Firefighting Foam Transition Guidance

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Contents

Introduction

This document is intended to share information on firefighting performance and safety practices to help improve firefighting performance and safety awareness throughout industry. The goal is to share work practices that can be used or considered by companies or sites when developing new process safety practices or improving existing ones. This document has been prepared leveraging input of many industry members, but this does not mean it must be used or that it will produce exemplary results when put into practice. Rather, it is an option to consider when implementing or adjusting programs and practices at a site.

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Firefighting Foam Transition Guidance

The following management-of-change (MOC) guidance provides the industry with suggestions and considerations for the transition from C8 legacy fluorinated foams concentrates to another type of foam concentrate [such as C6 or synthetic fluorine-free foam (SFFF)]. For each step of the MOC, a separate document is available that provides considerations and examples on how an entity may choose to execute the transition. While it is ideal to have a drop-in foam concentrate replacement with minimum changes in processes or practices to use during this transition, the MOC process plans for any changes that must be accounted for.

When switching from C8 legacy fluorinated foam concentrate to C6 or SFFF concentrate, a formal MOC should be developed that addresses (at a minimum) the following steps:

1 Review Existing Foam Use and Facility Scenarios

All emergency response fire scenarios should be assessed to establish the foam concentrate that should be used and its compatibility at a given facility. An emergency response assessment is an important component of an MOC to identify fire scenarios and respective foam use requirements (fixed systems and portable application). Foam use assessment (or foam risk assessment) examples are available in Annex A.

For sites where all fire scenarios cannot be addressed with SFFF, a site could consider selective use of foam such as SFFF for one fire scenario and and C6 foam for a different scenario (“two–foam solution”). This guidance does not advocate a two-foam solution where there is a potential impact to operational safety, process safety, or firefighting capability.

2 Selection of Replacement Foam

The selection of replacement foam(s) should be based on the foam assessment described in Section 1, the use of a checklist such as the one provided in Annex B, and consideration of the foam’s potential impact on human health and the environment. Updated procurement documentation should be developed to ensure that future purchases of foam concentrates are aligned with the foam transition plan. When considering replacement foam, the following areas should be considered:

a) Check approval listings and usage temperatures for foams.

— guidance on listing from UL and information in National Fire Protection Association (NFPA) Standard 11 *Standard for Low-, Medium-, and High-Expansion Foam*;

— foam storage temperature rating due to limited flow at low temperatures.

b) The compatibility of replacement foam(s) being considered with existing foam equipment should be verified through the suppliers. Foam quality produced from existing hardware may differ, impacting foam application rates and durations.

— API members with experience changing from fluorinated firefighting foam to SFFF have learned that they must confirm that the proportioning equipment and the foam nozzles are properly designed for the physical properties of the new SFFF.

— For storage tanks that have sub-surface foam application, C6 foam or SFFF should not be used without confirmation that the foam has been approved for that application method. Testing by the Large

Atmospheric Storage Tanks Project (LASTFIRE) suggests that some SFFF are effective via sub-surface application[1].

— Foam monitors (portable or fixed), when used with SFFF, may require an air aspirated nozzle, which may limit their effective reach. Testing by the Fire Protection Research Foundation (FPRF) suggests that some SFFF need to be air aspirated by a factor of 7–8 times to be as effective as the traditional AFFF[2]. Air aspirated nozzles are available with effective reaches similar to non-air aspirated nozzles.

c) Verify foam concentrate is compatible with the materials that could be released or be burning.

d) When considering a two-foam approach, the added complexity in storage, use, and training should be considered.

— Necessary measures required to manage multiple foam types (e.g., training foams and response foams, or SFFF and C6 foam to be used for separate scenarios) and implications to response plans, etc. should be evaluated as part of the MOC. Sites should consider implementing methods to ensure that the correct foam type is used when fighting a fire.

e) Foam compatibility with dry chemical needs to be evaluated where response plans include use of dry chemical with foam. Check with the foam manufacturer to see if they have this information. Finished foams can be compromised with the application of dry chemicals over the surface of the finished foam. Particulates falling on the finished foam can collapse bubbles. This information should be available from the foam manufacturers.

3 Review Engineered Foam System Modifications

Engineering modifications to existing fixed and portable foam proportioning systems and application devices should be assessed when transitioning the foam concentrate SFFF. Ensuring that all proportioning systems, foam nozzles, and other hardware are compatible with new foam agents is critical. The equipment should be listed or tested with the specific foam and its properties to ensure that it will operate correctly together as outlined in NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*. Ensure that necessary process safety information (PSI) is updated as a result of this MOC for the foam types, procedures, uses, equipment, etc.

4 Address Potential Worker Safety/Health Concerns Associated with Foam

A review of safety data sheets (SDS) for various SFFF foams and reviews by health professionals suggests that additional health and safety precautions should be taken until more information is learned about the potential health effects of these firefighting agents. These precautions are outlined in Annex D.

a) Generally, handle all foam concentrates, solutions, and finished foams in accordance with good industrial hygiene and safety practices for a hazardous substance.

b) Review the manufacturer’s SDS hazard information for additional precautions.

— Foam manufacturers may be contacted for additional information.

c) Determine personnel protective equipment requirements for each foam to be used.

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[1] LASTFIRE Foam Position Paper, http://lastfire.org.uk/uploads/Foam%20Position%20Paper%20Issue%202%20Oct%202016 %20s.pdf

[2] Back, G., and Farley, J. “Evaluation of the Fire Protection Effectiveness of Fluorine Free Firefighting Foams,” Fire Protection Research Foundation.

5 Update Existing Emergency Response and Training/Testing Processes

Once a new foam is selected, evaluate emergency response processes and incorporate updates into existing procedures, training, and assurance processes.

a) Any new environmental handling impact, such as containment or disposal of wastewater after an emergency.

b) Any changes in fixed application equipment and their operation.

c) Any changes in portable application equipment and its operation.

d) Changes in firefighting tactics (air aspiration of foam, use of foam with polar solvents, etc.) and implications to or from mutual aid agreements/arrangements should be considered.

e) Foams that will be used for firefighting training and engineering testing.

— It is recommended that SFFF be used for firefighting training.

f) Foam storage and handling at the facility.

6 Update Existing Environmental Practices

Sites should have documented environmental guidance for managing foam concentrates, solutions, and finished foams based on environmental regulatory requirements and/or the company or site's assessment of environmental risk. While sites with environmental processes for handling firefighting foam concentrates, solutions, finished foams, and firewater/foam runoff will likely largely remain unchanged in a transition between two different PFAS-containing foams, the aspects of these processes should still be included in environmental procedures and training MOC review.

Consider updating environmental practices to include the following:

a) system decontamination logistics/procedures and waste management;

b) how to manage firewater/foam concentrate, runoff, and rinse water;

— Foam risk assessments should include containment capabilities, including considerations for secondary containment in fixed storage systems;

c) disposal of foam concentrate, foam solution, rinse water, or fire water;

d) disposal/destruction of C8 legacy fluorinated firefighting foam;

— Sale or donation of C8 legacy fluorinated firefighting foams generally is not an appropriate form of disposal;

— Some foam manufacturers and state governments may develop programs that would allow users to turn in foam concentrate for disposal, which may warrant consideration if the programs include appropriate safeguards;

— Disposal or cleaning of C8 legacy fluorinated firefighting foam storage containers and firefighting systems prior to refilling with replacement foam.

7 Plan for Transition

Plans should address maintaining firefighting capabilities during transition using a staged approach. This can be done using several risk-reduction approaches:

— reduction or elimination of inventories of hazardous chemicals;

— staging a standby fire crew on-site;

— close coordination with the outside fire department and/or mutual aid partners;

— shutting down or reducing high-hazard operations;

— staging the change out to minimize the impact on operations in any one area, etc.

8 Terms and Definitions

8.1.1
fire water
Water delivered through automatic and manual firefighting means, including that precipitated or leaked from non-firefighting sources, and otherwise commingled into the automatic and manual firefighting water. Includes foam solution, incident contaminants, and waterborne sediment.

8.1.2
fluorinated firefighting foams
Aqueous film forming foam (AFFF), film forming fluoroprotein (FFFP), alcohol-resistant aqueous film-forming foam (AR-AFFF), alcohol-resistant film-forming fluoroprotein (AR-FFFP), and fluoroprotein (FP) foam.

8.1.3
foam concentrate
A concentrated liquid foaming agent as received from the manufacturer]see NFPA 11 (2016), Section 3.3.12].

— alcohol-resistant foam concentrate: a concentrate used for fighting fires on water-soluble materials and other fuels destructive to regular, AFFF, or FFFP foams, as well as for fires involving hydrocarbons;

— aqueous film-forming foam concentrate (AFFF): a concentrate based on fluorinated surfactants plus foam stabilizers to produce a fluid aqueous film for suppressing hydrocarbon fuel vapors; usually diluted with water to a 1 percent, 3 percent, or 6 percent solution;

— film-forming fluoroprotein foam concentrate (FFFP): a protein-foam concentrate that uses fluorinated surfactants to produce a fluid aqueous film for suppressing hydrocarbon fuel vapors;

— film-forming foam: a concentrate that, when mixed at its nominal use concentration, will form an aqueous film on hydrocarbon fuels;

— fluoroprotein foam concentrate: a concentrate very similar to protein-foam concentrate, but with a synthetic fluorinated surfactant additive;

— medium- and high-expansion foam concentrate: a concentrate, usually derived from hydrocarbon surfactants, used in specially designed equipment to produce foams having foam-to-solution volume ratios of 20:1 to approximately 1000:1;

— protein foam concentrate: concentrate consisting primarily of products from a protein hydrolysate, plus stabilizing additives and inhibitors to protect against freezing, to prevent corrosion of equipment and containers, to resist bacterial decomposition, to control viscosity, and to otherwise ensure readiness for use under emergency conditions;

— synthetic fluorine-free foam (SFFF): foam concentrate that is based on a mixture of hydrocarbon surface active agents that do not contain intentionally added fluorine compounds;

— synthetic foam concentrate: concentrate based on foaming agents other than hydrolyzed proteins and including aqueous film-forming foam (AFFF) concentrates, medium- and high-expansion foam concentrates, and other synthetic foam concentrates.

8.1.4
foam solution
A homogeneous mixture of water and foam concentrate in the correct proportions [see NFPA 11 (2016), Section 3.3.16].

8.1.5
legacy foam
Any PFAS foam manufactured prior to January 1, 2016 should be considered to contain C8 fluorinated materials. Foam that is manufactured after that date should be reviewed with the manufacturer to confirm whether it contains any intentionally added C8 fluorinated materials (exceptions are detailed in the guidance below).

— Fluorotelomer foams have been in use since the 1970s and became the predominant foam after 2001, when the major manufacturer of long-chain ECF-based foams (legacy PFOS foam) discontinued production. Fluorotelomerization-derived AFFF is still manufactured and used in the United States, but has been reformulated to limit, if not eliminate, long-chain PFAS; these foams are now referred to as “modern fluorotelomer foams.”

8.1.6
MIL-F-24385 (military specification), *Fire-extinguishing Agent, Aqueous Film-forming Foam (AFFF) Liquid Concentrate, for Fresh and Sea Water*
All AFFF used by the U.S. military must meet the requirements set forth in MIL-F-24385, which is under the control of the Naval Sea Systems Command Code 05P9.

8.1.7
other synthetic foam concentrate
A concentrate based on hydrocarbon surface active agents and listed as a wetting agent, foaming agent, or both.

8.1.8
PFAS (per- and poly-fluoroalkyl substances)
PFAS are a large, complex class of manmade fluorinated organic chemicals. Due to unique physical and chemical properties (for example, surfactant, oil-repelling, water-repelling), PFAS have been extensively manufactured and used worldwide and across many industries.

— For the purposes of firefighting agents, PFAS are a class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom, and designed to be fully functional in Class B firefighting foam formulations.

8.1.9
PFAS foam
Firefighting foams containing any per- or poly-fluorinated alkyl substances of any carbon chain length.

— C6 foam: firefighting foams that contain PFAS compounds of carbon chain length of 6 or smaller with no intentionally added longer chain PFAS or significant impurities;

— C8 foam: firefighting foams that contain PFAS compounds of carbon chain length of 8 or longer.

8.1.10
rinse water
Water that has been utilized to rinse foam contaminated equipment.

Annex A
(informative)

Review Existing Foam Use and Facility Scenarios

A.1 Sample Site Foam Risk Assessment—Example: Terminal

Emergency response fire scenarios should be assessed to establish the present foam concentrate use and compatibility at a given facility. An emergency response risk assessment should be done that reviews key fire/foam use scenarios and respective foam use requirements (fixed systems and portable application) at a given facility.

a) When selecting a replacement foam, consider the fire/foam scenarios that are a part of the site's emergency response program. For example, a small lubricants products terminal might have a checklist of their potential scenarios, which could involve the use of foam.

b) The present foam use requirements will then be compared to any new foam concentrates being considered and the effectiveness and compatibility of that new foam and the same use principles. In addition, other risk tradeoffs needed for comprehensive comparison (e.g., evaluation of chemical hazards) may need to be assembled to allow for a full and transparent recommendation.

A.1.1 Foam Risk Assessment: Terminal

A.1.1.1 Credible Scenario: Fire

A credible fire scenario can be defined as one of the following:

— small leaks with ignition from process equipment and piping, sampling systems, sight glasses, flange joints, etc.;

— one room and contents fire (electrical fire, kitchen, laboratory, utilities building. etc.);

— pump seal fire;

— rim seal fire;

— compressor seal fire.

A.1.1.2 Loss of Primary Containment (LOPC) Credible Scenario

A credible LOPC scenario can be defined as one of the following:

— LOPC scenario does not consider ignition of the product;

— LOPC from a drum or packaged product hit by a forklift;

— small leaks from process equipment, tank truck piping, railcar piping, piping, sampling system stations, tubing/instrument fitting failure, flange joints, sight glasses;

— pump or compressor seal failure;

— loading and unloading failures from railcar/tank truck;

— failure of packaged goods container (palletized material).

A.1.1.3 Identified Largest Credible Emergency Scenarios

A.1.1.3.1 Fire Largest Credible Scenario

Actual largest credible scenarios for this business:

— a loading rack fire, truck or rail, involving an entire loading spot;

— large warehouse, office building, large open/enclosed process unit fire that involves a significant portion of the unit;

— confined and/or congested vapor cloud release with or without explosions (VCEs);

— full surface fire in the largest storage tank.

A.2 Sample Site Foam Risk Assessment—Example: Scenario Table

The following example identifies where use of aqueous film-forming foam concentrate (AFFF) C6 foam or synthetic fluorine-free foam (SFFF) may be considered effective for use.

Foam Use Scenarios	Application Equipment	SFFF	C6 Foam
Fire at truck or rail loading/unloading rack	Fixed or semi-fixed or portable		
Fire at loading/unloading dock/jetty	Fixed or semi-fixed or portable		
Fire in atmospheric storage tank	Fixed or semi-fixed or portable		
EFR rim seal	Fixed or semi-fixed or portable		
EFR full surface	Fixed or semi-fixed or portable		
FR rim seal	Fixed or semi-fixed or portable		
IFR full surface	Fixed or semi-fixed or portable		
Cone roof full surface	Fixed or semi-fixed or portable		
Cone roof full surface (subsurface)	Fixed or semi-fixed or portable		
Pump seal fire	Fixed or semi-fixed or portable		
Compressor fire—with lube oil spill fire	Fixed or semi-fixed or portable		
Fire in containment area (dike/bund)	Fixed or semi-fixed or portable		
Spill fire not contained	Fixed or semi-fixed or portable		
Fires in buildings			
Laboratories or sample storage areas	Fixed or semi-fixed or portable		
Blending or process equipment	Fixed or semi-fixed or portable		
Vapor suppression	Fixed or semi-fixed or portable		
Fire in LNG equipment	Fixed or semi-fixed or portable		
Rundown trenches	Fixed or semi-fixed or portable		
Impoundment basins	Fixed or semi-fixed or portable		
Fire at offshore helideck	Fixed or semi-fixed or portable		

Foam Use Scenarios	Application Equipment	SFFF	C6 Foam
Fire at offshore platform	Fixed or semi-fixed or portable		
Fires in road transport trucks	Portable		
Fire in aircraft hangar			
High hazard flammable train (HHFT) fires	Portable		
Fires in confined spaces			
Mines			
Pits			
Sewers			
Vaults			
Ship Engine Rooms			
Foam and dry chemical/powder combinations (this could be during 3-dimensional fires or fires involving metals, or to combat fires around obstacles)	Finished foams can be compromised with the application of dry chemicals over the surface of the finished foam. Particulates falling on the finished foam can collapse bubbles. Check with specific foam manufacturers concerning this issue.		
Cold climate areas			
NOTE Review foam manufacturer's listings for scenario, fuel types, application rate, and equipment compatibility.			

Annex B
(informative)

Select Replacement Foam

The following checklist can be used to evaluate replacement foam. Additional considerations are provided below.

- ☐ Confirm whether existing foam in stock contains long-chain PFAS or does not. Fire-fighting foams that were manufactured before January 1, 2016 may contain long-chain PFAS as either active ingredients or manufacturing by-products above the limits for C6 foams and should be taken out of service and disposed of based on specific company management decisions or regulatory requirements.

— Confirm with the manufacturer, if needed. Foam manufacturers may provide documentation that foams manufactured after January 1, 2016 do not contain any long-chain PFAS material and/or provide access to the relevant U.S. Environmental Protection Agency Toxic Substances Control Act (USEPA TSCA) premanufacturing notice (PMN) for any restricted PFAS. Foam manufacturers must provide you with safety data sheet (SDS) content: if any proprietary ingredient is claimed, consider requesting clarification regarding fluorosurfactant content.

- ☐ Confirm the standards listing of the foam. A quality foam supplier will supply foam concentrates that meet one or more of the following standards:

— UL 162;

— BS EN 1568: 2008 Parts 1-4;

— ICAO Levels B and C;

— IMO MSC.1/Circ.1312.

- ☐ Check the regulations. When selecting a replacement foam(s) or installing a new foam fire-fighting system, all applicable regulations regarding foam type shall be followed.

- ☐ Develop and maintain a list of approved foams. For a foam to be considered for inclusion in the approved list, it should meet the appropriate testing or certification process for the intended use. For example: 1) UL162 or 2) EN-1568-3:2008 certified at IA or IB, 3) LASTFIRE foam tests, or 4) other testing that is specific for the foam use that is being evaluated. Alcohol-resistant foams must pass the equivalent protocols.

- ☐ Continue to prioritize emergency response and prepare for situations outside the site's control. In the event of an emergency response, before the removal of legacy (pre-2016, possibly long-chain PFAS-containing) foams from the site is complete, legacy foams may be used in the response, if legally permitted. Follow federal/state/local guidelines on the use of legacy foams in an emergency response setting. In emergency situations, legacy foams may arrive on-site from another company responding to the emergency under a mutual aid agreement; in those circumstances, the same requirements to follow federal/state and local requirements and guidelines apply. Consider adding special use procedures or prohibitions on legacy foam use in mutual aid agreements.

- ☐ Review or consider developing foam concentrate procurement specification and procedures. A detailed "fit for purpose" foam concentrate procurement specification can ensure that the foam concentrate procured meets all technical and commercial requirements and that enough certified information is available to make informed decisions related to its safe and effective use.

B.1 Options and Good Practice Guidance

There are many different types of foam concentrate, but unfortunately, not a single concentrate can be regarded as the universal product that meets the requirements of all applications. However, storage tank fires (fires involving fuels in-depth) and polar solvent fires have certain features that place greater demands on certain foam characteristics and fire extinguishment performance criteria. Coupled with the requirement to minimize environmental consequences of firefighting actions and ensure safety of use, practicality of application, and long-term performance capability, this means that it is critical to ensure that the product purchased is specified correctly and is provided with comprehensive certified test data related to these aspects. This data can then be used to ensure that the product can be applied effectively and efficiently, and that appropriate measures can be put in place to minimize environmental effects and/or develop appropriate remediation procedures. UL 62 allows testing on specific fuels; therefore, this should not deter the company from carrying out its own independent UL 162 testing on its own hydrocarbon products as a means of validation testing.

At first sight, it might seem that the recommendations for issues to be covered in the procurement are excessive, but it cannot be overemphasized that developing a detailed performance-based specification for the foam concentrate is key to achieving efficient and effective overall system or equipment performance.

The key operational levers of foam application effectiveness are:

— application rate;

— foam proportioning rate;

— amount of air aspiration (expansion ratio);

— method of application (gentle or banked/plunged);

— duration of application (the duration is based on the minimum foam induction concentration, as described in UL 162 and NFPA 11).

B.2 Foam Types and Application Rates

One of the main factors determining the selection of foam concentrate is the fuel types that are being handled at the facility. If anything other than standard, non-water-soluble hydrocarbons are on site in significant quantities (e.g., alcohols), it is necessary to have foams that are suitable for water-soluble fuels. Such foams are often deemed “alcohol resistant,” but more correctly should be called “multi-purpose,” as a good quality grade can give good performance on both hydrocarbons and water-soluble fuels.

Therefore, if significant quantities of such fuels are present on a site, it is important to get specific test information related to that fuel with the concentrate in question—again remembering that a test rate should not be applied as a design rate as safety factors should be applied. Any data from manufacturers should be appropriate to the application method and backed up with independent certification.

Another aspect of foam selection is the proportioning rate that is to be used.

In principle, the lowest concentration would be the most efficient for any application, but in practice, there are other factors related to compatibility with equipment or system characteristics. For example, 1 % grades tend to be more viscous and have a higher specific gravity than 3 % grades, so there could be issues related to pumping or proportioning such materials.

Some users have applied 1 % foam at a 3 % rate to extinguish fires. One-percent foam tends to be significantly more expensive than 3 % foam.

Any data from manufacturers should be applicable to the application method and backed up with independent certification.

B.3 Multiple Foams at a Site Policy

Ideally, a site should standardize one foam concentrate in order to minimize the possibility of cross-contamination or use of an incorrect type in any particular situation. This might not always be possible or economic, or perhaps a two-foam policy might be adopted in order to minimize application environmental effects. An example could be a policy of having a foam concentrate that is less efficient but with fewer environmental effects for smaller incidents and a higher performance type with more potential environmental effects used for major incidents demanding higher fire performance (this might be an interim policy to hold current stocks until more foam types with all other required characteristics are available or the older stock requires replacement). The site management must provide necessary policies and procedures to guard against several potential issues, such as mixing of foams or using the incorrect foam on a particular hazard.

B.4 Maximum/Minimum Use/Storage Temperatures

High temperatures can degrade foam concentrates; therefore, details of the maximum ambient temperatures at site should be provided along with a request for the recommended maximum temperature for long-term foam concentrate storage.

Low temperatures can make foam concentrates more viscous and difficult to proportion correctly or pump. The extreme is that they can, of course, freeze and become solid. Therefore, a mininum-use temperature should be specified and confirmed. The minimum-use temperature is normally defined as the lowest temperature at which it is possible to proportion the concentrate correctly using standard venture-type inductors (line proportioners).

B.5 Foam Concentrate Performance Specification, Testing, and Certification

Although the most important aspect of foam concentrate performance is extinguishing capability, there are, in fact, many other issues that should be addressed, and appropriate assurance provided prior to final selection. These are addressed here with no particular order of priority apart from the initial one of critical fire performance. UL 162 allows testing on specific fuels. A user may conduct UL 162 or equivalent testing using their preferred foam on their specific fuel composition to understand the foam properties when used on specific fuels as fuels properties vary. Other tests, such as the LASTFIRE foam tests, have also been shown to be representative of actual fire conditions for different foam concentrates.

B.6 Fire Performance

It is vital that foam can demonstrate appropriate fire performance for the specific application in mind. In the case of tank fires, although faster control and extinguishment are always beneficial, these are not as critical as with rapid rescue situations, such as aircraft crash fires. The priority for tank fires is secure extinguishment with ongoing vapor suppression and prevention of reignition.

An ideal fire performance test simulates real conditions but on a smaller scale (to be economic), specified in detail (to be reproducible), and validated through real-life performance (to be credible and appropriate).

A LASTFIRE test protocol is available for water-soluble fuel applications as well as hydrocarbon applications.

There are, of course, other fire performance tests [Underwriters Laboratory (UL), Factory Mutual (FM)] for assessment of foam concentrates, but the LASTFIRE protocol is the only one developed specifically for storage tank fires.

Annex C
(informative)

Review Engineered Foam System Modifications

C.1 Compatibility with Proportioning Equipment and/or Foam Concentrate Pumps

It has been known that some foam concentrates, particularly the alcohol-resistant SFFF, are viscous and will not easily be pumped through a pipework system, especially after a long period of being static, or proportioned by basic devices such as venturi-based inductors. In addition, foam stored in atmospheric storage containers should be monitored. There are cases when the water in the foam concentrate has evaporated and caused the foam to become more viscous. Many foam systems are tested (operated) on an annual basis, which would allow for confirmation that the system and foam was still functional at this frequency. If this is a concern, a confirmation that the foam concentrate can be correctly used with such equipment must be provided. This is best done by including a specific performance test within the procurement specification requiring a demonstration of correct proportioning capability through a matched proportioner/nozzle pair. It should also be done with the concentrate at typical ambient temperature. In addition, an assessment should be made to ensure that it will work at the lowest use temperature.

Typically, in standards such as NFPA 11 or EN 13565, the acceptable tolerance on proportioning accuracy from the nominal value is +30 %, -0 %. Thus, for a nominal 3 % grade, the acceptable range would be 3 %–3.9 %. This basic test also gives some indication that the concentrate will be suitable for some pumped systems, although long pipework runs will almost certainly be a problem for concentrates that have varying viscosity properties (non-Newtonian) and are very viscous. Absolute demonstration for suitability for pumped systems of such concentrates can realistically only be done on site, but knowledge of physical properties will assist in an initial evaluation through hydraulic analysis. Flow calculations of varying viscosity properties (non-Newtonian) of viscous liquids are notoriously difficult to carry out with any degree of accuracy.

Specialized foam application vehicles (foam pumpers) often have variable concentrate proportioning settings and will be required to produce the correct proportioning over different flow rates according to demand. The concentrate chosen must, therefore, be such that acceptable proportioning will occur over this wide range of possible operating conditions.

Key questions that need to be resolved as part of the MOC process for foam equipment:

- ☐ Have all foam application systems, including mobile attack systems, acting as primary response or backup to systems where applicable been designed in accordance with recognized appropriate standards?
- ☐ Have hydraulic calculations been carried out and recorded to demonstrate that all foam application devices will be operating within their design range?
- ☐ In the case of systems such as semi-fixed or mobile large capacity systems involving hose deployment, have the hydraulic calculation programs used been validated through testing directly related to the specific hose types and sizes?
- ☐ Will the introduction of air aspirating foam require personnel or equipment to be closer to the fire, and thus expose them to high radiant heat? Where are portable application locations, or foam logistics sites where personnel will be required to set up safely, during the incident for which the new system is intended (kW/m^2 limit should be set)?
- ☐ For systems that are automatically or remotely actuated, are there alternative actuation devices relying only on mechanical means?
- ☐ Will the new foam result in increased corrosion of system pipework that causes an increased threat to ongoing performance?

- ☐ Are design features incorporated into foam systems so that the foam system can be tested without jeopardizing safety, operations, or stored product quality?

Storing foam concentrate in totes and drums or in firefighting equipment:

— Procedures for storage may not change during a transition between firefighting foams. Regardless of the foam used, it is necessary to regularly inspect storage containers and equipment and perform regular performance tests based on foam manufacturer requirements.

Early testing by the Fire Protection Research Foundation (FPRF) would suggest that with SFFFs, the proper aspiration of the foam is a critical factor in producing quality foam. These foams need a higher air aspiration ratio than previous AFFF foams. The compatibility of the nozzles and foam chambers with the SFFF is critical.

If the change of foam type results in a change in concentrate percentage (from 1 % to 3 %), the necessary storage and logistical support systems must be evaluated and revised. For example, the user may need larger or more portable foam storage devices to transport foam to the fire.

The new generations of SFFF developed show Newtonian fluid characteristics and may not have as much of a challenge in pumping and proportioning as previous SFFFs. The more challenging characteristic that comes through from the FPRF and LASTFIRE research is the fuel pickup in SFFF due to plunging in fuel in-depth. The application technique and aeration are critical considerations in the MOC transition planning (in choosing a foam or delivery system upgrades to your transition MOC plan.)

Annex D
(informative)

Health Information Summary for All Firefighting Foams

The following chart provides example recommendations for personal protective equipment (PPE) when handling firefighting foam. This is for foam concentrate, foam solution (concentrate and water), and finished firefighting foam (concentrate, water, and air).

D.1 Health Information Summary for Firefighting Foam—All Types of Class B Foam

General precautions:

— Handle in accordance with good industrial hygiene and safety practice for a harmful chemical.

— Avoid contact with skin; if foam concentrate or solution gets on the skin, wash it off as soon as possible.

— Do not ingest foam solution or concentrate.

— Take off contaminated clothing, and wash before reuse.

Review the manufacturer's safety data sheet (SDS) information and hazard information for the specific foam that is being used for additional precautions. Follow the instructions on the specific SDS provided by the firefighting foam concentrate manufacturer if they include heightened or additional requirements beyond these minimum recommendations.

Foam Form and Uses	Respiratory Protection	Protective Gloves and Footwear	Eye Protection	Skin Protection
Foam concentrate — Use: loading and uploading concentrated foam, collecting samples for testing, during cleanup of foam spills, or after use, during decon of personnel, PPE, or equipment after exposure (direct contact with foam concentrate) .	— Do not inhale vapors/fumes. — Not needed under typical handling conditions of firefighting foam concentrate. — If vapors reach irritating levels, wear a NIOSH-approved respirator equipped with organic vapor cartridges.	— Wear neoprene gloves or equivalent impervious gloves. — Wear impervious boots.	Wear a full-face shield with safety glasses.	When using large quantities or where heavy contamination is likely, wear disposable Class C protective clothing (for example: Tyvek) over normal work clothing.
Foam solution or finished firefighting foam — Use: firefighting operations	— Do not inhale vapors/fumes. — Not needed under typical handling conditions of firefighting foam concentrate. — If vapors reach irritating levels, wear a NIOSH-approved respirator equipped with organic vapor cartridges or self-contained breathing apparatus.	— Wear impervious gloves under firefighting gloves or firefighting gloves with this type of an inner barrier. — Wear impervious boots.	Wear a full-face shield with safety glasses, or eye protection supplied with fire helmet.	Wear normal firefighting ensemble during firefighting. Decon after use with soap/water.
NOTE 1 Hazards associated with foam chemicals can include skin and eye irritation or damage, skin sensitivity, specific organ damage, effects on reproduction or development, and possibly cancer. NOTE 2 This information has been compiled from manufacturers' safety data sheets for firefighting foam and other hazard sheets.				

Annex E
(informative)

Update Existing Emergency Response and Training/Testing Processes

The following should be considered when updating emergency response or training/testing processes:

a) Any new health and safety impacts, such as new personnel protective equipment requirements;

b) Any new environmental handling impact, such as disposal of wastewater after an emergency;

c) Any changes in fixed application equipment and its operation;

d) Any changes in portable application equipment and its operation;

e) Changes in firefighting tactics (air aspiration of foam, use of foam with polar solvents, etc.) and implications to or from mutual aid agreements/arrangements should be considered. All firefighting training using foam should be conducted using SFFF foams or C6 foam. Special training foam is available for some of the training needs. All foam must be contained and collected for proper disposal;

f) Replacement of legacy foams with approved SFFF or C6 purity foam in accordance with the MOC guidance;

g) Foam storage and handling at the facility;

h) Foam use competency training.

Regardless of the foam being used, a foam competency training program should include communication of the risks involved in handling firefighting foam and the appropriate site procedures for the above processes. A possible outline for foam use competency training is provided below:

a) Health

— Training should communicate that there is an evolving understanding of the risks associated with firefighting foams, and follow-up training should be provided if a company's assessment of health risks related to foam use has shifted.

b) Environmental impact

— Companies should communicate the environmental hazards of foarm, including those from fluorinated chemicals.

c) Regulatory environment

— A robust training program will also include information on the federal, state, and local regulations governing firefighting foam. Generally, such regulations are increasing in complexity.

d) PPE (firefighting, decon, etc.)

— cleaning turnout gear after firefighting;

— procedures to ensure gear from cleanup is properly disposed of, if included in site procedures;

— assumption of contamination in any testing scenario.

Annex F
(informative)

Update Existing Environmental Process

F.1 Environmental Regulations to Consider

Regulations of firefighting foams and of fluorinated surfactants in the environment are evolving very quickly in many countries. Compliance with applicable regulations may impose constraints on firefighting foam and fire-water management, which may vary significantly from country to country or region by region. Each site should determine which regulations apply to its operations.

Regulations relevant to a site may address the management of the foam and fire water in a facility (typically operating permit constraints that may require full containment or specify discharge criteria).

F.1.1 Considerations During Transition to Aqueous Film-Forming Foam Concentrate (AFFF) C6 Foam or Synthetic Fluorine Free Foam (SFFF)

The formal MOC should include a staged approach to foam removal, disposal, and replacement with considerations for the following:

1) maintaining firefighting capabilities during transition (previously discussed);

2) identifying locations of all existing Legacy Foam in storage and in service as part of the environmental review;

3) equipment decontamination logistics as part of the environmental review;

4) waste reduction and disposal options as part of the environmental review.

The following table demonstrates the range of company/site policy changes that may be necessary during foam transitions. It is important to note that this document generally recommends maintaining environmental procedures in a transition from C8 legacy fluorinated foam to C6 foam, but there are a few scenarios where procedures may change when transitioning to SFFF. Additionally, companies should follow local, regional, national, and international regulations that precede these general recommendations.

Evolution of Company/Site Policy			
	Stage 1: Typical Existing Policies for C8 Legacy Fluorinated Foam (Baseline)	**Stage 2: Transitioning from C8 Legacy Fluorinated Foam to C6**	**Stage 3: Transitioning from C8 Legacy Fluorinated Foam or C6 to SFFF**
Cleaning firefighting PPE	Clean in water with chosen additive.	Nothing changes.	Nothing changes.
Specific PPE required for decon	Procedures require firefighting PPE or Level C disposable protective clothing for decon procedures.	Nothing changes.	Nothing changes.
Cleaning and disposal of decon PPE	Procedures would require cleaning and/or disposal of PPE. PPE contaminated with PFAS foam concentrate or rinse water require cleaning and/or disposal. Contaminated gear should be disposed properly, as PFAS-contaminated waste may have specific disposal requirements set by regulations.	Nothing changes.	PPE contaminated with SFFF can be washed with water.
Equipment maintenance/cleaning	Site/company-specific rinse practices: All rinse water and foam solution generated during the process should be collected and disposed of properly. Maintenance and cleaning procedures may vary between foam types (i.e., C8, C6, SFFF).	Nothing changes.	Nothing changes.
Treatment of foam concentrate storage vessels	Clean or dispose of used containers; replace as needed. Do not repurpose used containers to store materials other than replacement foams.	Clean or dispose of used containers.	Clean or dispose of used containers.
Storing foam concentrate in totes and drums or in firefighting equipment	Regularly inspect containers for leaks and perform regular performance tests based on foam manufacturer requirements. Consider options for secondary containment in fixed storage systems based on a risk assessment of the hazards.	Nothing changes.	Nothing changes.
Operational controls to minimize discharge into the environment	Ensure site practices prioritize containment and do not allow for unnecessary discharges of foam into the environment.	Nothing changes.	Nothing changes.
Containment of contaminated fire water/foam runoff	Include containment capabilities in risk assessments and pre-fire plans.	Nothing changes.	Nothing changes.
Disposal of foam concentrate, foam solution, fire water/foam runoff, and rinse water (see latest guidance from the user's environmental specialists, hazardous waste disposal, company experts, or other technical direction).	Select preferred destruction/immobilization or treatment method based on environmental regulatory requirements.	Nothing changes.	Nothing changes.

F.1.1.1 Cleaning Firefighting PPE

The practices for cleaning firefighter PPE will not change as a site transitions between foam types. Sites have experienced variable success in using different additives in water to clean firefighter PPE, so a recommended practice does not exist.

F.1.1.2 Specific PPE Required for Decon

Waterproof clothing with gloves and boots are required for workers during the decon process in order to minimize dermal contact of foam (i.e., Level C hazmat gear). The practice of requiring specific PPE for decon processes will not change as sites transition their firefighting foam type. An important component of decon PPE is H_2S detection because, for some foam products that contain sulfate-based hydrocarbon surfactants, gaseous H_2S can form from rinse water when stored in closed tanks for long periods of time (i.e., >2 weeks) during the decon process.

F.1.1.2.1 Indentification of Potential H_2S Hazard

Several foam products have 5 % to 10 % of sulfate-based hydrocarbon surfactants. This means that when diluted, these foam solutions will go through biodegradation, and if they are stored in closed containers, large amount of H_2S can be generated. H_2S monitors should therefore be included in required PPE during decon procedures.

F.1.1.3 Cleaning and Disposal of Decon PPE

The process of cleaning decon PPE will change based on the type of firefighting foam being used. Decon PPE previously exposed to PFAS may have specific disposal requirements set by regulations.

F.1.1.4 Equipment Maintenance/Cleaning

Sites/companies should develop their own procedures for cleaning equipment as they transition firefighting foam types. Equipment includes storage containers, vehicles, and pipe systems. There is currently no industry standard that documents the best way to clean equipment. This is partially because neither a regulatory standard or sufficient testing mechanisms exist for rinse water. Procedures should therefore be based on company/site needs. Considerations for site-specific cleaning procedures include:

1) choice of additives:
   a) surfactants;
   b) pH adjusting reagents;
   c) coagulants;
   d) defoaming reagent;s
2) multiple rinse process:
   a) the number of required rinses;
   b) specific considerations for emergency response equipment, such as fire trucks (e.g., minimize additional foam creation);
   c) considerations for different storage devices, such as frac tanks (e.g., minimize additional foam creation),
3) physical removal of contaminants:
   a) draining;
   b) scraping;
   c) water jet;

4) rinse water quality considerations:

   a) salt vs. fresh water:

      i) disposal methods likely unchanged with the addition of salt water;

      ii) salt compatibility of equipment and storage tanks;

      iii) effect of salt on additive performance.

   b) background PFAS levels in water supply.

See F.2 for a sample equipment flushing procedure.

F.1.1.5 Treatment of Foam Concentrate Storage Vessels

When transitioning to shorter-chain PFAS or fluorine-free foams, contaminated storage vessels that previously held PFAS foam must be properly cleaned or disposed to avoid cross-contamination of the replacement foam. The determination to dispose of the vessels or clean to a sufficient level will be based on company/site needs.

F.1.1.6 Operational Controls to Minimize Discharge into the Environment

Regardless of the foam type being used, facility personnel should evaluate the location of foam storage and fixed foam systems in relation to potentially sensitive receptors, such as bodies of water or off-property areas, and implement appropriate practices and facilities to reduce the likelihood of and contain spurious/accidental spills and discharges of foam concentrate and solutions.

Guidance on cleaning, collection, and segregation of fluorinated firefighting foam is provided in the steps below:

1) Thoroughly gravity drain and remove existing freestanding foam concentrate and solution from equipment (including mobile equipment, storage tanks, piping, etc.), and place in drums or totes for storage and disposal.

2) If changing from PFAS foam to C6 or SFFF, following gravity drainage, all equipment and piping shall be at least triple-rinsed with water and drained to enhance removal of residual PFAS foam.

3) Pending final disposal, collect and store securely in a bunded area all legacy foam concentrates and rinse water. The containers should be clearly labeled and separated by foam type to avoid misidentification.

4) Move PFAS foam and rinse water offsite, transported by an approved contractor and disposed via an appropriate destruction or immobilization method (e.g., high-temperature incineration, solidification, downhole injection) at an approved location.

5) Consideration should be given to pre-treatment of rinse water with a process such as one that uses granular activated carbon (GAC) in order to concentrate the PFAS-impacted waste.

F.1.1.7 Containment of Contaminated Fire Water/Foam Runoff

Regardless of the foam type being used, sites should assess their ability to collect contaminated water that is likely to be spent during training, testing, or firefighting scenarios. Containment capacity should be a component of site/company risk assessment. The containment plan includes site-specific practical information, such as containment locations and method of transfer. The plan may also include considerations for secondary containment in fixed storage areas.

Depending on foam used, used fire water may contain PFAS compounds following an emergency response incident. The site/company should have a plan in place to minimize soil and groundwater impacts. Options for disposal of fire water/foam runoff should exclude discharge directly to the water environment.

F.1.1.8 Disposal of Foam Concentrate, Foam Solution, Fire Water, Rinse Water, and Foam Contaminated Runoffs

Every site needs its own disposal procedure for waste and waste waters contaminated with foam. Procedures may vary between waste streams and foam type used. A site-specific environmental risk assessment may be used to assist the development of such a procedure that includes information on important receptors, such as nearby waterways. Some specific considerations for different foam types are outlined below:

a) SFFF:

— biological waste water treatment process may be sufficient for on-site treatment;

b) C8 legacy fluorinated foam and C6:

— must be disposed of through appropriate destruction or immobilization method (e.g., high-temperature incineration, solidification, downhole injection) at an approved location.

It is important for sites to consider the firefighting foam resources of its mutual aid group. It is possible that, in an emergency scenario, mutual aid firefighters will bring PFAS-containing foams to a fluorine-free site. Therefore, it is important for a site to plan for possible contamination even if it has completed its own fluorine-free transition. This must be considered in the overall environmental planning for handling of firefighting foams.

F.2 Sample Site Practice—Foam System Flushing Procedure

The foam system flushing procedure is a sample company practice that outlines the precautions that need to be taken, the equipment required, and the steps necessary to properly flush a foam system and all of the related plumbing, plus the foam tank, if required.

The sample site practice is not provided here as an industry best practice. It is simply an example practice provided by an individual company. The sample practice described below does not guarantee sufficient cleaning of equipment. Each site/company must determine the appropriate level of cleanness based on applicable regulations.

F.2.1 Foam Flushing Procedure

The foam system flushing procedure utilizes water and water softener[3] to flush out (wash away) foam concentrate from inside of and on the surfaces of the foam system plumbing, foam system plumbing components, foam pump, foam strainers, and foam tank. The flush procedure is done using a systematic, “top down” method, with an emphasis on using as little water and water softener as possible. All flushed-out foam, foam concentrate, water, and water softener (referred to as waste foam/water) must be recovered and disposed of properly. The facility will contract with approved vendors that will be used to vacuum, pump, transport, store, and dispose of the waste foam/water. Intentional discharge of waste foam/water onto the ground is prohibited, and every effort will be made to properly recover, contain, and dispose of the waste foam/water.

Personnel assigned to flushing projects must be familiar with the normal operation of the foam system and water pumping system being flushed. Additionally, they must have proper protective wear in order to protect themselves from exposure to the waste foam/water. Recommended safety equipment includes but is not limited to waterproof rubber boots/footwear, rubberized gloves, and ANSI-rated eye protection. Recommended equipment includes but is not limited to copious amounts of fresh water from a pressurized source, a supply of flushing water such as through a fire hose, a spill berm or permanent water catch area and storage basin, a pump system to move waste foam/water to a holding or transport tank, and a holding or transport tank.

[3] When provided to API, the original text of the sample flushing procedure specified the use of a name-brand fabric conditioner as the water softener additive.

Part 1: Drain/flush the foam system plumbing (major flush)

1) Place the apparatus on the containment berm or within the containment area. Set up and test the pump and hose lines that will be used to move the waste foam/water from the containment berm or area to the storage tank or transport tank.

2) Drain as much concentrate as possible from the foam system using gravity and air pressure. Water will be pushed through the foam pump during this procedure. It is recommended to operate the foam pump in manual control mode during this operation in order to improve the flow through the pump. Catch and properly dispose of any foam concentrate in a container separate from the waste foam/water that will be present during the remaining steps.

3) Flush the foam system plumbing with fresh pressurized water, starting with the foam intakes and foam concentrate discharges (if a foam tank drain/flush/wash is required, route the water from this process back into the tank using discharge hose lines).

4) Remove, clean, and visually inspect any and all foam strainers.

5) Flush all foamed discharges with fresh pressurized water by opening each metering valve and blocking valve, if applicable (if a foam tank drain/flush/wash is required, route the water from this process back into the tank using discharge hose lines).

6) Flush the foam tank fill valve and lines with fresh pressurized water only if a foam tank drain/flush/wash is required.

7) Drain the foam system.

8) Close all valves, metering valves, and blocking valves.

9) Remove, clean, inspect, and reinstall the foam vacuum breaker vents.

10) Briefly test the operation of the foam system foam pump in manual mode.

Part 2: Drain/flush/wash foam tank (if applicable and/or desired)

1) Drain the foam tank before adding water, preferably through a direct tank drain, if one is provided. If there is no tank drain, drain the foam tank through the foam inlets. Catch and properly dispose of any foam concentrate in a container separate from the waste foam/water that will be present during the remaining steps.

2) Close the drain(s) and run the discharge waste foam/water from the foam system flush procedure into the foam tank until the tank is full.

3) Add one bottle of chosen additive to the foam tank.

4) Agitate the waste foam/water in the tank. It is recommended to drive the truck to agitate the waste foam/water and water softener in the tank.

5) Drain the foam tank.

6) Continue the previous steps until the tank is clean.

7) Ensure that the tank has completely drained.

8) Close all drain valves and foam system valves going to or coming from the tank.

Annex G
(informative)

Plan for Transition

Review and understand the risks associated with the protected equipment, and develop a mitigation plan to provide risk reduction and/or provide equipment coverage using alternative protection.

Risk-reduction examples:

- Stop all loading or unloading of trucks or rail cars.
  - Review other planned work that may already lead to loading/unloading stoppages.
- Stop incoming receipts to affected storage tank(s).
- Storage tank planned outages.
- Discontinue loading/offloading of watercraft.
  - Review other planned work that may already lead to loading/unloading stoppages.
- Planned equipment turnarounds or outages.

Thoroughly review the type of foam system to determine methods to use as much of the fixed foam system to maintain coverage to protect equipment.

Alternative protection examples:

- Fixed system bypass loop through fire department connection.
- Portable firefighting equipment, including water monitors, pumping equipment, foam, and manpower.
- If the facility does not have a fire brigade and the necessary equipment to provide standby coverage, it may be necessary to contract with a third party.
  - If you have not used the services of a third party, this will need to be worked through your contracting department.
  - Consider having a site visit with a third party to fully review and develop a written plan that describes the needed equipment, pressure and flow rates, foam needed, water supply, and equipment logistics.
- If a foam system outage involves isolation of the water supply, plan an alternative supply.
  - This may require a separate discussion with the water provider.
  - This may require a separate permit and water meter for usage.
- Schedule a meeting with local fire authorities.
  - Review the planned activities and provide necessary testing data for new SFFF.
  - Provide and discuss the risk reduction and/or alternative protection plan.
    - Consider having a site visit with local fire authorities to fully review changeout activities and overall plans.

    - Discuss the interaction between the fire department and third-party resources, if used, should an event occur.

- Understand the local plan/permit submittal process.
  - Number of sets of plans and or drawings
  - Any costs for the review and inspections
  - Expected approval timeline (could be weeks to months)
- Discuss the commissioning/testing process to fully understand the requirements and assurances
- Develop the necessary plans and permit documents for submittal.

References

Some material in the annexes is being used with special permission from:

— the LASTFIRE consortium (some material came from their Foam Assurance Guidance);

— API member companies; and

— The Fire Protection Research Foundation research study, “Evaluation of the Fire Protection Effectiveness of Fluorine Free Firefighting Foams.”

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