increase drain time.

Foams with high drain times release their water slowly, making them best suited for exposure protection and pretreatment of structures.

Foams with faster drain times are ideally suited for initial attack and applications requiring quick soaking of the fuels. A good example is a large hay bale. The use of a slow draining foam isn't tactically the best choice for fast suppression, and inversely a wet, fast draining foam isn't best suited for exposure protection.

Be aware of a dried foam blanket that leaves only a foam skeleton. It gives the appearance of a foam blanket, but the water has long since drained from the bubbles leaving only a skeleton. Reapply as needed.



Viscosity is foam's inherent property to coat and cling to the surface upon which it is applied.

Especially important to Class A foam applications, the foam viscosity is key to the quality of sticking to vertical surfaces.

Viscosity also describes the ability to surround fuels when only applied to one side. The foam will move around and cover areas that cannot be reached from the applicator's angle.

Viscosity is the FLUIDITY OF THE FOAM. More viscous / less fluid, less viscous / more fluid.

Foam Specifications

- AFFF, ARC, PROTEINS, SYNDET
  - Underwriters Laboratories
  - Mil. Specs. & FAA
- CLASS A FOAM CONCENTRATE
  - USDA-USFS Missoula, MT, Fire Sciences Lab
  - NFPA Standard 298

Standards for performance, storage, compatibility and others are listed in UL and Canadian UL specifications.

AFFF, ARC, and newer proteins have good storage characteristics, good compatibility among their groups and meet or exceed very specific performance criteria on test fires.

Military specifications demand very rigid performance as does the FAA for airports of a certain size that require suppression equipment.

Class A foams in the U.S. rely on the testing done in Missoula, MT, USFS/USDA Labs, and the standards currently presented in NFPA 298.

Key Items tested for by the USDA:

- Corrosion...Minimum criteria
- Viscosity and Solubility
- Density of Finished Foam / Specific Gravity
- Biodegradation
- Flash Point of Concentrate
- Surface Tension
- Storage Capabilities
- Toxicity

Foam Test / Corrosion

Approval Will Mean Acceptable Corrosion on :

- Aluminum
- Mild Steel
- Yellow Brass
- Copper
- For Aircraft, Tests are also Conducted on Magnesium

Corrosion with Class A foam concentrate is greatly reduced from what AFFF would be, but when routinely tank mixed, some corrosion can be seen on susceptible metals.

Typically, corrosion is not nearly the issue, as the cleaning and rinsing that goes on with repeated tank mixing is. The slight amount of foam concentrate in the water acts as a detergent removing tank scale left by the last tank load of water. Over a period of time this process can lead to tank leakage.

Current approvals can be checked with the Labs in Missoula. The labs test the physical properties, storage etc. over an extensive 18 month trial. Actual foaming performance is not measured currently.

Stainless and polypropylene tanks seem to offer the best in foam concentrate storage.

NFPA 1906 standard also specifies that any foam concentrate tank must be protected from the outside atmosphere with a pressure/vacuum vent. This protection will prevent the

Foam Tests / Toxicity

HEALTH AND SAFETY

- **Acute Oral and Acute Dermal Limits**
- **Primary Dermal and Eye Irritation Limits**
- **Acute Inhalation Tests**

ENVIRONMENTAL SAFETY

- **Aquatic Toxicity**
- **Plant Toxicity**

Acute Oral LD50 >500 mg/kg

Acute Dermal LD50 >2000 mg/kg

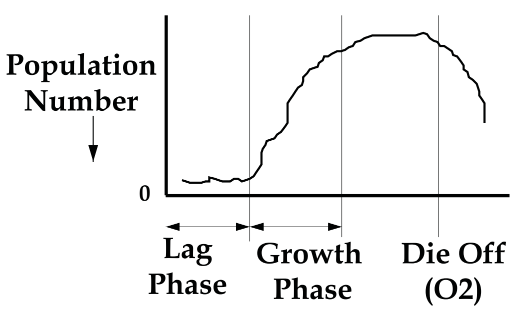
Primary Dermal Irritation Mildly Irritating

Primary Eye Irritation Score <5.0

Acute Inhalation LC50 >2.0

Aquatic Toxicity: Rainbow Trout, Fathead Minnows, Daphnia magna, and Algae are all tested and must provide acceptable results for USDA/USFS approval.

Foam Tests / Biodegradation



USFS/USDA Missoula Lab tests require a minimum 50% ultimate biodegradation within 28 days.

This degradation is necessary since a huge volume of these foam agents are dispersed into the environment, and into some environmentally sensitive areas, via aircraft, helicopter and ground applications each fire season.

This ultimate environmental safety is only certified on federally approved Class A foam concentrates.

AFFF and ARC foams do not biodegrade and are considered and classified as non-biodegradable waste and when applied on the ground, must be cleaned up by a licensed disposal company. Not a great idea for training.

A fire department is liable for the foams it puts on the ground. Training can only be safely done with an approved Class A foam.

The reason this has not been a big issue in the past is due partly because when a department is called to apply foam, there usually is a bigger problem to be cleaned up.

A sample of responses of typical fire departments: Source NFPA.

Only 5% of all fire related responses involve some sort of flammable liquid.

Of this 5%, only 5% of these require the involvement of suppression activities on a live fire. Most foam applications are for vapor suppression to prevent an ignition of the vapors.

95% of fire related calls involve Class A combustibles in some form. This group is a potential target for Class A foam applications. This volume of use absolutely dictates an environmentally approved concentrate

Storage of Foam Concentrates

- Follow Manufacturer's Recommended Instructions for Storage
- Use USDA Approved Class A and UL/FM Approved Class B Foams
- Avoid Extreme Temperature Conditions
- Keep Concentrates in Original Containers

Storage of Foam Concentrates

All federally approved Class A concentrates are evaluated on ability to maintain performance characteristics over time. Production of foam is evaluated after 12 months of storage as it compares to foam production of original fresh concentrate.

General storage for both Class A and B concentrates suggests avoiding below freezing or above 100 degrees F storage. Immediate use of concentrates that have been stored in cold (below 45 degrees F) conditions, may have an effect on eduction, injection, or mixing of these concentrates with water. Eductors and some injection equipment are sensitive to the viscosity of cold concentrates.

Storage of concentrates in their original containers is suggested. When concentrates are placed in on-board storage tanks, the use of polyethylene, polypropylene, fiberglass storage tanks are suggested. Storage in mild steel, aluminum, and even 304L and 316L stainless steel tanks may cause product degradation.

Foam solutions should not be stored any longer than necessary in any container. Water impurities and temperature will tend to speed the biodegradation process. Batch mixing should take place as close to the time of application as possible and complete flushing of equipment should be completed as soon as possible afterwards.

All on-board foam concentrate storage tanks should be protected from the outside atmosphere by a pressure/vacuum valve. This protection will prevent the volatile active ingredients from vaporizing

Personal Safety with Foams

- Follow ALL Manufacturer's Recommendations When Working with Concentrates
- Keep a Current MSDS Sheet of All Products Being Mixed
- Use Required Personal Protective Equipment
- Follow Stated Hygienic Precautions

Personal Safety Considerations When Working with Concentrates:

Beware of any written evidence of health effects of inhalation or contact of the concentrates.

Involvement in mixing, handling, or application of foam agents must require the use of necessary protective equipment. Skin, eye, and inhalation protection will be stated in MSDS sheets. Personnel should be aware of and practice the procedures stated in the manufacturer's operational procedures.

Failure to follow the stated protection and application requirements may lead to unnecessary health risks.

* Goggles, waterproof gloves, disposable coveralls, and rubber boots are required items.
* Soaked clothing should be properly disposed of.
* Eyewash equipment should be available for splash protection.
* Skin contact should be flushed immediately.
* Respirators should be used as recommended in confined spaces.
* Ingestion of concentrate or solution may be harmful and should be avoided.
* Spills can be slippery and should be cleaned up quickly to avoid falls.
* Avoid flushing spills. Use an absorbent and dispose of properly.
* Report any spills or contact immediately to a supervisor.

Environmental Safety with Foams

- Class A Foams Designed to Biodegrade within Window of Testing
- Protein Foams Biodegrade within Reasonable Time
- Film Forming Foams Do Not Biodegrade Well

Class A foam concentrates, though tested and approved, have a window of testing. This means that from 0.1% up to 1% it is tested and approved to be within the established biodegradation requirements.

Class B foam concentrates that form films (Flourine) do not biodegrade well and must be considered as a hazardous material when spilled and cleaned up with care following recommendations of the manufacturer.

Considerations when using concentrates:

* Inform personnel of potential problems when concentrates get into waterways.
* Locate foam mixing areas well away from watershed area.
* Exercise care during mix procedures to avoid spills.
* Avoid applications that will put solution into surrounding waterways and watersheds.
* Notify a supervisor should any spill occur.
* Make safe handling a part of training with foam applications.
* Flushing of equipment after use should be done with care to avoid further contamination of the fireground area.
* Build a good working relationship with local environmental authorities. (DEM, DNR, EPA)

Foam Solution Accuracy Testing

NFPA Standard #11

- Refractive Index and Refractometer

Other Methods in Use Today

- For AFFF a Test of Total Flourine Content
- For Class A Foams Conductivity of TSD (Total Dissolved Solids)

Abstract from "Fire Technology" February 1990 authors G. Timms and P. Haggar

"Three types of foam concentration measurement techniques are examined: total fluorine content, optical absorption, and specific conductivity. Specific conductivity was found to be the most useful for field measurements and was therefore compared with the traditional refractive index approach. It was found that electrical conductance provides a more accurate method of estimating the concentration of AFFF solution than does the refractive index technique described in NFPA 11."

Refractive index uses a subjective visual meter and a fixed solution to determine accuracy. Total fluorine content is used specifically for foams that have a fluorine content i.e. AFFF.

Most tests are arranged to use the water at the test location and the foam concentrate to be tested in the temperature to be used. To take any accurate measurements, no matter which test is used, all of these considerations must be looked at.

Current trends indicate, for field tests, that the testing of conductivity of a solution, or the value of total dissolved solids, has the simplest temperature compensating meters available.

Making a Foam Solution:
(Water + Concentrate = Solution)

- **Batch Mixing (Tank Mix)**
- **Suction Side Regulator**
- **In-Line (Eductor)**
- **Around the Pump Proportioning**
- **Discharge-Side Foam Injection**

There are many ways of creating a foam solution, or the addition of foam concentrate into the water stream.

The choice of the proportioning method will have to be determined by the local agency after determining and accessing the use of foams within their department's tactical procedures.

Manual Regulation
- Batch Mixing
- Suction Side Proportioner
- In-line Proportioners and Eductors
- Around the Pump Proportioning Systems

Automatic Regulation
- Discharge Side Foam Injection Systems
- Balanced Pressure Bladder Tank
- Balanced Pressure Pump
- Electronically Controlled Direct Injection
    * Flow Sensing
    * Conductivity Sensing

Each version does expose equipment to foam concentrate and solution. Good maintenance procedures need to be followed by flushing and lubricating critical parts.

Batch Mixing

Advantages
- **Unlimited Hose Lengths**
- **Unlimited Choice of Hose Lines**
- **Minimal Investment**

Disadvantages
- **Tank and Pump Corrosion**
- **Bubble Generation in Tank**
- **Removes Lubricants**

Advantages of Batch Mixing:
- Premix will maintain the desired ratio over the length of the mix.
- The use of unlimited hoseline lengths and choices of attack lines.
- Not flow or pressure sensitive and relatively inexpensive.
- No moving parts or additional equipment needed.

Disadvantages of Batch Mixing:
- Corrosion problems in pump, tank, and plumbing.
- Possible pump cavitation and level sensor error.
- Refilling of water tank will cause a mess of bubbles from tank fill.
- Foam solution will degrade over time and contaminates other water supplies.
- Excessive concentrate may be used and cleaning is required after every use.

Suction Side Regulator

Advantages

- **Unlimited Hose Lengths**
- **Unlimited Choice of Hose Lines**
- **Adjustable Mix Ratios**

Disadvantages

- **Tank, Pump and Plumbing Corrosion**
- **Dependent on Pump Vacuum**
- **Concentrate Viscosity Sensitive**

Advantages of a Suction Side Regulator:

•The use of unlimited hoseline lengths and choices of attack lines.

•No loss in water pressure or flow and no moving parts.

•Adjustable mix ratios and minimal cost of equipment.

Disadvantages of a Suction Side Regulator:

•Only a single flow and single mix ratio may be used and changes in flow or ratio require operator adjustments.

•Contamination of pump water supply and waste of foam concentrate as water is bypassed during standby operations.

•Corrosion problems in pump, tank and plumbing.

•Pump priming and cavitation problems.

•Removal of lubricants throughout the pumping systems. Concentrate viscosity sensitive and reliant on vacuum created on the suction side of the pump.

In-Line Proportioning (Eductors)

Advantages

- **No Moving Parts**
- **Common to Most Structural Engines**
- **Capable of 1%, 3%, 6% Mix Ratios**

Disadvantages

- **Limited Hoselays and Elevation Losses**
- **High Inlet Pressures (200psi)**
- **Matching of Nozzle to Specific Flows**

Advantages of Eductors:

•Most structural engines that have AFFF or protein foams on board typically carry either an eductor as loose equipment or it is plumbed into the trucks pumping system. These units can also be modified to work with the lower injection rate of Class A foam agents.

•Eductors, being fixed orifice type units, are relatively simple in design, though restrictive in operation.

Disadvantages of Eductors:

•Limited hose lay lengths (typically 150 to 200 feet) restrict operational flexibility.

•High inlet pressures. Most current models require nearly 200 psi inlet pressure. There are some forestry and European versions that require less.

•Limited flexibility in percentage choices.

•When selectable gallonage nozzles are used, nozzle flow must be matched to the flow of the eductor, typically 60gpm, 95gpm, or 125gpm, and 240gpm with 2 1/2” hose. When automatic nozzles are used, providing a fully opened valve will allow the flow to match the eductor.

•Nozzle must always be used in a full open position to be effective.

Rule of Thumb = *For Hydrocarbon based fuel fires, use a factor of 10 for the coverage rate (a 95 gpm eductor can cover about 950 sq ft). For alcohol based fires, the number is 1/2 that, or a factor of 5 (a 95 gpm eductor will cover 475 sq ft).*

In-Line Proportioning (Pump)

Advantages

- Discharge Side Injection
- No Loss of Pressure or Flow

Disadvantages

- Single Flow / Single Mix Ratio
- Electronic Flow Meter Components
- Concentrate Viscosity Sensitive

Advantages of an In-Line Pump Proportioner:

•It will keep all foam concentrate away from the pump and tank.

•There is minimal or no loss of pressure or flow.

Disadvantages of an In-Line Pump Proportioner:

•Single set flow rate and single set mix ratio allow for no flexibility in initial attack. To change either, the system must be shut down and recalibrated.

•Systems use electronic flow sensing equipment to drive an electric motor and positive displacement pump.

•System is very sensitive to corrosion and viscosity of foam concentrates.

Around the Pump Proportioners

Advantages

- Unlimited Hose Lengths
- Easily Adjusted Mix Ratios
- No Moving Parts

Disadvantages

- Tank, Pump and Plumbing Corrosion
- Removes Lubricants
- Excessive Foam Concentrate Use

Advantages of Around the Pump Proportioning:

•Unlimited use of hose lengths and choices is possible.

•There are no moving parts and mix ratios are easily adjusted.

Disadvantages of Around the Pump Proportioning:

•Corrosion problems in the tank, pump and truck plumbing.

•Possible pump cavitation, refill problems, and tank level indicator errors.

•Excessive concentrate is used and will require thorough flushing.

•Removal of lubricants throughout the system.

Discharge Side Foam Injection

- Automatically Injects Concentrate on the Discharge Side of the Pump
- Engine Pressures, Hose Choice, Length, or Nozzle Choice Have No Effect on Injection
- Automatically Adjusts for Changes in Flows
- Minimal Losses in Pressure and Flow
- Automatic Mix Ratios from 0.1% to 1%

Advantages of Discharge Side Injection Systems

•These systems will maintain the desired mix ratio over a wide variety of pressures and flows.

•Unlimited use of hose lengths and choices is possible.

•They will keep all concentrate away from pump and water tank.

•Multiple hose lines, nozzles, and applicators may be used simultaneously.

•Simple pump operator procedures to use.

Disadvantages of Discharge Foam Injection Systems

•Requires an outside power source (water, electrical, hydraulic or four cycle engine) to drive concentrate injection.

•Requires an investment and installation for truck mounted units.

Types of injection systems (general)

Bladder Type - uses the pressure of the water in the hoseline to surround and squeeze a bladder with foam concentrate through a metering valve into a low pressure area created by a differential valve.

Direct Injection - Flow Meter based - Uses an electronic flow meter and receiving device to direct a concentrate pump and motor to inject a metered amount of foam that corresponds to the flow.

Direct Injection - Venturi based - Uses a venturi to create a low pressure area that is sensed and mechanically transmitted to a pilot valve. More differential in the venturi, more foam will be injected proportionally.

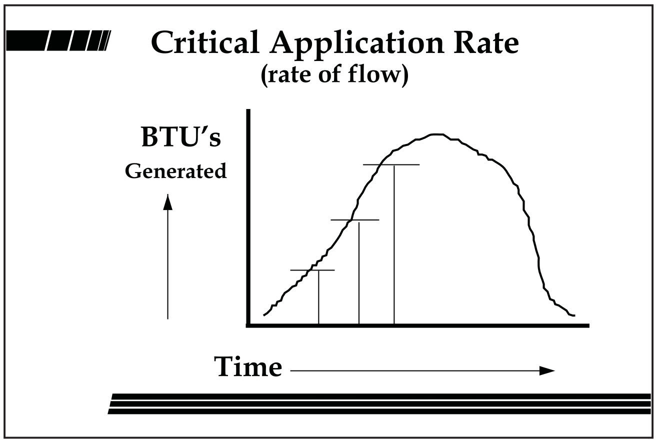
Tactical Considerations with Foams

- Critical Application Rates
- Low Energy Delivery Systems
  Conventional or Aspirating Nozzles
- High Energy Delivery Systems (CAPS)

Critical Application Rate or Rate of Flow is all important to those involved in initial attack operations. It is this set of formulas, some created long ago, that determine success of suppression activities.

Low Energy Foam Delivery Systems include the use of conventional fog and straight stream nozzles to apply product. Typical nozzles will provide a certain level of application and aspirating nozzles another.

High Energy Delivery Systems cover systems that will use an additional source of energy, typically a compressor, or compressed air tank to provide an additional source of energy for delivery.



The basic importance of the critical application rate or basic rate of flow cannot be overlooked on any initial fire attack. Listed below are a couple of the more commonly accepted rules of thumb for figuring these rates.

The Old Iowa Formula:

$$\frac{\text{Length of area x Width of area x Height}}{100}$$

equals GPM FLOW

Rule of thumb...the length x width x height of the room divided by 100 would give the necessary rate of flow for initial attack. Within thirty to sixty seconds of this application, the fire should darken down.

Another commonly accepted formula states that application rate needs to be three to four gallons per minute rate for each 100 cubic feet of involvement. A room 10x10x8 would be 800cu.ft. divided by 100 x three to four gpm flow...24 to 32 gpm rate of flow.

NFPA provides Standard 1231 which also helps determine critical application rates needed for structures and also takes into account exposures, building classification, and construction.

National Fire Academy, Factory Mutual, and Underwriters Laboratories have all done lengthy studies on critical application rates for fixed systems and initial attack in compartment fires.

Foam enhancement of the water has no effect on critical application rate!

Fire Flow Formulas

- ISO Formula - for Insurance Purposes
- Iowa Formula - for Compartment Fires
- NFA Formula - for Daily Structural Suppression Operations

The ISO formula for insurance rating purposes gets quite complicated as it takes into account design density and the greatest available fire flows. Not practical for fire ground operations, it is ideal for the purposes for which it was designed, insurance rating.

The Iowa formula has been taught extensively for years as an easy size up tool for first arriving engine companies with fire showing.

L x W x H divided by 100 = Needed Fire Flow

The flow determined by this formula is ideal for a single compartment type fire. Exactly the scenarios Keith Royer and Chief Lloyd Layman worked with on shipboard firefighting activities. The NFA formula takes much more into account the actual fireground operational needs for critical application rates.

[(L x W) divided by 3 + Exposure Charge]
x % Involvement equals the needed for flow

This process led to the more easily used (LxW) divided by 3. As materials have changed in the construction of homes and fire loads have increased in commercial structures, the more realistic flows afforded by this formula have proven effective.

Latent Heat of Vaporization

- **Water is the Agent of Choice for Fire Suppression because of the High Amount of BTU's Absorbed**

From 60 degrees F. to Steam, One Pound of Water will Absorb 1,122 BTUs

- **The Use of Steam to Cool and Smother a Fire Can Be a Tactical Consideration**

One Cubic Foot of Water will turn to 1700 Cubic Feet of Steam (@ 212 degrees)

Technical Data Used When Working with Water as a Fire Suppression Agent

•One pound of ice needs 143 BTUs to convert water.

•One pound of water at 60 degrees F. will need 1,122 BTU's to convert to steam.

•In general..one gallon of water will absorb 8,000 BTUs.

•Heat of combustion generally states that one pound of Class A combustibles will generate 8,000 BTUs, and Class B flammable liquids will generate 16,000 BTUs per pound.

•One cubic foot of water (7.5 gal.) will convert to 1700 cubic feet of steam at 212 degrees (much more in higher fire compartment fires).

Factors Affecting Heat Transfer during Initial Attack

•Best maximization of transfer is accomplished with fog pattern.

•The more surface area exposed to the heat the better the transfer.

•Maximum transfer is affected by distance and velocity of the stream.

•Droplet size must be sufficient to provide reach, overcoming distance, air resistance, and convective actions.

The Use of Class A foam as an enhancement to the water has no affect on the heat of vaporization, but only on the ability to hold the water to the surface of the fuel and the ability to provide increased surface area for more complete vaporization.

Class A Foam Characteristic Rate

- **Solution - Clear milky fluid lacking any bubble structure (wet water)**
- **Wet - Watery, inconsistent bubble structure, lacking any body, very fast drain time**
- **Fluid - Watery shaving cream consistency, medium to small bubbles, moderate drain time**
- **Dry - Similar to shaving cream, medium to small bubbles, mostly air, slow drain time**

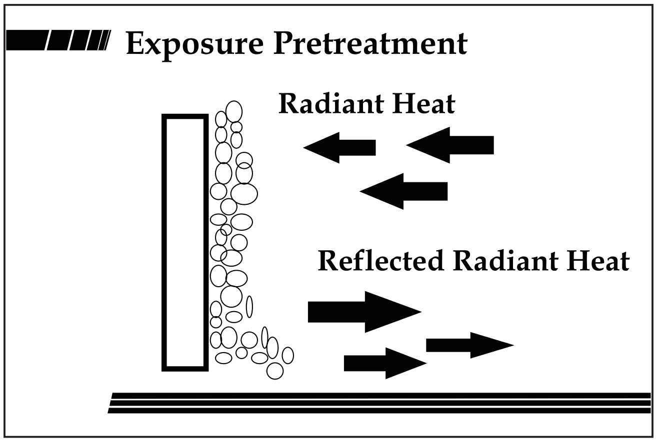
Tactical Uses of the Different Foam Characteristics (USFS/BLM Rating)

Solution: Typically, called wet water, foam solution has virtually no bubble structure and will work only as a soaking type application. The reduced surface tension of the solution is ideal for soaking applications (coal bunkers, peat bogs, saw dust piles, dumps, rag houses, hay bales, grain fires, cotton bales, structural overhaul).

Wet: A wet sloppy foam, this type application will have a minimal inconsistent bubble structure that tactically can be used the same way a solution is, but will provide a little smothering ability for short term applications. Quick drain times restrict the use of this type foam for exposure pretreatment.

Fluid: A wet shaving cream type consistency, this application is ideally suited for blanketing and smothering. With the moderate drain out time, limited success can be achieved in exposure pretreatment. Ideally, this type foam works well in hay bale attack, tire fires, and other attacks that will need water drain out for deep-seated suppression and some medium term smothering characteristics.

Dry: Shaving cream consistency allows this type foam to be used primarily for long term foam blanket application. Exposure protection, pretreatment, long term wet lines, and long term smothering can all be easily achieved. Because of the long drain out time of moisture in this



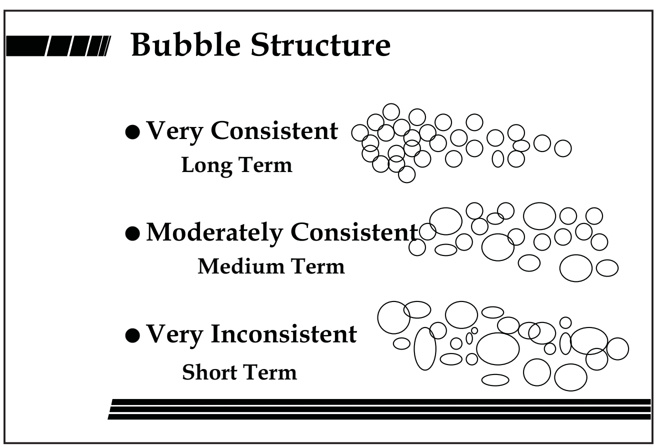
The use of finished foam as a tool for exposure protection and pretreatment has gained wide acceptance for three main reasons:

#1. Since finished foam is nothing more than water with some surfactants added, its ability to coat and cling allows water to hold and soak into the fuels to be protected. As long as the exposure is wet (water must boil off the exposure before the fuel can be preheated to ignition point), the chance to burn is limited. The reduced surface tension will hold and allow the water to completely soak into the fuel.

#2. Finished foam bubbles are one of the best insulators. Encapsulating air, foams will insulate the fuel from the radiant and convective forces of the fire, again preventing the fuel from preheating to the point of ignition.

#3. Because it is white in color, the foam blanket will also provide reflective protection from the radiant heat being generated. In some cases as much as 70% of the radiant heat may be reflected away from the fuels to be protected.

Tactically, the use of foam for this type of application relies heavily on the quality of the foam blanket generated. A wet sloppy foam will not have the success of a dry sticky foam. Though wetting will be achieved, the long term insulating and reflective capabilities will be diminished. Reapplication of a foam blanket under heavy fire or extreme weather conditions may need to be considered for the necessary long term exposure protection.

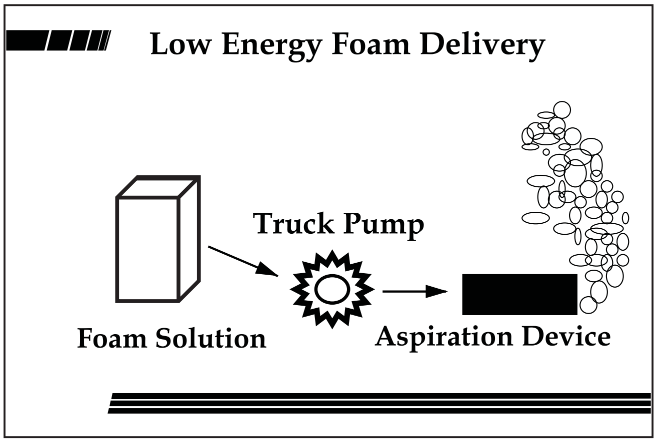


The Structure of bubbles in the finished foam blanket can best be tactically characterized in three categories:

Inconsistent bubble structure is typically produced with Low Energy Delivery Systems (i.e. regular fog nozzles and low expansion foam tubes, or a fog nozzle on a High Energy Delivery System). The bubble structure tends to break down quickly releasing either the film forming characteristics of an AFFF or the water in a Class A foam blanket into (or onto) the fuel beneath. Faster drain out time of this type of foam is ideally suited for deep-seated fires when quick soaking is needed. Initial attack and overhaul operations are well suited for this type of bubble structure with Class A foams. Fast draining foam is not desirable with AFFF due to the need to reapply the foam blanket for continued vapor suppression and security more often.

A **moderately consistent** bubble structure is normally produced with some low and, more often, medium expansion foam tubes. With Class A foams the longer drain down time of this type application makes it well suited for the construction of “wet” line, smothering foam for tire or railroad tie fires, and for short term exposure protection and pretreatment. The less consistent the structure, the faster the drainout rate. With Class B foams the necessity of a more consistent bubble structure is part of reapplication and long term vapor suppression. Different types of foam concentrates will produce differing structures even through the same application devices.

Highly consistent structures are best used for exposure pretreatment and any area where a “dry” long lasting, slow draining foam is needed. Typically produced with a High Energy Foam Delivery System, these structures aren’t well suited with the use of AFFF due to the extremely slow drain out of the solution. CAFS has produced this type of foam blanket using only an open butt ball valve. Any restrictions in a High Energy



Low Energy Foam Delivery Systems, or nozzle aspirated foam, take the energy from the horsepower of the truck engine, transferred through the fire pump, throughout the hose line to the end of the line at the nozzle.

The velocity of the fire stream (nearly 65 mph at 100 psi nozzle pressure) is nothing more than transferred energy that is being used up at the nozzle.

Expansion {- reach and expansion -} reach

Foam may be tank mixed, injected, or used with an eductor to create solution. The nozzle entrains the air to provide a finished foam.

Combination fog nozzles entrain enough air to produce approximately a 5 to 8 to 1 expansion ratio.

Attachments, the most common method, are the most versatile way of increasing expansion to provide greater volume. Many of these are capable of as much as 20 to 1 expansion, but with limited reach.

THREE TYPES OF FOAM APPLICATION TECHNIQUES

BOUNCE OFF TECHNIQUE - straight stream for reach

BANK IN TECHNIQUE - roll foam over the surface

RAIN DOWN TECHNIQUE - expansion down through thermal

Avoid PLUNGING of streams into the flammable liquid!!!

Conventional Combination Nozzles

Advantages

- **Standard Equipment Used on Initial Attack**
- **No Modification to S.O.Gs**

Disadvantages

- **Restricted to Solution or Wet Foam Performance Only**
- **May Require Higher Foam Ratio for Longevity**

Though 95% of initial attacks on structural fires use the first two lines off the engine, these limitations have not been greatly discussed. On initial interior attack, extensive foam creation is not necessary. The “wet” solution type of foam is ideal for the soaking and coating need of this type attack. Overhaul operations actually begin upon initial attack. The soaking ability immediately reduces the opportunity for rekindle.

Tactically, water savings in attacks are noted as personnel realize that if it’s “white” they don’t have to reapply to that area. The foam is there sticking and clinging and soaking into that fuel. Any reapplication to this area would be a waste. Now that there is a cost to the application agent, this needs to be taught. The “paint brush” effect of an interior attack has proven to be very productive. A 15 degree fog pattern provides the best coverage.

The drawbacks of a conventional nozzle tend to arise when the need to do exposure protection or pretreatment of a structure is necessary. Conventional nozzles just don’t aspirate the foam enough to provide a long lasting white blanket.

Piercing applicators, and specialty nozzles can be effectively used with Class A foaming agents to reach hard to get to areas (hay bales, cotton bales, rag houses, car fires, coal bunkers). Conventional Fog/Straight stream Nozzles are designed only to provide a limited amount of air

Low Expansion Aspirating Nozzles

Advantages

- **Will Provide "Wet" and "Fluid" Foam Performance**
- **Inexpensive, Simple, and Easy to Use**

Disadvantages

- **Limited Discharge Distance and Foam Variability**
- **Incompatibility of Equipment Needed for Initial Attack**

Low Expansion Aspirating Nozzles, and/or attachments are designed to provide a higher level of foam expansion by using energy of the fire stream. That higher expansion does come with a price. An increase in expansion will provide a decrease in stream reach.

The performance of a low expansion nozzle or attachment may very well limit its total use as an initial attack tool. Many have limits on how the fog pattern can be adjusted, or limits in the ability to provide reach or pattern changes. These restrictions limit these nozzles or attachments to the truck compartment where they wait for use during a specialty application. Tactically, this group of nozzles is well designed for building wet line in wildfire applications, and for short term exposure protection and pretreatment. The quality and longevity of the foam blanket created by these nozzles is certainly better than a conventional nozzle, but lacks in long term applications.

An example of multiple tactical considerations is a tire fire. Two items need to take place: #1. A wet sticky water needs to be applied to absorb heat. #2. A wet sloppy foam needs to be added to provide the necessary smothering blanket. A low expansion nozzle or attachment can do both effectively.

There are some low expansion nozzles that can provide a protective fog pattern, as well as low expansion foam. These nozzles have a better opportunity of being in first line operation because of their versatility and safety. There are also attachments to conventional nozzles that will provide the same versatility.

Medium Expansion Nozzles

Advantages

- **Will Provide "Medium" to "Dry" Foam Performance**
- **Simple and Easy to Use**

Disadvantages

- **Requires Higher Mix Ratio for Longevity of Foam Blanket**
- **Discharge Distance is Limited**

Medium Expansion Aspirating Nozzles and/or attachments are designed to use the maximum amount of energy from the fire stream for conversion of solution to a finished foam. This use of energy will severely limit the reach of these nozzles.

The limits of reach of these tools relegate them to the truck compartment and are rarely used on an initial attack. These nozzles and attachments are normally used tactically on the building of wet lines in wild fire operations or for building a long term foam blanket for vapor suppression of flammable liquids and smothering of problem deep-seated Class A fuel fires.

Best performance, or highest expansion, is achieved with a somewhat reduced nozzle pressure (reduced velocity). The faster the stream is traveling through the medium expansion nozzle (screen), the less time is available to create bubble structure. This is called "shear" factor. Reduced velocity will provide more time to create a more consistent and highly aspirated bubble structure. Many medium expansion nozzles are rated for 60-80psi operation. This may become a problem when an attachment is used on a conventional fog nozzle rated at 100psi nozzle pressure.

There are some medium expansion attachments that can be used variably on a conventional nozzle. These can be adjusted for reach or expansion or a moderate combination of each. Also, some automatic nozzles have a normal (100psi) and low pressure (75psi) selection. ***This combination tactically will provide the highest degree of versatility.***

High Expansion Delivery Systems

Advantages

- **Will Provide Extremely "Dry" Foam Performance**
- **Ideally Suited, Tactically, for Life Safety Applications**

Disadvantages

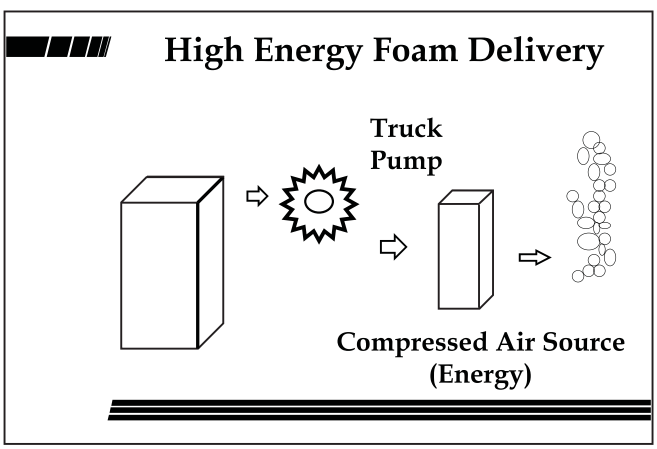
- **Requires Large Amounts of Equipment**
- **For Compartment Type Situations**

High Expansion Systems are designed to produce a highly expanded foam (200:1 + expansion). These systems use a fan and netting to add energy to the foam solution. Once aspirated, it is also directed through tubing with the energy of the fan pushing the foam into the cavity to be filled.

The theory of these type applications is to fill a burning cavity with foam and smother the fire. It is used extensively in areas where there is a life safety hazard for the fire suppression forces (coal mine fires, shipboard compartment fires, telephone vault fires, and, for some time, has shown effectiveness on basement fires).

Regular pumping operations and injection of the foam concentrate still need to take place up to the fan and netting location. The energy is then injected into the solution from the four cycle or electrically powered fan. The netting acts as a location for agitation of the solution, and, finally, the tubing directs the foam to the area of application.

The light finished products are so unstable in the outside environment, due to wind currents, that, tactically, little use has been found. This tends to be an extremely specialized



High Energy Foam Delivery Systems, or CAFS (compressed air foam systems), do not use the energy transferred to the hoseline from the fire pump. Instead, a third component, an air compressor, is mounted on board the apparatus and adds compressed air (energy) in the form of pressure (psi) and flow (cfm). This energy is transferred into the hose line, which holds it in the form of stored energy awaiting release at the tip.

Water doesn't compress, but compressed air foam will compress in the hoseline holding a tremendous amount of "stored" energy for use. This additional energy will translate into additional reach, and a high quality, very consistent bubble structure in the finished foam.

High energy systems use 1 cfm of air matched to 1 gpm of fire flow, at the same pressure, for tactical applications.

Constant foam injection is imperative for effective applications. Inconsistent injection will allow slug flow to hamper operations.

High Energy Foam Delivery Systems

Advantages

- Requires Less Water and has Greater Discharge Distances than Low Energy Systems
- Stored Energy in the Hose will More Completely Convert Solution to Finished Foam

Disadvantages

- More Mechanical Components Lead to More Complex Operating Procedures
- Misunderstanding of Fire Ground Hydraulics and the Inclusion of Pneumatics

Most compressed air systems use an on-board air compressor either powered directly from the truck drive train or via some sort of secondary power source. Other types of systems also will use pressurized tanks to supply energy. These may be used in a fixed system or portably.

The choice of components is important to system longevity, maintainability, and performance. Many varieties are coming into the marketplace on a monthly basis. The use of "totally" engineered packages offer more long term results than component buildup systems.

The foam quality and reach associated with these high energy systems provide tremendous tactical consideration for use in exposure protection and pretreatment of structures in advance of fires.

The choice of nozzles is unusual for initial attack. Typically, only a ball valve is used to achieve best foam performance. The addition of a nozzle will have an adverse affect on the quality of the foam, stripping out the bubbles generated in the hose line. This will give versatility in the quality of the foam. Different nozzle choices will provide differing types of foam from "wet" to "dry".

Hose lines are extremely lightweight. Though deceptive, because of the amount of stored energy in the line, hose lines are filled with mostly air and bubbles allowing for easy movement of hose lines in initial attack.

High Energy systems make best use of foam concentrate. Typically, 0.2% to 0.4% is all that is needed to create excellent quality foam. With low energy systems, it may vary from 0.2% up to 1%

Discussion of National Usage

Examples of Current National Usage in:

- **Urban Structural Initial Attack**
- **Wildfire / Structural Intermix Responsibilities**
- **Forestry and Wildfire Responsibility**

Discussion of current activity of usage in the U.S. and Canada by agencies involved in:

- Structural Initial Attack
- Deep-Seated Problem Fires
- Coal Fired Facilities
- Wildfire Structural Intermix
- Wildfire and Forestry Applications
- Mop up Operations
- Car Fires
- Industrial Use
- Grain and Fabric Processing
- Exposure Protection and Pretreatment
- Pretreatment

Overview of National Testing

Examples of Current National Studies:

- Initiatives from the National Fire Protection Association
- Initiatives Under the USDA, BLM and USFS
- Testing Underway with Underwriter's Laboratory
- Independent Evaluations

Discussion of current activity of testing in the U.S. and Canada:

NFPA activity including pending standards and work of the research and development group at the foundation

Current work from the Missoula Fire Sciences Laboratories, Equipment Development Group in San Dimas, CA, and the National Interagency Fire Center in Boise, ID

Testing underway and proposed by Underwriter's Lab, the insurance industry, Factory Mutual, and Southwestern Labs

Independent testing being conducted by the Canadian government, foam companies, and independent consultants

- Summary of Course Material
- Questions
- Written Quiz
- Course Evaluation

Glossary of Foam Terminology

Absorption: *The act of absorbing or being absorbed.*

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

AFFF - Polar (ATC): *An AFFF that contains a plastic material that forms a polymeric layer only on polar solvents to separate and protect the finished foam.*

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 at a tank shell fire, or to describe Class A foam applications to exposures.*

Airfoam: *Foam produced by the physical agitation of a solution of water and foaming agent and air. Also called mechanical foam.*

ARC - Alcohol Resistant Concentrate: *See AFFF Polar.*

Aspirate: *To draw in air; nozzle aspirating systems (low energy delivery) draw air into the nozzle to mix with the foam solution.*

Batch Mix: *Manual addition of foam concentrate to a water storage container or to make a foam solution.*

Barrier: *Any physical obstruction that impedes the spread of the fire; an area or strip devoid of flammable fuels*

Biodegradation: *Decomposition by microbial action as with synthetic detergent based agents.*

Boilover: *The violent ejection of flammable liquid from its container caused by the vaporization of water beneath a 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 the storage tank. It will not occur to any significant degree with water soluble liquids or light products, such as gasoline.*

Bubble: *The building block of foam; bubble characteristics of water content and durability influence foam performance.*

Bareback Resistance: *The ability of the finished foam to resist direct flame impingement such as would occur with partially extinguished petroleum fire or with Class A foam in exposure protection and pretreatment.*

Carcinogenic: *Cancer causing.*

Class "A " Fire: *A fire in combustibles that exhibit deep-seated burning characteristics such as wood, paper, fabric, tires and peat, where the cooling, smothering and soaking ability of Class A foam and water are best utilized.*

Class "B" Fire: *A fire involving any type of flammable liquid, where blanketing and smothering for vapor suppression is of the first importance.*

Class "C" Fire: *A fire in "live" electrical equipment, where the use of non-conducting fire suppression agents is of prime importance.*

Cohesive Quality: *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).*

Compatibility: *The ability or inability of extinguishing agents to be mixed together or used simultaneously.*

Compressed Air Foam System (CAFS): *A generic term used to describe high energy foam delivery systems consisting of an air compressor (or air source), a water pump (or pressurized water), and foam injection equipment (or foam solution).*

Concentration: *The amount of foam concentrate contained in a given amount of foam solution. The type of foam used determines the foam concentration used (i.e. AFFF 1%, 3%, or 6%, and Class A foams from 0.1% up to l%).*

Corrosion: *Resulting chemical reaction between a metal and its environment (i.e. air, water and impurities).*

Degradation: *A negative change in the characteristics of qualities of a foam.*

Density: *The weight of a specific volume of solution.*

Discharge Device: *A fixed or portable device which directs the flow of solution or finished foam onto the hazard (example: fixed master stream device or an aspirating handline).*

Downstream: *The direction to which the water is flowing.*

Drainage (Dropout) Rate: *The rate at which bubbles from a finished foam blanket burst and release their solution; generally measured as quarter drain time.*

Expansion Ratio: *The ratio of volume of foam formed to the volume of solution used to generate the foam (example: an 8:1 expansion ratio means 800 gallons of finished foam were created from 100 gallons of foam solution). Expansion ration is determined by the use of different aspiration devices, low energy and high energy delivery.*

Eductor: *A proportioning device which uses the vacuum created by the water moving through a venturi to draw concentrate into the hose line.*

Environment: *The complex surrounding an area such as water, air and natural resources and their physical conditions (temperature, humidity, etc.).*

Film Forming Fluoroprotein- FFFP: *A foam concentrate composed of protein and film forming fluorinated surface active agents, which makes it capable of forming a water solution film on the surface of a flammable liquid, and conferring a fuel shedding property to the finished foam blanket. See also Oleo phobic.*

Fluoroprotein Foam - FP: *A foam concentrate composed of protein polymers and fluorinated surface active agents to confer a fuel shedding property to the finished foam blanket. See Oleo phobic.*

Fire Retardant: *Any substance that by its chemical nature or physical action reduces or impedes the flammability of a combustible.*

Flammable Liquid: *A substance that is liquid at ordinary temperatures and pressures and has flash point below 100ºF (38°C).*

Flash Back: *Re-ignition of a flammable liquid caused by the exposure of its vapors to a source of ignition, such as a hot metal surface or spark.*

Flash Point: *The point at which a flammable liquid gives off enough vapor to ignite.*

Fluorocarbon: *An inert organic compound in which fluorine replaces hydrogen.*

Foam - (Finished): *A homogeneous blanket obtained by mixing water, foam concentrate, and the addition of air or an inert gas by the use of energy.*

Foam - (Concentrate): *The foaming agent for mixing in the right proportion with water and air to produce finished mechanical foam.*

Foam Maker: *A device designed to introduce air into a pressurized foam solution stream (i.e. low/medium expansion nozzle, high expansion nozzle, or compressed air foam system).*

Foam Solution: *A homogeneous mixture of water and foam concentrate.*

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

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, and also elevation.*

Heat Resistance: *The ability of a finished foam to withstand exposure to heat (radiant, convective or conductive).*

High Energy System: *A foam generating system that adds the energy of the air source to the energy of the water pump. CAFS is a high energy foam delivery system.*

High Expansion Foam: *Special foam designed for high air-to-solution ratios with 200 parts air to each part foam solution.*

Hydrocarbon: *An organic compound containing only carbon and hydrogen.*

Hydrocarbon Pickup: *The characteristic of a fuel that is suspended or absorbed by expanded foam.*

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

Hydrophilic: *Water-liking; having the property of mixing with water readily.*

Ingestion: *To take things into the body as by swallowing, breathing, or absorbing.*

Line Proportioner: *A device that siphons foam from a container to make a foam solution (i.e. an eductor).*

Low Energy System: *A foam generation system that uses the energy of the velocity of the water stream, delivered from the water pump, to mix air at the nozzle tip with the solution to deliver a finished foam. An aspirating foam tube is a low energy delivery system.*

Minimum Operative Temperature: *The lowest temperature a foam concentrate will proportion with venturi devices in accordance with UL and USDA/USFS requirements.*

NFPA - Requirements / Recommendations: *Standards established for foam extinguishing systems as outlined in Standard #11 and Standard #298.*

Oleo Phobic: *Oil - hating; having the ability of shedding gasoline, oil and similar products.*

Pickup: *The induction of foam concentrate into the water stream by the use of a venturi or suction side injection system.*

Polar Solvent: *In fire fighting, any flammable liquid which destroys regular foams. The alcohol aggressively attacks the bubble by mixing with the water in the bubble structure. Polar solvents require special foam agents and mix ratios. Examples: esters, ethers, alchohols, aldehydes, and keytones.*

Polymeric Membrane: *A thin, durable, plastic layer formed by the application of an alcohol resistant foam on a polar solvent fuel surface protecting the foam cells from destruction by the fuel.*

Pour Point: *The lowest temperature at which a foam concentrate is fluid enough to pour, generally about 5 degrees 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 may be applied to flammable liquids.*

Proportioner: *The device where foam concentrate and water are proportionally mixed to form a foam solution. Also a unit that pumps foam concentrate, as demanded, into the attack hose line.*

Protein: *Complex nitrogen containing compounds derived from natural vegetative and animal sources. Hydrolysis products of protein provide exceptionally stable, cohesive, adhesive, and heat resistant properties to foam.*

Protein Foam Concentrate: *Concentrated solution of hydrolyzed protein to which chemicals are added to obtain fire resistance and other desirable characteristics.*

Quarter-life (Drain Time): *The time required in minutes for one-fourth of the total liquid solution to drain from the finished foam. Also referred to as 25% drainage time.*

Residual Pressure: *The pressure existing in a line at a specific flow (as opposed to static pressure).*

Short Term Retardant: *A viscous, water based substance wherein water is the suppressing agent.*

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

Slug Flow: *In CAFS only, when the foam solution is not rich enough or unevenly mixed with air, inadequate mixing occurs. This sends pockets, or slugs, of water and air to the nozzle.*

Soluble: *The ability to become readily dissolved or mixed with.*

Spray Pattern: *The pattern produced by a 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 during a no flow situation. This can be considerably higher than 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.*

Suppressant: *An agent used to extinguish flaming or glowing phases of combustion by direct application to the burning fuel.*

Surface Active Agent (Surfactant): *A chemical that lowers the surface tension of a liquid.*

Syndet: *Synthetic detergent or cleaning agent.*

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 concentrate is introduced in many types of proportioning equipment.*

Viscosity: *The fluidity of a foam. An indication of the foam's ability to spread and cling.*

Wetting Agent: *A chemical that, when added to water reduces the surface tension of the solution and causes it to spread and penetrate exposed objects more effectively. A wetting agent may not be a foam concentrate.*

Class A Foam Awareness Level Test

1) Match the correct Material to the correct Combustible Classification.

A) Class A	_____ Electrical Source
B) Class B	_____ Flammable Metals
C) Class C	_____ Woods, Paper and Fabrics
D) Class D	_____ Flammable Liquids

2) The Four sides of the Fire Tetrahedron are _______________, _______________, _______________ and Chemical _______________ _______________.

3) What side of the Fire Tetrahedron does a typical structural attack with water try to interrupt?

____

4) Match the Classification of Foam Concentrate with the statement that describes one of its characteristics.

A) Protein Foam	_____ Forms as aqueous film
B) Syndet, High Expansion	_____ Used in fighting Class A combustibles
C) Alcohol Resistant	_____ Hydrolyzed proteins
D) Syndet, Class A	_____ Used for filling a cavity with foam
E) Fluoroportien	_____ Foam concentrate for keytones and polar solvents
F) AFFF	_____ Fluorochemical surfactants and protein

5) The film created on a flammable liquid surface by AFFF prevents what from happening?

____

____

6) Can a Class A foam safely be used on a flammable liquid fire? _____ yes _____ no

7) What is the minimum application rate for a hydrocarbon fuel fire per square foot of burning liquid for a minimum of 15 minutes? (1 gpm), (0.3 gpm) or (0.1 gpm) __________

8) Class A form solution is ideal for reducing the surface tension of water. _____ yes _____ no

9) Which Class B foam concentrate is most concentrated? _____ 1% _____ 3% _____ 6%

10) You have attacked a pile of burning hay bales. You put hundreds of gallons of water on them, but it just runs off on the ground. Which attribute of Class A foam could work for you?
A) Expansion Ratio B) Drain Time C) Viscosity D) Reduced Surface Tension

11) A low expansion nozzle can provide up to 50:1 expansion ratio._____ yes _____ no

12) It takes a foam solution plus ____________________ to make a finished foam.

13) A foam with a short drain time means that the water drains (quickly) or (slowly) out of the bubble structure into the fuel? _________________________

14) Foam concentrates are corrosive. _____ yes _____ no

15) Which one of these foams is designed to biodegrade quickly and safely?
A) Protein B) Fluoroprotein C) AFFF D) Class A E) Syndet, High Expansion _____

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