PFAS Use in Fire Fighting Foams: Evolution of Fire Fighting Agents and Critical Decision Criteria

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Introduction

Over the past 10-15 years and particularly the past two, fire fighting foam agents of all types – Fluorine-free (FFF) and Fluorinated (AFFF) – have been a) under attack, b) in the news, c) sources of activist campaigns, d) the focus of academics globally as well as regulators and new regulations in various countries, e) their performance debated, f) the focus of significant research and development activities to produce the most effective and more sustainable short-chain fluorotelomer-based agents and g) the focus of industry and industry groups to provide safer and best practice handling guides. In addition to AFFF, fluorinated surfactants and repellents of all types and chain lengths have been scrutinized for their toxicological properties, their environmental fate and effects (EF&E), their PBT properties and lately their Persistence (P) and Mobility (M) properties and been questioned whether they are needed at all in any applications. The objective of this poster discussion will be to establish where these valuable fluorinated products are needed and where they should be used – and not. The environmental impacts of smoke and combustion products must also be considered. We suggest there needs to be a balance struck between uses of the precautionary principle, a risk-based approach and required performance/value-in-use. This balance or holistic viewpoint, which will be explored here, is often cast aside in favor of emotion or cause.

Evolution of Fire Fighting Agents

Water → Chemical → Mechanical → AFFF: 'Lightwater' by 3M

None | None | None | ECF-based Long Chains 1960's on — Approx 1 – 3.2% | PFAS F Content

FT- based AFFF | Modern FFF | Fluorotelomer-based AFFF

Telomer-based all C6 Short Chains 2015 on — Approx 0.4 – 1.5% | Fluorine Free Class B Foams 2000's on — None | Telomer-based Short Chains 1970's on — Approx 0.6 – 1.5% | Telomer-based Long Chains 1970's on — Approx 0.6 – 1.5% | PFAS F Content

The poster author is a former employee of both DuPont and Chemours and is currently working with both the FluoroCouncil and the Fire Fighting Foam Coalition in a science , regulatory advocacy and consulting capacity

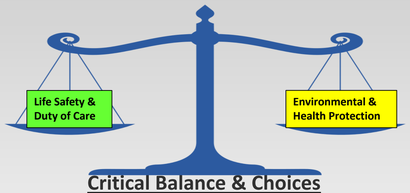
Toxicology and Product Safety

PFHx(A) Summary

- Not damaging to DNA, not genotoxic or mutagenic
- Not a selective developmental or reproductive toxicant
- Not carcinogenic
- Rapid bioelimination, not bioaccumulative
- Not expected to be harmful to human health or the environment at environmentally relevant concentrations

Elimination Half Lives in Plasma

Elimination $t_{1/2}$ (Days)	short-chain			long-chain		
	PFBA	PFBS	PFHxA	PFHxS	PFOA	PFOS
Rat	0.3	0.2	0.2 – 0.05	7	5	25
Monkey	2	4	1	100	21	45
# Fluorinated Carbons	3	4	5	6	7	8

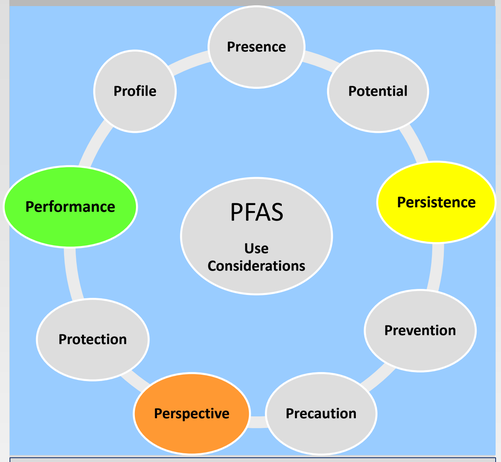


Critical Balance & Choices

The Coordinated Campaign Against Fluorine

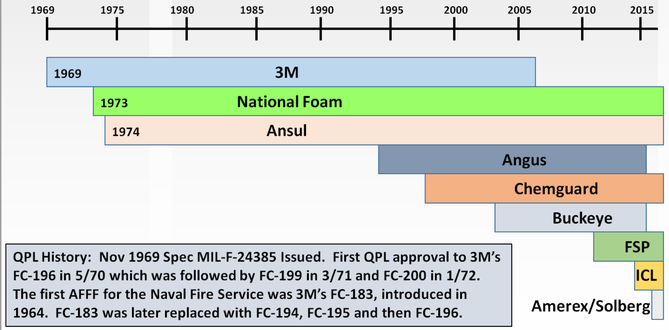
- Shift from PBT (all 3) to PB(M)&T (2 of 4) to just P!!
- Regulate/classify PFAS as a Single Category – Grouping
- Definition is evolving from *PFOA/PFOS->Short Chains -> PFAS->Fluorine*
- Goal to Eliminate All Fluorinated Substances
- Claims Unjustified as they Ignore Robust Body of Peer-Reviewed Data; Use Opinion and Speculation in Place of Science and Facts
- Blur the World of PFAS Chemistry; Ignore Best Practices

P's: How Do You Chose What's Important



The Conversation has Shifted from Performance - to Presence and Persistence is all that Matters. Perspective is Critical. Users of PFAS Products Must Consider the Tox Profile, the Potential for Exposure, Prevention of Emissions, Protection of People, Property and the Environment and Use of Risk-based Analysis vs the Precautionary Principle

QPL Products and Suppliers



QPL History: Nov 1969 Spec MIL-F-24385 Issued. First QPL approval to 3M's FC-196 in 5/70 which was followed by FC-199 in 3/71 and FC-200 in 1/72. The first AFFF for the Naval Fire Service was 3M's FC-183, introduced in 1964. FC-183 was later replaced with FC-194, FC-195 and then FC-196.

From NRL Report 7437, July 20, 1972

PFAS: Perfluoroalkyl Substances; PFHx: Perfluorohexanoate; PFHxS: Perfluorohexane Sulfonate

Foam Selection – Comparison of AFFF vs FFF

Foam Property [1]Includes Short-chain AFFF	Advantage	AFFF[1]	FFF
Fuel Repellency	Yes	Yes	No
Film Formation	Yes	Yes	No
Foam Spreading on Fuel	Yes	Yes	No
Fuel Spreading on Foam	No	No	Yes
Fuel Shedding	High	High	Low
Fuel Pickup	Low	Low	High
Fuel Emulsification	Low	Low	High
Flammability of Contaminated Foam	Low	Low	High
Degradation of Contaminated Foam	Low	Low	High
Heat Resistance of Foam	High	High	High

AFFF Summary: What Best Practice Guidance Means:

1. Fluorinated Class B foams should only be used in situations that present a significant flammable liquid hazard, where their superior performance and unique film-forming properties are required. Before deciding to use fluorinated Class B foam for a specific hazard, investigate whether other non-fluorinated products [Fluorine Free Foam (FFF)] can achieve the required extinguishment and burnback resistance.
2. Use training foams that do not contain fluorosurfactants for training purposes. And use surrogate liquid test methods that do not contain fluorosurfactants for testing fixed system and vehicle foam proportioning systems. Follow applicable industry standards for design, installation, maintenance, and testing of foam systems.
3. Provide for containment, treatment, and proper disposal of foam solution – do not release directly to the environment. Develop firewater runoff collection plans for the use of fluorinated Class B foam; and all foams for that matter. Plan system testing so as to properly contain and dispose of foam solution effluent generated by the tests.
4. Minimize foam releases from fixed systems as a result of accidental discharges by using approved detection/control systems and proper maintenance of the system. Develop plans for dealing with unplanned releases of foam concentrate or foam solution so as to minimize the environmental impact. Alternative techniques and agents must be evaluated well in advance of an emergency situation that requires urgent response.
5. Disposal: for Firewater one should consider either incineration or other available collection/segregation techniques. For Foam Concentrate incineration at an approved facility is recommended

Environmental – Comparison of AFFF vs FFF

Environmental Property [2]Short-chain AFFF [3]With pre-treatment	Advantage	AFFF[1]	FFF
Aquatic Toxicity	Low	Low	High
Persistence	No	Yes	No
Reduced Foam and Water Resources Used	Yes	Yes	No
Reduced Smoke and Breakdown Products Generated	Yes	Yes	No
Risk to Life Safety	Low	Low	Higher
Escalation Potential	Low	Low	High
Reduced Volumes of Firewater Runoff	Low	Low	High
Bioaccumulation	No	No[2]	No
Disposal Through POTW or WWTP	Yes	Yes[3]	Yes

Important Conclusions to Consider

- When one considers both "Duty of Care" and "Life Safety" and "Performance Matters", it becomes very clear that use of AFFF agents has to be considered as a primary option to extinguish Class B liquid fires in many circumstances.
- Fire fighters and facility managers must consider the following: extinguishment time and time to control the fire, burnback resistance and consequences of "Let it Burn". In addition, when comparing an AFFF agent to the use of FFF agents one needs to strongly consider foam properties including fuel repellency, film formation, foam spreading on fuel, fuel spreading in foam as well as volume of firewater runoff, fire escalation potential, generation of toxic smoke and breakdown products, along with the active surfactant(s)/polymer(s) bioaccumulation, mobility, persistence and aquatic toxicity.
- And as noted, a holistic/balanced approach will clearly show there is room for both types of products – fluorine-free and fluorinated. Care must be taken to control releases of whatever agent is used regardless of type. Following best practice guidance is crucial to safeguarding the neighboring areas and overall environment.