Module 6:

Fire Fighting Foam Principles

RFA
RENEWABLE FUELS ASSOCIATION

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Objective

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

Introduction

- Emergency responders need to be prepared for incidents associated with flammable liquids
- Ethanol-blended fuels have similarities to other flammable liquids but also present unique burn characteristics
- Hazards associated with production, storage, & transportation by cargo tank trucks & rail tank cars carrying these products require special considerations

Basic Foam Principles

- What is foam?
  - "…foam a stable aggregation of bubbles of lower density than oil or water." (NFPA 11 version 2016)
- 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)

Basic Foam Principles

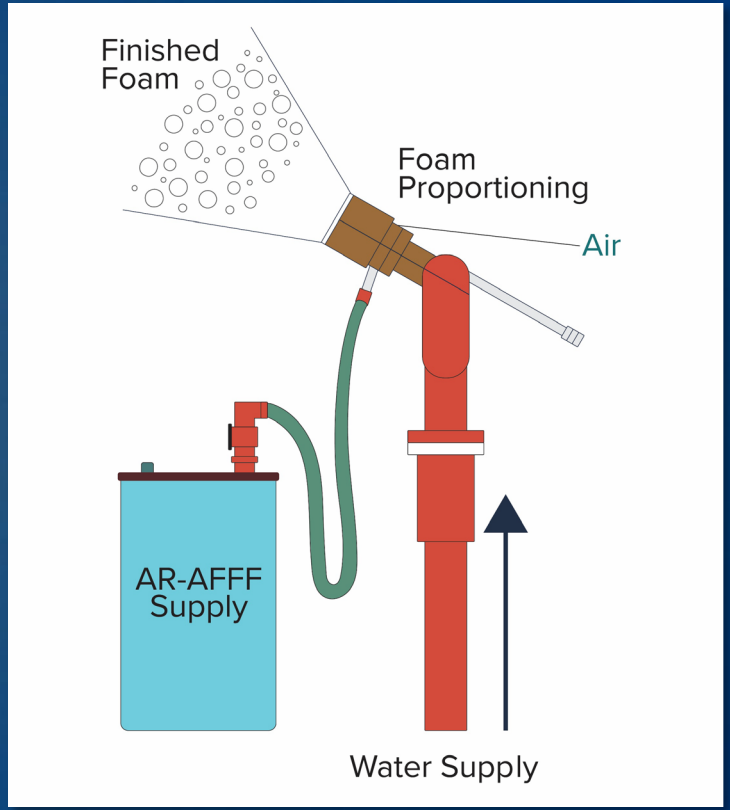
Why use foam?

- Can provide protection from flammable liquids for fire & rescue personnel during emergency operations
- Can provide post-fire security by protecting hazard until it can be secured/ removed

Basic Foam Principles

How foam works:

- Foam tetrahedron:
  - Before being used must be proportioned & aerated
  - 4 elements:
    - Foam concentrate
    - Water
    - Air
    - Aeration



Basic Foam Principles

- What is foam effective on?
  - Effective at suppressing vapors & extinguishing Class B fires
    - Not effective on pressurized flammable gases
    - Not effective on combustible metals
  - 2 categories of Class B products:
    - Hydrocarbons
      - Foams listed such as AFFF
    - Polar solvents
      - AR-AFFF
- Never mix foam concentrates from different manufactures together

Basic Foam Principles

Types of foam:

- Protein foam
  - Made of natural protein products such as soybeans, chicken beaks, fish bones, & animal hooves, along with some other stabilizing additives
- Fluoroprotein foam
  - Combination of protein-based foam derived from protein foam concentrates & fluorochemical surfactants

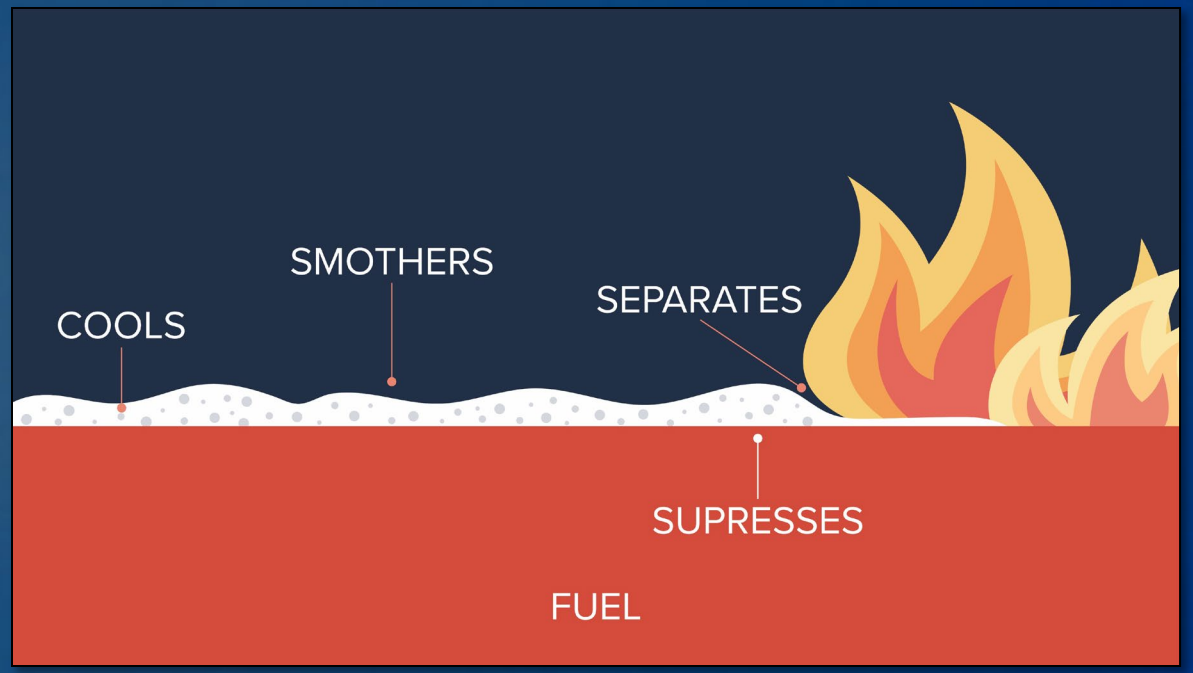
Basic Foam Principles

Types of foam:

- Aqueous Film Forming Foam (AFFF)
  - Synthetic foam consisting of fluorochemical & hydrocarbon surfactants combined with high boiling point solvents & water
- Film Forming Fluoroprotein Foam (FFFP)
  - Based on fluoroprotein foam technology with AFFF capabilities
  - Capabilities of AFFF with the heat resistance of fluoroprotein foam
- Alcohol-Resistant Aqueous Film-Forming Foam (AR-AFFF, ATC)
  - When applied to a polar solvent fuel, AR foams will often create a polymeric membrane rather than a film over the fuel

Basic Foam Principles

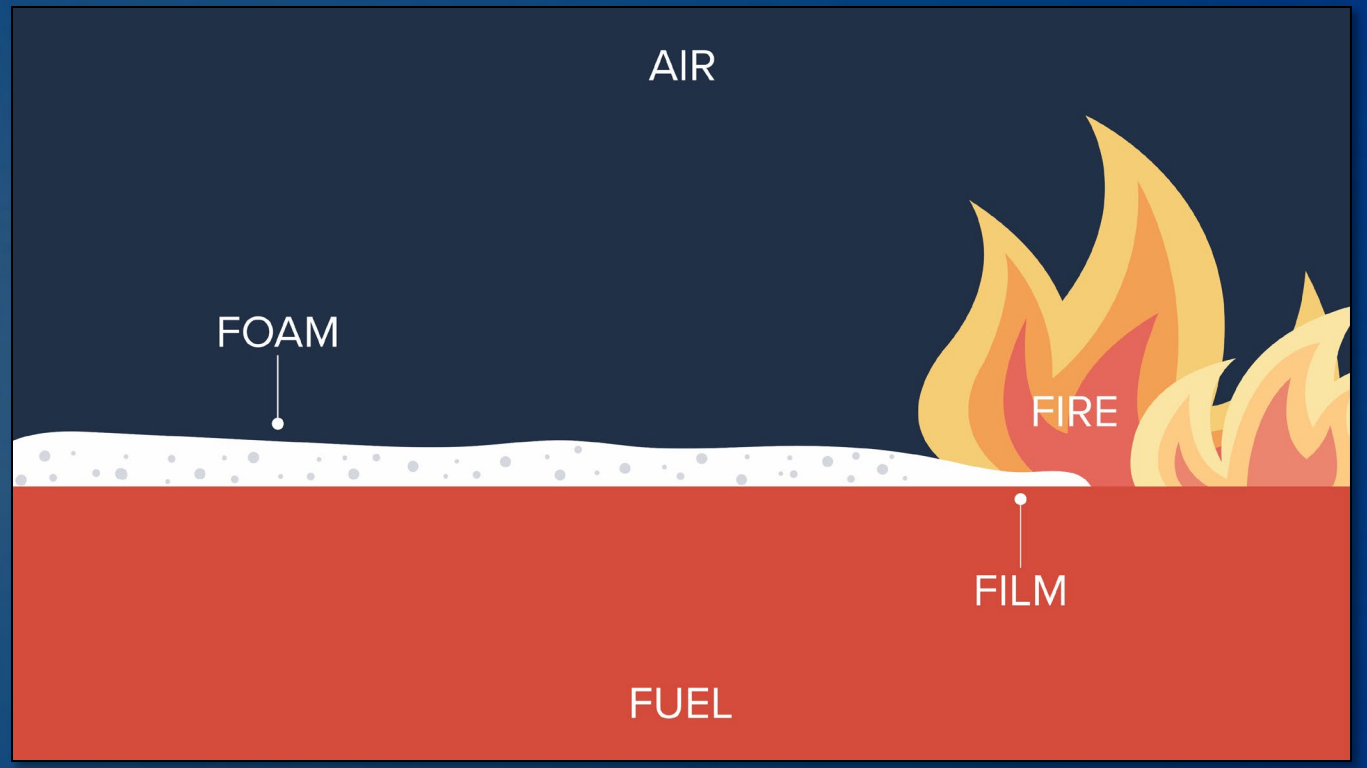
- Remove heat at a faster rate than it is released
- Separate the fuel from the oxidizing agent
- Dilute the vapor-phase concentration of the fuel &/ or oxidizing agent below that necessary for combustion
- Terminate the chemical chain-reaction sequence



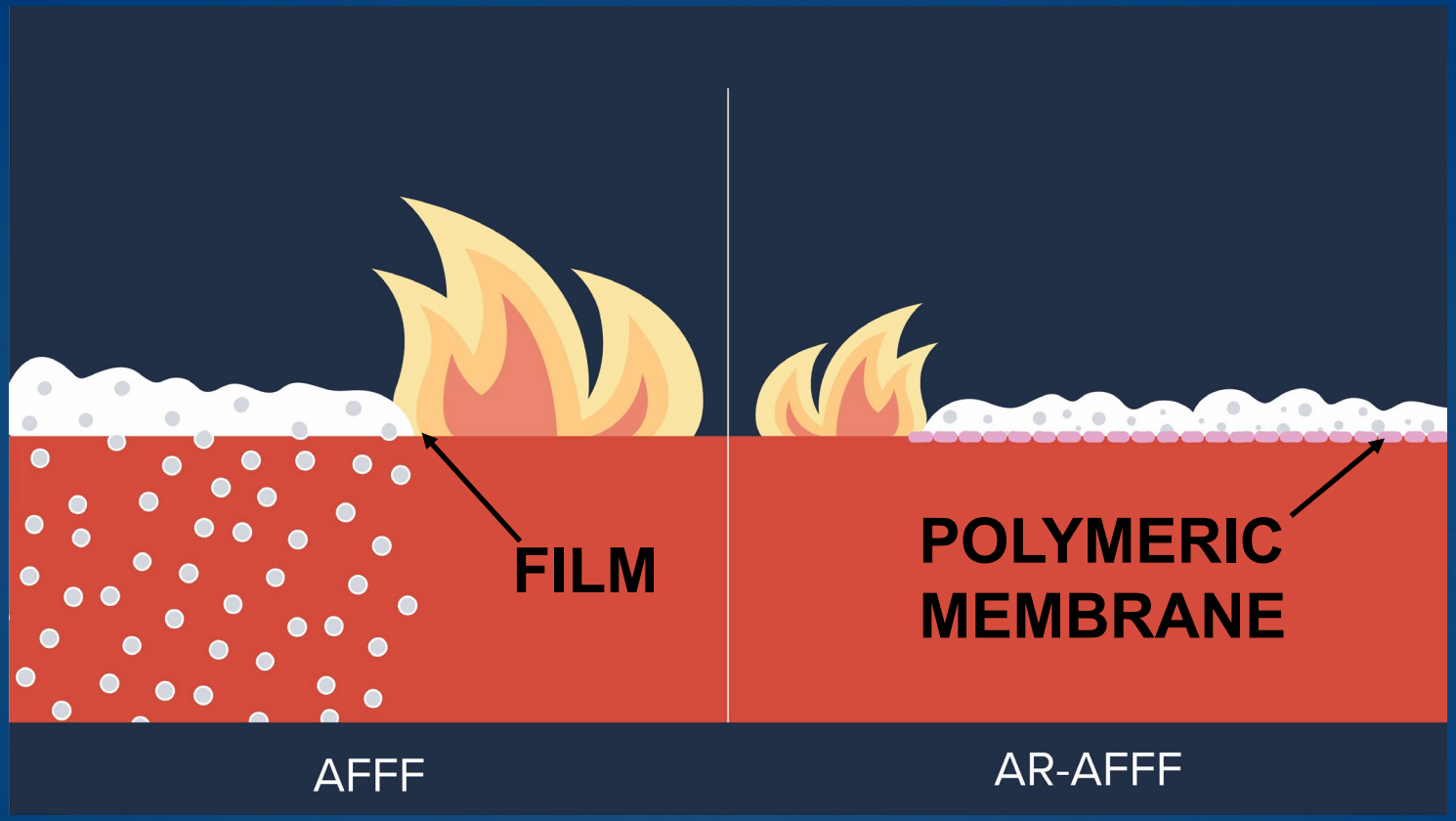
Basic Foam Principles

AFFF

- Low surface tension
- Rapidly spreads across surface
- High burn back resistance
- Quick knockdown



Basic Foam Principles



Water miscible fuel
(alcohol, esters, ketones, etc.)

Basic Foam Principles

Why use alcohol resistant (AR) foam?

- Only agent capable of extinguishing a fire, suppressing vapors & providing visible proof of security
- Foam blanket on un-ignited spill can prevent fire
- Suppression of vapors prevents them from finding ignition source
- Polymeric membrane prevents the ethanol from mixing with the water element of finished foam
- AR foam provides protection from flammable liquids for fire & rescue personnel during emergency operations

Foam Characteristics

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					

Basic Foam Principles

Foam proportioning & delivery systems

- Concentration levels:
  - Hydrocarbons - 3%
  - Polar solvents - 6%
- Foam proportioning systems:
  - Eductors
    - In-line eductors have advantages

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Basic Foam Principles

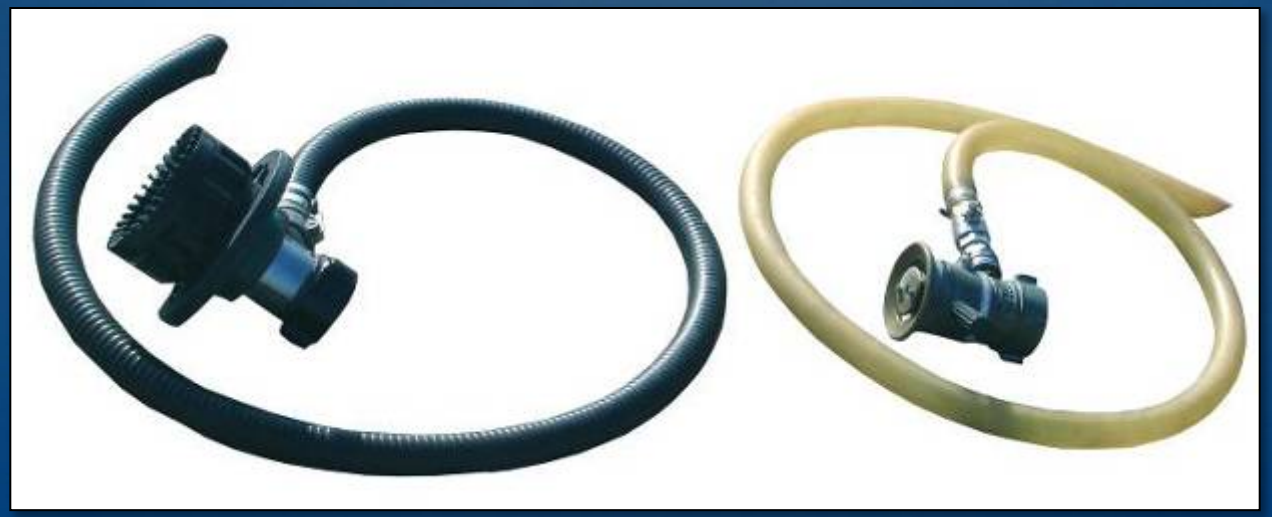
Foam proportioning & delivery systems:

- Foam proportioning systems:
  - Eductors
    - Bypass eductors
    - Common eductor failures

Basic Foam Principles

Foam proportioning & delivery systems:

- Foam nozzles
  - Foam proportioning nozzles have advantages



Hydrant with Foam Nozzle

Basic Foam Principles

Foam proportioning & delivery systems:

- Foam nozzles
  - Air aspirating
  - Non-air aspirating

Foam Trailer

Specialized Foam Equipment

4,000 GPM – 475’ reach

300 gal. AR-AFFF &
600 gal. water

Basic Foam Principles

Application techniques:

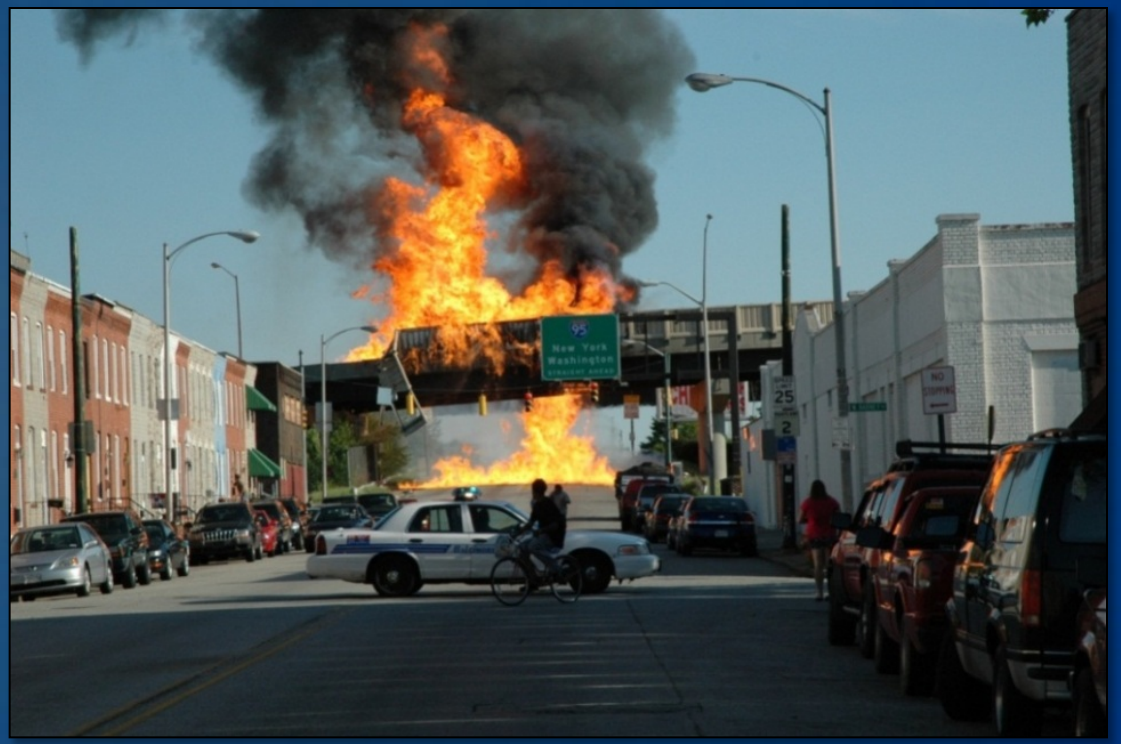
- Never plunge foam directly into the fuel
- Bounce-off:
  - Effective if there is an object in/ behind spill area
- Bank-in:
  - Particularly effective with non-air aspirating fog nozzles
- Rain-down:
  - An alternative application technique is the rain-down method. The nozzle is elevated and the foam is allowed to fall over the spill as gently as possible

Basic Foam Principles

Foam for Ethanol and Ethanol-Blended Fuels

Principles for dealing with ethanol-blended fuels

- Only AR-AFFF or equivalent foams
- Gentle application methods
- Increased foam application rates



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Foam for Ethanol and Ethanol-Blended Fuels

AR foams

- Use of Type II application techniques:
  - Foam is applied indirectly to fire through fixed or semi-fixed foam chambers
- Use of Type III application techniques:
  - Portable monitors & hand lines
  - Effective only when deflected off surfaces
  - Best option may be to protect surrounding exposures

Foam Recommendations for Fire Departments

- Consider converting to AR foam concentrates
  - Ensure foam is UL certified to meet NFPA standards
- Develop means of having cache of AR foam readily available:
  - Mutual aid resources maybe available

Foam Application Rates

- Foam application with portable application devices may require higher rates
  - Application device types whether portable or stationary have operational set points
- Foam application rates vary by manufacturer
  - Ethanol-blended fuels require higher flow rate of foam to extinguish fires, suppress vapors & increase emergency responder safety
  - Flow rates start at 2 gpm foam/ 10 sqft of AR type foam (0.2 gpm/ sqft) for any ethanol-blended fuel incident

Alcohol Resistant Foam Facts

- Ensure all AR-AFFF foam supplies meet UL-162 testing certifications & so indicated in documentation & stamped on containers
- Effective on both alcohol & hydrocarbon fires
- Some have quicker knockdown abilities & longer foam retention times than protein-based hydrocarbon foams
- Foam can stratify; must have maintenance program for re-agitation
- Foam delivery systems such as foam tanks & totes cannot be shaken & remixed easily

Ethanol Scene Evaluation

Proper scene evaluation will assist in making the right choices for successful incident mitigation:

- Size-up
- Situation report to include addressing life safety issues and/or
- Evacuate impacted areas
- Establish Unified Command
- Establish hot, warm and cold zones

Ethanol Scene Evaluation

Continued - Proper scene evaluation will assist in making the right choices for a successful incident mitigation:

- 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

Application Formula

- To determine the amount of foam concentrate required, you must find out the type of fuel & 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 & percentage rate for the concentrate to be used
- Time duration depends on the nature of the incident
  - Typical times are:
    - 60 minutes for tanks
    - 20 minutes for ground spills

Reference: Williams Fire & Hazard Control

Application Rates

- The application rates for spill fires of shallow depth are recommended by NFPA 11
- Increasing the foam application rate over the minimum recommendation will generally reduce the time required for extinguishment
- NFPA recommended application rate for film forming type foams equals 0.1 gpm (foam solution) per square foot of fire with a minimum run time of 15 minutes for hydrocarbon only based incidents
- Due to the characteristics of ethanol-blended fuels the application rate and flow time is based on the manufacturers recommendations. The application rate will be at least doubled to 0.2gpm/ sqft

Application Rates

Quick Foam Flow

Worksheet

1. **Determine Area of hazard**
   (LxW) or (.785 D^2) = ____ SQ FT

2. **Choose Application Rate** = .2 GPM / SQ FT

3. ____ SQ FT x ____ GPM = ____ SQ FT

4. ____ GPM (Flow Rate of Solution) x ____ % (% of FLC) = ____ Gallons (Gallons of FLC Per/Minute)

5. ____ Gallons (Gallons of FLC Per/Minute) x ____ Minutes (Duration of Flow) = ____ Gallons (Total FLC Required)

PRINT, LAMINATE and PLACE ON RESPONSE VEHICLES

Application Rates

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**	=	

Application Rates

Concentrate requirements

GPM Solution	X	% of Foam Concentrate	=	Foam Concentrate GPM	X (Time)	Total Concentrate (Gal)
	X		=		30 Min. (Spill/fire) 40 Min. (Bulk Storage Ancillary spill/fire)	
	X		=		120 Min. (Tank Fire)	

Application Rates

Incident foam needs rule of thumb:

- Double the amount of foam concentrate on hand prior to initiating fire attack (covers fire attack & maintaining foam blanket following knockdown)

Total Concentrate (Gallons)	X 2	Incident Foam Needs Prior to Initiating Fire Attack
	X2 (Spill/fire or bulk storage ancillary spill/fire)	
	X2 (Bulk storage tank)	

Example: Spill Calculation

- Determine Area of Hazard
- Choose Appropriate Application Rate
- Rate x Area = GPM of Foam Solution
- Solution GPM x % Used = Concentrate GPM
- Concentrate GPM x Time = Total Concentrate

Spills - 30 Minutes Minimum Flow Time for Ethanol-Blended Fuels
(The incident flow time will be based on the recommendations from the foam manufacturer and the type of foam.)

Flow rates will dictate what nozzles or combination of nozzles will be required…

Example: Ethanol-Blended Fuel

Spill Calculation

- Determine Area of Hazard
  - 80’ x 50’ = 4000 sqft
- Choose Appropriate Application Rate
  - .20 GPM for product not in depth
- Rate x Area = GPM of Foam Solution
  - 800 GPM
- Solution GPM x % Used = Concentrate GPM
  - 800 GPM x 3% (.03) = 24 GPM
- Concentrate GPM x Time = Total Concentrate
- Spills - 30 Minutes Flow Time
  - 30 minutes x 24 GPM = 720 gallons of concentrate

Summary

- AR-AFFF foam is the best choice for incidents
- AR-AFFF foam is recommended for all incidents involving ethanol-blended fuels
- AR-AFFF foam performs well on hydrocarbon incidents