Fire Suppression Systems Association

FSSA FOAM FACT SHEET

1. SCOPE

The firefighting foam industry is currently confronted with rapidly changing regulations on the use, testing, and disposal of AFFF foams and compliance with environmental regulations surrounding AFFF foam concentrates systems. Many FSSA members are stakeholders in the regulatory outcomes associated with AFFF foam. The scope of this fact sheet is to help educate and prepare the FSSA membership by providing current information on the issues and changes that are taking place. Additional information is available from the Fire Fighting Foam Coalition: https://www.fffc.org.

2. DEVELOPMENT/HISTORY

In 1902 Aleksandr Loran, a Russian engineer and chemist intrigued by the difficulty of extinguishing flammable liquid fires was determined to find a liquid substance for firefighting. In 1903 he succeeded in creating a firefighting foam.

The original foam mixture included water and two powders, sodium bicarbonate and aluminum sulfate. Small amounts of saponin or licorice were added to stabilize the foam bubbles. The chemical reaction in a foam generator produced frothy foam and carbon dioxide gas, hence the name Chemical Foam.

Chemical Foam found use in both firefighting systems and hand-held extinguishers. Although hand-held extinguishers used the same chemicals as firefighting systems, the chemicals were maintained as separate solutions. As a result, the user had to invert the extinguisher to promote mixing and create foam and carbon dioxide gas.

Chemical foam is a stable solution of small bubbles containing carbon dioxide. Chemical foam is characterized by a lower density than oil or water and its ability to cover flat surfaces uniformly. Because it is lighter than the burning liquid, it flows freely over the liquid surface and extinguishes the fire by a smothering (removal of oxygen) action. Chemical foam became obsolete as firefighting foams continued to evolve.

3. TYPES OF FOAM

Class A Foams were developed in the mid-1980s for fighting wildfires. Class A foams lower the surface tension of water, thereby assisting in the wetting and saturation of Class A fuels with water. Wetting the fuels aids fire suppression and can prevent reignition. In addition, favorable experiences in fighting wildfires led to the acceptance of Class A foams for fighting other types of Class A fires, including structure fires.

Class B Foams are designed for use on class B fires—flammable and combustible liquids. The use of Class A foam on a Class B fire may yield unexpected results, as Class A foams are not designed to contain the explosive vapors produced by flammable liquids. Class B foams have two major subtypes - synthetic foams and protein foams.

Synthetic foams

Synthetic foams are produced using synthetic surfactants. Synthetic foams can knock down flames faster than protein foams because the surfactants allow for smooth flow and "spreading" over the surface of most Class B liquids. However, synthetic foams offer limited post-fire security and are toxic groundwater contaminants. The following are types of synthetic foams:

Aqueous Film Forming Foams (AFFF) are water-based. They frequently contain hydrocarbon-based surfactants such as sodium alkyl sulfate and fluorosurfactants, such as fluorotelomers, containing poly or perfluorinated alkyl substances (PFAS). AFFF foam concentrates are intended for the extinguishment of hydrocarbon or non-miscible[1] type fuel fires only.

Alcohol-Resistant Aqueous Film Forming Foams (AR-AFFF) contain a polymer that forms a protective layer between the burning fuel surface and the foam blanket, preventing foam breakdown by polar solvent (miscible) fuels. Alcohol-resistant foams are used on burning fuels containing oxygenates, e.g., methyl tert-butyl ether (MTBE), or fires of liquids based on or containing polar solvents. In addition, AR-AFFF foam concentrates are intended to extinguish fires burning polar solvents (miscible type fuels), hydrocarbons (non-miscible type fuels), or a combination of both types.

Synthetic Fluorine Free Foams (SFFF) do not contain fluorinated surfactants or compounds. The active ingredients may vary significantly depending on the foam manufacturer. SFFF foams are available for the protection of hydrocarbon-based and polar solvent fuels.

Protein foams

Protein foams contain natural proteins as foaming agents. Unlike synthetic foams, protein foams readily break down in the environment. Protein firefighting foam concentrates are formulated with naturally occurring hydrolyzed proteins combined with foam stabilizers, bactericides, corrosion inhibitors, anti-freeze additives, and solvents. Protein-based firefighting foams provide a robust foam blanket for Class B fire and vapor suppression. Typical uses include onboard marine systems, oil and gas tank farms, refineries, and storage facilities.

Fluoroprotein Foam (FP) and alcohol-resistant fluoroprotein (AR-FP) are a foam concentrates containing fluorinated surfactants in a carefully formulated protein foam liquid base. This formulation ensures the production of stabilized fluid foam, which will cover a burning hydrocarbon fuel surface rapidly. In addition, the water-soluble fluorosurfactant makes the foam hydrocarbon repellent and reduces the amount of burning particles absorbed by the foam in fighting hydrocarbon fuel fires.

Film-forming fluoroprotein (FFFP) and alcohol-resistant film-forming fluoroproteins (AR-FFFP) foams additionally provide a film layer over the fuel. This film layer separates the fuel from the flames to aid in extinguishment.

---

[1] In this discussion, liquids which dissolve in water are considered "miscible" fuels while liquids that to not dissolve in water are considered "non-miscible" fuels. Typically, polar solvents are miscible while hydrocarbons are non-miscible.

4. FOAM APPLICATIONS

Foam system selection includes consideration of the fuel to be extinguished and the available method of applying finished foam to extinguish the fire.

- Film-forming foams (FF, AFFF, FFFP) are best for spills or in-depth non-polar solvent fuel fires;
- Alcohol resistant versions (AR-AFFF, AR-FFFP) are required for burning alcohols.

Low-expansion foams are used on burning spills. Low-expansion foams, such as AFFF, have an expansion rate less than 20:1, flow freely over a surface, and can quickly cover large areas.

Common Hazards protected with Low-Expansion Foam Systems

- Aircraft Hangers (NFPA 409 or UFC)
- Dike Protection/Tanks (NFPA 11)
- Flammable Liquid Storage Facilities (NFPA 30)
- Loading and unloading areas (NFPA 11)
- Flammable Liquid Process areas (NFPA 11, NFPA 16)
- Marine (NFPA 11, US Coast Guard - USCG)
- Roof top Heliport (NFPA 418)

Medium and High-expansion foams are used when an enclosed space must be quickly filled. Medium-expansion foams have an expansion ratio greater than 20:1 and less than 200:1. High-expansion foams have an expansion ratio over 200:1.

Common Hazards protected with Medium-Expansion Foam Systems

- Some plastic or tire fires (Mobile Equipment, NFPA 11)
- Smoldering fires (Mobile Equipment, NFPA 11)
- Channels, pits, dikes (NFPA 11)

Common Hazards protected with High-Expansion Foam Systems

- Aircraft Hangers (NFPA 409 or UFC)
- Tire Storage (NFPA 13 and NFPA 11)
- LNG Facilities (NFPA 11) Total Flooding (NFPA 11)

5. WHY DOES FOAM WORK SO WELL?

Foam has been one of the best weapons used to combat flammable and combustible liquid fires. It has been recognized, accepted and, in many situations, it is the preferred method of fighting fires by property owners, underwriters, municipalities, and governments for the following reasons:

- Foam provides rapid extinguishment, burn-back resistance, and protection against vapor release.
- Foam blankets the fuel surface and smothers the fire.
- Foam separates the flames and ignition source from the fuel surface.
- Foam cools the fuel and surrounding surfaces.
- Foam suppresses the release of flammable vapors that can mix with air.

6. US STANDARDS AND REGULATIONS

FM Global (FM)
NFPA 11 - Standard for Low-, Medium-, and High-Expansion Foam
NFPA 16 – Standard for Installation of Foam–Water Spray Systems
NFPA 30 - Flammable and Combustible Liquids Code
NFPA 409 - Standard on Aircraft Hangars
NFPA 418 – Standard for Heliports
UFC - United Facilities Criteria 3-600-01 and 4-211-01 Aircraft Maintenance Hangars
US Military
US Coast Guard (USCG)

7. PUBLIC HEALTH CONCERNS

There has been a growing concern regarding the presence and use of a family of man-made chemicals known as poly- and perfluoroalkyl substances (PFAS) and their reported effect on public health. The most widely produced and studied PFAS chemicals are Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonic Acid (PFOS), which are found in a wide variety of household and consumer products and some firefighting foams. These PFAS chemicals include carbon chain molecules that are among the strongest chemical bonds known to science and tend to resist environmental breakdown. To begin addressing the issue, the EPA launched a stewardship program to manage PFOA production in the United States. PFOS was the by-product of one manufacturer's production process, which was ceased in 2002.

> **Note:** "C_8" refers to the maximum number of carbon atoms (8 carbon atoms) linked together in a perfluorinated molecular composition carbon chain length. "C_6" refers to a perfluorinated molecular composition carbon chain length with the number of carbon atoms less than or equal to 6. The EPA looks at fluorosurfactants that are C_8 to have the following traits and to be issues in the environment: ***Persistence, Bioaccumulation, and Toxicity (PBT)***. C_6 type molecular structures are, for the most part, only ***Persistent (P).***

Under the EPA 2010/15 PFOA Stewardship Program, eight international fluorochemical manufacturers voluntarily agreed to reduce plant emissions and product content of PFOA, PFOA precursors, and related higher homologue chemicals (fluorochemicals with a carbon chain length of C_8 or above) by 95% by year-end 2010, and work towards total elimination by the end of 2015. This also included some of the fluorosurfactants contained in AFFF agents. In response, AFFF manufacturers began reformulating their products to contain only C_6 fluorosurfactants. Because AFFF agents historically contained predominantly C_6 fluorosurfactants, the new products were usually compatible with existing products, providing a seamless transition that did not generally require system or equipment changes.

In recent years, several states have passed laws that further restrict the sale and use of AFFF. These laws are focused on eliminating the use of PFAS (per- and polyfluoroalkyl substances), which include the C_6 fluorosurfactants that are key ingredients in AFFF. See www.fffc.org for information on some of these laws. PFOA is in the family of chemicals that falls under the category of PFAS. The inclusion of PFAS restrictions will require more changes to testing and refilling procedures that are not included in the current Stewardship Program. Some of the laws restrict only the use of AFFF for testing and training, while others have restrictions on the sale of AFFF. In addition, best practice for AFFF use now calls for the collection of foam and firewater and disposal by high-temperature incineration or other approved methods.

In response to these changes, some users will be transitioning to Class B fluorine-free foams. Fluorine-free foams do not contain fluorosurfactants, do not form a film on hydrocarbon fuels like AFFF, and are generally less effective. Transitioning to the use of fluorine-free foams may require equipment or system changes and will require existing equipment (if intended for reuse) to be drained, flushed, and cleaned of all existing AFFF concentrates.

Foam standards and listings are still being developed to address the use of fluorine-free foams properly.

8. REASONS FOR CHANGE

Under the EPA's voluntary PFOA Stewardship Program, some PFOA manufacturers included an agreement to reformulate certain foam agents that utilized the C_8 PFAS chemicals into agents that use C_6 PFAS while still maintaining firefighting efficacy. This phased approach has resulted in most US-based foam manufacturers no longer producing foam agents containing C_8 PFOA chemicals in favor of C_6 reformulated versions.

It is important to note that while the aqueous film-forming foam family of foam agents (commonly represented as AFFF or AR-AFFF), Fluoroprotein (FP), and Film Forming Fluoroprotein (FFFP) foam agents contain PFAS, not all firefighting foams contain PFAS chemicals.

9. TRANSITION AND REPLACEMENT TO C6 FLUOROSURFACTANTS AND FLUORINE-FREE FOAMS

Because the regulations surrounding PFAS concentrates are currently evolving, it is important to check with foam agent manufacturers and federal, state and local laws and regulations (hereinafter "government laws and regulations") about current requirements before planning testing or replacement of system equipment.

An engineering assessment for compatibility with the original system design is imperative. Product lines from the same manufacturer can require vastly different designs for the same hazard. Approvals and certifications are foam concentrate specific and may not be valid if concentrates are mixed or changed. The published approval or listing for the individual foam concentrates must be consulted.

CAUTION!
Each manufacturer of firefighting foams will have differing recommendations and requirements for replacing or refilling foam concentrates that contain C_8 PFAS. For specific mixing or replacement recommendations, please consult the appropriate foam concentrate manufacturer. In situations where re-formulated C_6 concentrates are necessarily mixed with older C_8 versions, manufacturers should have tested the mixture for compatibility. Combining any foam concentrates that are not formulated according to the same specifications and tested by the manufacturer is not recommended.

Below are general requirements and details in common for all foam manufacturers participating in the EPA PFOA Stewardship program:

- Different types of foam concentrates should never be mixed. (For example, do not mix 3% AFFF with a 1% AFFF).
- Mixing reformulated C_6 concentrates with older C_8 concentrates may not be in accordance with the 2015 EPA PFOA Stewardship program.

- Concentrates that are a mixture of newer agents with older agents are considered the same agent as the oldest agent. For example, adding a C_6 to a formally C_8 system tank would result in a mixture that is considered to be C_8.
- Annual testing of foam concentrates to relevant standards should be completed.
- Approvals and certifications are foam concentrate specific and may not be valid if concentrates are mixed or changed. The published approval or listing for the individual foam concentrates must be consulted.
- An engineering assessment for compatibility and performance with the original system design is required.
- When transitioning to a replacement foam concentrate, the existing foam concentrate must be captured and disposed of in accordance with the manufacturer's guidelines and government laws and regulations.

When handling, capturing, and testing AFFF, consider the following:

- Avoid foam discharge into the open environment, including storm drains and any potential runoff onto the ground.
- Firefighting foam is highly mobile on the ground and in water. Therefore, discharge into the open environment may lead to contamination of groundwater drinking sources, which would conflict with the Safe Drinking Water Act.
- Some foams may contain high aquatic toxicity substances and could lead to high death rates of aquatic organisms.
- Check the Safety Data Sheet (SDS) for specific safety considerations.
- Follow the final requirements of AHJs and government laws and regulations.

WARNING!
Some firefighting foams contain PFAS chemicals that have been linked to adverse health conditions.

10. PERSONAL PROTECTIVE (PPE) REQUIREMENTS FOR HANDLING OF AFFF

Technicians can perform different tasks when installing, testing, or maintaining an AFFF system.

- To properly evaluate the potential hazards, a Job Safety Analysis (JSA) should be performed. The JSA must assess each task being performed and consider the potential for AFFF exposure. Refer to the SDS for the agent.
- To avoid contact with skin, technicians should wear rubber gloves, long sleeves or Tyvek coverings, and, as necessary, a face shield. If AFFF comes in contact with skin, it should be washed off.
- Ingestion of AFFF must be avoided.
- Check the Safety Data Sheet (SDS) for specific safety considerations.
- Final requirements of AHJs and government laws and regulations must be followed.

11. SYSTEM TESTING

Maintaining existing AFFF systems under the new regulations requires a deliberate focus on managing the water and test solutions discharged from the systems. Know your government laws and regulations regarding testing, containment, treatment, and disposal of PFAS solutions generated during the test and maintenance of these systems.

In most cases, the AFFF solutions discharged during the test should be controlled with a direct connection to a containment vessel, i.e., direct connection from your AFFF test header to the containment vessel. So, essentially, a closed-loop test configuration is required.

NFPA and FM address alternative testing methods that allow for testing that reduces the consumption of AFFF and PFAS waste streams.

Surrogate Liquid testing and Water Equivalency testing methods are recognized in NFPA 11. Currently, FM Approvals has tested and certified two testing companies' procedures referenced in FM Data Sheet 4-12 Foam-Water Sprinkler Systems as accepted means of testing without the use of AFFF. While FM Approvals has certified these alternative methods, NFPA 11 contains language questioning Water Equivalencies' ability to replicate system performance of AR-AFFF systems due to the viscosity characteristics of the AR concentrates.

While these testing methods nearly eliminate the AFFF/PFAS substances generated, there is still a small amount of AFFF concentrate displaced from the concentrate line that will need to be managed to comply with specific government laws and regulations.

Existing AFFF systems will have to trace PFAS throughout the piping and equipment connected to the system. Water generated through testing, surrogate testing, and water drained/flushed from these systems should be assumed to contain trace PFAS. How the contents of the discharges are disposed of is currently determined by the State or local AHJ's. It is important to familiarize yourself with the current municipal regulations for these discharges to ensure you follow state and AHJ rules.

12. SUMMARY

The benefits of firefighting foam solutions are invaluable to our current infrastructure environment. However, the environmental issues that have been found with AFFF/PFAS are causing manufacturers to develop alternate solutions. Alternatives have been created that are environmentally non-hazardous, and these approaches are recommended and, in some cases, required. Additionally, there may be modifications required for existing systems to use these solutions. Please check with the applicable manufacturer to ensure the proper procedures are being followed. Finally, make sure you check with your government authorities for current laws and regulations related to these firefighting foams.

13. REFERENCES

Testing FOAM systems – Acceptance Testing/Maintenance/Inspection

NFPA 11
NFPA 11 (2021), Annex D.5.2, Tests Using Alternative Listed and Approved Methods
NFPA 16
NFPA 25
NFPA 409
NFPA 418

FM Global Data Sheet 4-12, Section 2.5.6.1.1, Proportioning Systems

14. FOR ADDITIONAL INFORMATION

Please contact:

Fire Suppression Systems Association (FSSA)
3601 East Joppa Road, Baltimore, MD 21234
admin@fssa.net