Aqueous Film-Forming Foam (AFFF)

1 Introduction

Aqueous film-forming foam (AFFF) is a highly effective firefighting product intended for fighting high-hazard flammable liquid fires. AFFF products are synthesized by combining hydrocarbon foaming agents with fluorinated surfactants to achieve a product that has been used at military installations, civilian airports, petroleum refineries, bulk storage facilities, and chemical manufacturing plants (Hu et al. 2016; CONCAWE 2016).

This fact sheet targets local, state, and federal regulators and tribes in environmental, health and safety roles, as well as AFFF users at municipalities, airports, and industrial facilities, and is not intended to replace manufacturer specifications or industry guidance for AFFF use. The information provided is a high-level summary on AFFF use, the associated hazards, and how to reduce and eliminate potential harm to human health and the environment. Additional information is available in the Guidance Document.

ITRC has developed a series of fact sheets that summarizes recent science and emerging technologies regarding PFAS. The information in this and other PFAS fact sheets is more fully described in the ***ITRC PFAS Technical and Regulatory Guidance Document (Guidance Document)*** (*https://pfas-1.itrcweb.org/*).

This fact sheet outlines methods to properly identify, handle, store, capture, collect, manage, and dispose of AFFF to limit potential environmental impacts, and includes:

- Definition of AFFF
- Best Management Practices for AFFF use
- Regulations Affecting Sale and Use
- Foam Research and Development

2 What is AFFF?

Class B firefighting foams are commercial surfactant solutions that are designed and used to combat Class B flammable fuel fires. For the purpose of this fact sheet, Class B foams can be divided into two broad categories: fluorinated foams that contain PFAS and fluorine-free foams (F3) that do not contain PFAS.

There are six groups of Class B foams that contain PFAS and four groups of Class B foams that do not. Figure 1 illustrates all categories of Class B foams. This fact sheet focuses on AFFF because it is the most widely used and available type of Class B foam.

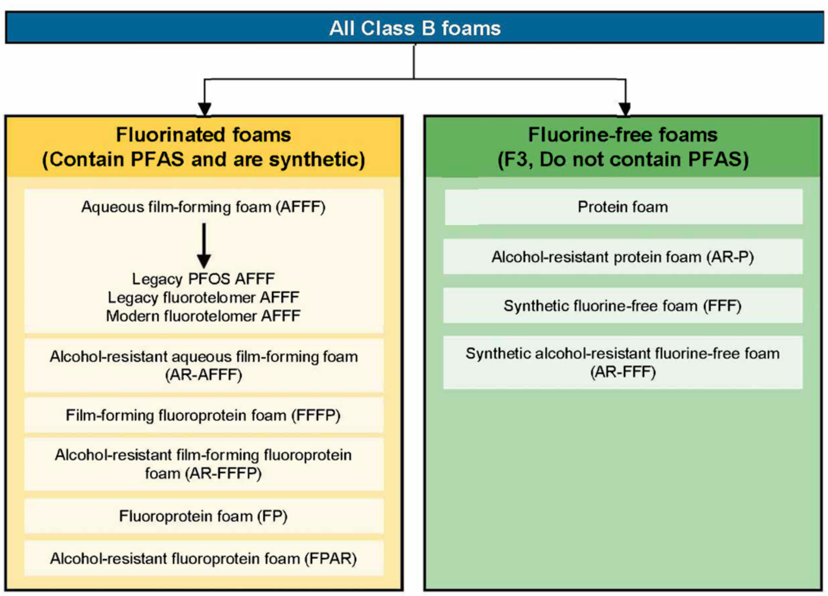

Figure 1. Types of Class B foams.
Source: S. Thomas, Battelle. Used with permission. PFAS-1, Figure 3-2.

AFFF is a fluorinated foam and when mixed with water, the resulting solution achieves the interfacial tension characteristics needed to produce an aqueous film that spreads across the surface of a hydrocarbon fuel (petroleum greases, tars, oils, and gasoline; and solvents and alcohols) to extinguish the fire and to form a vapor barrier between the fuel and atmospheric oxygen to prevent re-ignition. This film formation is the defining feature of AFFF.

AFFF has been used at chemical plants, flammable liquid storage and processing facilities, merchant operations (oil tankers, offshore platforms), municipal services (fire departments, firefighting training centers), oil refineries, terminals, and bulk fuel storage farms, aviation operations (aircraft rescue and firefighting, hangars), in some industrial fire extinguishers, and military facilities.

There are three types of AFFF. Each is presented in Figure 1:

- legacy PFOS AFFF (manufactured in the US from the late1960s through 2002)
- legacy fluorotelomer AFFF (contain some long-chain PFAS) (manufactured in the US from the 1970s until 2016)
- modern fluorotelomer AFFF (short-chain PFAS became the predominant fluorochemicals used in manufacturing in response to USEPA 2010/2015 voluntary PFOA Stewardship Program)

Most foam manufacturers now produce Class B F3s, and evaluation of the performance of these foams is an important consideration for future purchase decisions. As part of preplanning for replacement foams, it is important to ensure that the Class B F3 is an adequate substitution for AFFF and can achieve the required performance specifications for the target flammable liquid hazards (FFFC 2016).

The NDAA of fiscal year 2020 (signed into law Dec 20, 2019) requires the DOD to phase out its use of AFFF at all military installations by Oct. 1, 2024, with limited exceptions, and immediately stop military training exercises with AFFF. In January 2023, the secretary of the Navy published specifications for PFAS-free firefighting foam; it is referred to as the performance specification for F3 land-based fresh water applications (MIL-PRF-32725). This latest specification requires manufacturers to certify that PFAS has not been intentionally added to the formulation and that the concentrate contains a maximum of 1 ppb of PFAS (USDOD 2023 Ref#2848). Per the NDAA, F3 that meets this new military specification is required to be available for use by Oct. 1, 2023. The NDAA of fiscal year 2022 also addresses AFFF, specifically requiring new reviews and guidance to prevent and mitigate AFFF spills. In October 2021, the USEPA published the PFAS Strategic Roadmap: EPA's Commitments to Action 2021–2024 (USEPA 2021 Ref#2223). The USEPA's stated goals for addressing PFAS are focusing on research, restriction, and remediation. The strategic roadmap includes actions across the different divisions of USEPA. More information about USEPA's actions in 2021 to address PFAS are available on their website (USEPA 2021 Ref#2223).

3 Best Management Practices (BMPs) for Class B Foam Use

Firefighting foams are an important tool to protect human health and property from flammable liquid fire threats. Proper management and usage strategies combined with the ongoing refinement of environmental regulations will allow an informed selection of the viable options to sustainably use firefighting foams. BMPs should be established for the use of any firefighting foam to prevent possible releases to the environment that can lead to soil, groundwater, surface water, and potentially drinking water contamination. The discharge of firefighting foams to the environment is of concern because of the potential negative impact they can have on ecosystems and human health. AFFF, due to the presence of PFAS, poses a unique challenge to protecting the environment when it is released. Specifically, for AFFF, the amount of PFAS from foam that may enter groundwater depends on the type and amount of foam used, the degree of containment, when and where the foam was used, the type of soil and the depth to groundwater. AFFF is typically discharged on land but can run off into surface water or stormwater or infiltrate to groundwater. A conceptual site model (CSM) is presented in Figure 2.

BMPs start with pre-planning and deciding which foam to keep in stock. The team should consider key factors such as these:

- Whether F3 alternatives can meet site-specific performance requirements
- Site-specific evaluation of likely fire hazards and potential risks for life, public safety, and property
- Potential environmental, human health, and financial liabilities associated with AFFF releases
- Site constraints, including existing equipment retrofit requirements to adapt to alternate foams

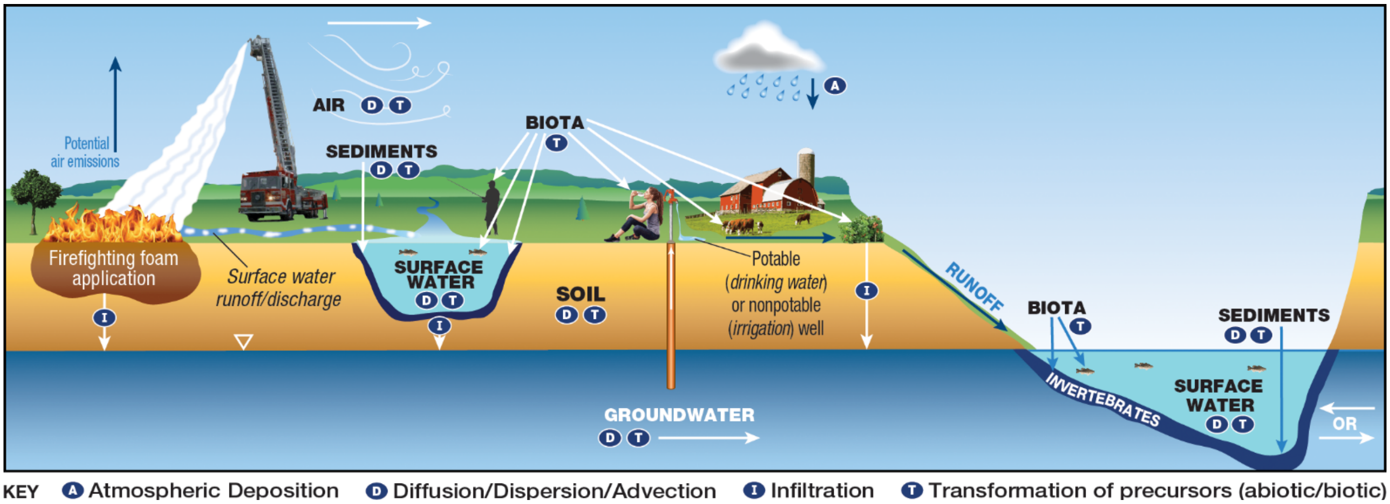

Figure 2. CSM for fire training areas.

Source: Adapted from figure by L. Trozzolo, TRC. Used with permission. PFAS-1, Figure 2-21.

BMPs should consider the entire life cycle for AFFF, Figure 3, including procurement and inventory, foam systems and operations, emergency firefighting operations, immediate investigative and clean-up actions, treatment and disposal and system replacement. Other foams such as alcohol-resistant foams (AR-AFFF), film-forming fluoroprotein foams (FFFP), alcohol-resistant film-forming fluoroprotein foams (AR-FFFP), fluoroprotein foam (FP), and alcohol-resistant fluoroprotein foam (FPAR), also contain PFAS and similar precautions and considerations should be taken. While F3 does not contain intentionally-added PFAS, some F3 may contain other additives or chemicals that could be harmful to the environment or human health. As such, any training involving any type of foam should also consider the mitigation measures established for AFFF.

The procurement and inventory of foam should be carefully considered. Foams should be selected that meet the performance specification requirements governing the use. Foams procured should be documented, labelled clearly and adequately contained. Foam use and disposal should be carefully tracked and recorded.

When evaluating foam systems and operations, from fixed-system testing, mobile firefighting equipment testing and appropriate training exercises, engineering and administrative controls as well as personal protective equipment (PPE) should be carefully evaluated. During emergency firefighting operations following a release of firefighting foam, PPE should be used correctly, maintained, and decontaminated routinely. Immediate investigative and clean-up actions include initial mitigation efforts such as source control, containment tactics, and recovery tactics.

Figure 3. Life cycle considerations for Class B Foams.

Source: S. Thomas, Battelle. Used with permission. PFAS-1, Figure 3-1.

The treatment and disposal of AFFF products and environmental media impacted with PFAS can be complex, time consuming, and costly. Practitioners should be aware of approved and available disposal options prior to the generation of PFAS-impacted waste or the start of an AFFF replacement project to avoid potentially lengthy waste storage timeframes. Currently, available disposal options for AFFF and PFAS-impacted materials are limited and each option has its advantages and disadvantages. More information is in the Guidance Document, as well as in the PFAS Regulatory Programs Summary Table (see the External Data Tables on https://pfas-1.itrcweb.org).

Firefighting foam replacement is complex and could require a complete system review and, potentially, redesign and modification of system components to meet the new objectives or material and performance requirements. Foam replacement should include an evaluation of specific hazards and application objectives, a review of applicable performance standards, an understanding of engineering requirements for foam product storage and application, and a check to ensure that the foam product is approved for use for the specific hazards being mitigated.

4 Regulations Affecting the Sale and Use of AFFF

There are many State, Federal, and International regulations and guidance documents governing the procurement, use, and disposal of AFFF. Activities range from AFFF take-back programs and prohibition of manufacture, sale, use, and import of AFFF through to restrictions and requirements for disposal. More information is in the Guidance Document, as well as in the PFAS Regulatory Programs Summary Table (see the External Data Tables on https://pfas-1.itrcweb.org).

5 Foam Research and Development

A substantial amount of research related to AFFF alternatives and replacement chemistries has recently been completed or is being considered at the time of publication. Several organizations globally have made investments in research and development around AFFF from the assessment of their use, environmental impacts, as well as socioeconomic impacts of transiton to and performance specifications of F3 alternatives. For more information related to this topic, please refer to the Guidance Document.

6 Alternatives Considerations

Some organizations have developed certification processes to help consumers understand which products are considered “PFAS-free.” For example, Clean Production Action (CPA) developed anecolabel for firefighting foam products via their GreenScreen certification process, which identifies products as eco-labeled but does not include a release of liability. CPA defines PFAS-free as zero PFAS intentionally added to the product and PFAS contamination in the product less than 0.0001 percent by weight of the product (1 part per million) total organic fluorine. There are currently more than two dozen certified firefighting foam products available. Go to https://www.greenscreenchemicals.org/certified/fff-standard for more information.

Alternatives assessments have been another mechanism to further evaluate F3 alternatives in terms of regrettable substitution., Tickner (2022) recently completed an alternatives assessment for AFFF and developed six guiding considerations, including:

1. “Determine the function of the chemical of concern for the specific application. Understand this function within the production chain.
2. Define the application-specific use scenario(s). Identify alternatives that are fit for that particular purpose.
3. Establish and/or use performance standards independent of the standards dependent on using chemicals/materials of concern. Adjust based on available alternatives or alternatives on the horizon.
4. Use a range of performance standard benchmarks, e.g., ‘inadequate’ to ‘sufficient’ to ‘best in class.’
5. Consider technical performance separately from technical feasibility.
6. Consult stakeholders for determining acceptable tradeoffs between performance results and other elements such as environmental health and safety.”

7 References and Acronyms

The references cited in this fact sheet and further references can be found at https://pfas-1.itrcweb.org/references/. Reference numbers are included in this fact sheet for non-unique citations in the Guidance Document reference list.The acronyms used can be found at https://pfas-1.itrcweb.org/acronyms/.

Per- and Polyfluoroalkyl Substances (PFAS) Team Contacts

Sandra Goodrow • New Jersey Department of Environmental Protection
609-940-4164 • Sandra.Goodrow@dep.nj.gov

Kristi Herzer • Vermont Department of Environmental Conservation
802-461-6918 • Kristi.Herzer@vermont.gov

September 2023

ITRC
1250 H St. NW, Suite 850
Washington, DC 20005
itrcweb.org