FFFC Fire Fighting Foam Coalition

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2017

FACT SHEET ON AFFF FIRE FIGHTING AGENTS

Nearly 15 years after the end of production of PFOS-based AFFF agents, there is continued discussion within the fire protection industry on the environmental impact and efficacy of fire fighting foams. The discussion of environmental impact is usually focused on foams that contain fluorochemicals, while the discussion of efficacy is usually focused on foams that do not contain fluorochemicals. The Fire Fighting Foam Coalition (FFFC) has produced this fact sheet to provide you with accurate, up-to-date information about these issues.

Key Facts

- All modern AFFF agents contain fluorotelomer-based fluorosurfactants.
- Fluorotelomer-based AFFF agents are the most effective foams currently available to fight flammable liquid fires in military, industrial, aviation, and municipal applications. They provide rapid extinguishment, burnback resistance, and protection against vapor release.
- Fire test results presented at international fire protection conferences in 2011, 2013 and 2016 all show that AFFF agents are significantly more effective at extinguishing flammable liquid fires than fluorine-free foams.
- Fluorotelomer-based foams do not contain or break down into PFOS (perfluorooctane sulfonate) or homologues of PFOS such as PFHxS (perfluorohexane sulfonate).
- Fluorotelomer-based foams are not made with PFOA (perfluorooctanoic acid) or any PFOA-based products, but may contain trace quantities as an unintended byproduct of the surfactant manufacturing process.
- The short-chain (C6) fluorosurfactants that have been the predominant fluorochemicals used in fluorotelomer-based AFFF for the last 25 years are low in toxicity and not considered to be bioaccumulative based on current regulatory criteria.
- Foam manufacturers have transitioned or are in the process of transitioning to the use of only short-chain (C6) fluorosurfactants in their fluorinated foam products.
- Proposed regulations on long-chain (≥ C8) perfluorinated chemicals (PFAS) in Canada, the European Union, and the United States allow for the use of short-chain (C6) fluorochemicals as alternatives to long-chains in foam and other applications. These regulations do not restrict the use of existing stocks of fluorotelomer-based foams.
- Foam and fluorochemical manufacturers are promoting the use of best practices in order to minimize emissions of fire fighting foams to the environment. Best practices include the containment and treatment of foam discharges and the use of non-fluorinated fluids and methods for training and the testing of foam equipment.

Efficacy

At the 2011 SUPDET Conference, the Naval Research Laboratories (NRL) presented results of fire testing of AFFF agents and fluorine-free foam[1]. Although the testing was limited in scope, it provided clear evidence of the importance of film formation to foam performance. Extinguishment times for AFFF agents on 28ft^2 pool fires tested at full strength were on average 77% faster for gasoline, 88% faster for methylcyclohexane (MCH), and 70% faster for heptane when compared to fluorine-free foam. For isooctane, where the tested AFFF agents were unable to form a film, fluorine-free foam extinguished the fire about 10% faster.

AFFF agents extinguished all gasoline and heptane fires in less than 30 seconds, the time required to pass the United States military specification (milspec). The fluorine-free foam was unable to extinguish any gasoline or heptane fire in less than 30 seconds. Foam agents must meet the requirements of the milspec in order to be listed on the US Department of Defense (DoD) qualified products database (QPD) and used for military applications[2]. The Federal Aviation Administration (FAA) requires all US airports to carry AFFF agents that meet the milspec and are listed on the QPD[3]. In addition many national authorities outside of the US require the use of AFFF agents that meet the milspec.

At the 2013 Reebok Foam Conference, VS Focum summarized the company's development of a fluorine-free foam agent[4]. The presentation contained side-by-side test data done at the same facility under the same conditions comparing the fire performance of AFFF agents and fluorine-free foams. The results showed that AFFF agents performed significantly better than fluorine-free foams in spray extinction tests (0.785m^2) and pan fires ranging in size from 0.25m^2 to 7.06m^2.

At the 2016 American Chemical Society Symposium, NRL presented additional test data comparing AFFF agents and fluorine-free foams[5]. In pool fire tests, an AFFF agent achieved extinguishment in less than half the time (18 seconds) compared to fluorine-free foam (40 seconds). In foam degradation tests, fluorine-free foam degraded after 1-2 minutes while AFFF lasted 35 minutes before degrading. Similar results from a series of foam degradation tests on AFFF agents and fluorine-free foams were published in International Fire Fighter in 2012[6].

Fluorine-free foams are inherently oleophilic (fuel attractive). In the absence of oleophobic (fuel-repelling) fluorosurfactants, fluorine-free foam can easily pick up fuel and the contaminated foam degrades quickly and becomes flammable. This fuel contamination problem compromises the fire performance and severely limits the application of fluorine-free foams.

In July 2016 the Singapore Aviation Academy (SAA) and the International Aviation Fire Protection Association (IAFPA) jointly organized a firefighting foam seminar[7]. The major focus of the seminar was on the advantages and disadvantages of fluorine-free foam versus short-chain (C6) AFFF agents. One of the highlights of the seminar was a planned fire test demonstration scheduled with fluorine-free foam on an ICAO level B fire. This was of great interest to many of the delegates, some who have had difficulty replicating tests showing that fluorine-free foams can pass ICAO level B. Unfortunately, the planned demonstration of fluorine-free foam was run instead with a short-chain (C6) AFFF. According to the company sponsoring the fire test demonstration, the fluorine-free foam test was not undertaken because "too many environmental factors were not under our control." Not surprisingly, several delegates noted, "those variables usually happen during fire incidents." The short-chain (C6) AFFF agent had no problem extinguishing the ICAO level B fire in the required time, despite the environmental factors.

Also during this seminar, foam manufacturer ICL/Auxquimia presented results from a series of new fire tests run on five commercially available short-chain (C6) AFFF agents and five commercially available fluorine-free foams. The tests were run with four different fuels: gasoline, heptane, Jet A1, and diesel. The results showed that AFFF agents performed significantly better than fluorine-free foams on all fuels except diesel. None of the fluorine-free foams were able to extinguish the Jet A1 fire, which is the fuel used in the ICAO fire tests that determine the acceptability of foams for airport use in many countries.

Enviromental Impact

The environmental impact of AFFF-type fluorosurfactants has been extensively studied and a large body of data is available in the peer-reviewed scientific literature. The bulk of this data continues to show that short-chain (C6) AFFF fluorosurfactants and their likely breakdown products are low in toxicity and not considered to be bioaccumulative or biopersistent according to current regulatory criteria.

Groundwater monitoring studies have shown the predominant breakdown product of the short-chain (C6) fluorosurfactants contained in fluorotelomer-based AFFF to be 6:2 fluorotelomer sulfonate (6:2 FTS)[8]. A broad range of existing data on 6:2 FTS indicate that it is not similar to PFOS in either its physical or ecotoxicological properties[9,10,11,12]. Recent studies on AFFF fluorosurfactants likely to break down to 6:2 FTS show it to be generally low in acute, sub-chronic, and aquatic toxicity, and neither a genetic nor developmental toxicant. Both the AFFF fluorosurfactant and 6:2 FTS were significantly lower than PFOS when tested in biopersistence screening studies that provide a relative measure of biouptake and clearance[13].

Aerobic biodegradation studies of 6:2 FTS in activated sludge have been conducted to better understand its environmental fate[14]. These studies show that the rate of 6:2 FTS biotransformation was relatively slow and the yield of all stable transformation products was 19 times lower than 6:2 fluorotelomer alcohol (6:2 FTOH) in aerobic soil. In particular, it was shown that 6:2 FTS is not likely to be a major source of perfluorocarboxylic acids or polyfluorinated acids in wastewater treatment plants. Importantly neither 6:2 FTOH nor PFHpA (perfluoroheptanoic acid) were seen in this study.

PFHxA is a possible breakdown product and contaminant that may be found in trace quantities in fluorotelomer-based AFFF. Extensive data on PFHxA presented in 2006 and 2007 gave a very favorable initial toxicology (hazard) profile[15,16,17]. Testing was done on four major toxicology end points: sub-chronic toxicity in rats, reproductive toxicity in rats, developmental toxicity in rats, and genetic toxicity. Results show that PFHxA was neither a selective reproductive nor a selective developmental toxicant. In addition it was clearly shown to be neither genotoxic nor mutagenic. In 2011 results were published from a 24-month combined chronic toxicity and carcinogenicity study, which demonstrated that under the conditions of this study PFHxA was not carcinogenic in rats and its chronic toxicity was low[18].

In 2014 an independent report was published that assessed several short-chain (C6) fluorinated chemicals with regard to the criteria used to define persistent organic pollutants (POPs)[19]. The report assessed these chemicals based on the four criteria that must be met to be considered a POP under the Stockholm Convention: persistence, bioaccumulation, potential for long-range transport, and adverse effects (toxicity and ecotoxicity). It concludes that none of the chemicals meets the criteria to be considered a POP, and at most they only meet one of the four criterion. The report also concludes that the three short-chain (C_6) fluorotelomer intermediates and PFHxA "are rapidly metabolized and eliminated from mammalian systems. None of these materials appear to bioaccumulate or biomagnify based on laboratory data and available field monitoring data, and none show severe toxicity of the types that would warrant designation as POP."

An extensive compilation of peer-reviewed and other relevant available data on short-chain PFASs can be found at the following link:
https://fluorocouncil.com/resources/research

Conclusions

Fluorotelomer-based AFFF agents are the most effective agents currently available to fight class B, flammable liquid fires. They do not contain or breakdown into PFOS and are not likely to be a significant source of long-chain perfluorochemicals. They do contain fluorosurfactants that are persistent, but are not generally considered to be environmental toxicants. AFFF and fluorochemical manufacturers are in position to meet the requirements of upcoming regulations with short-chain (C6) fluorosurfactants that provide the same fire protection characteristics with reduced environmental impacts.

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