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FACT SHEET ON AFFF FIRE FIGHTING AGENTS

More than a decade after 3M stopped 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 has produced this fact sheet to provide you with accurate, up-to-date information about these issues.

Key Facts

- All modern AFFF agents (except some produced in China) contain telomer-based fluorosurfactants.
- Telomer-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 the 2011 SUPDET conference and 2013 Reebok conference showed that AFFF agents are significantly more effective at extinguishing flammable liquid fires than fluorine-free foams.
- Telomer-based foams do not contain or break down into PFOS (perfluorooctane sulfonate) or homologues of PFOS such as PFHxS (perfluorohexane sulfonate).
- Telomer-based foams do not contain or break down into any chemicals that are currently listed as persistent organic pollutants (POPs) under the Stockholm Convention.
- Telomer-based foams are not made with PFOA (perfluorooctanoic acid) or any PFOA-based products.
- Telomer-based foams are not made with any chemicals that are currently considered by environmental authorities to be persistent, bioaccumulative, and toxic (PBT).
- Telomer-based foams are not banned or restricted from use. We are aware of no pending legislation to regulate telomer-based foams in Australia, Canada, Europe, Japan, or the United States.
- The C6-based fluorosurfactants that have been the predominant fluorochemicals used in telomer-based AFFF for the last 25 years are low in toxicity and not considered to be bioaccumulative or biopersistent.
- Foam manufacturers are in the process of transitioning to the use of pure C6-based fluorosurfactants in response to the US EPA PFOA stewardship program.

Efficacy

At the 2011 SUPDET Conference, the Naval Research Laboratories (NRL) presented the 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 (Table 1).

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 qualified products database (QPD) and used for military applications[2]. The Federal AviationAdministration (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, including the Australia Department of Defence.

At the 2013 Reebok Foam Conference, a paper was presented by Manuel Acuna of VS Focum summarizing his 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 $7.06m^2$ (Table 2 and 3).

Table 1: Fire Out Times (seconds)

Foam Type	Heptane	Gasoline	MCH	Isooctane
AFFF (3%)	25	21	19,20	32, 33
AFFF (6%)	23, 28	22	22, 23	32, 33
Fluorine-free (6%)	43	35, 41	33, 46	29, 30

Table 2: Spray Extinction Fire Out Times (minutes)

Foam Type	Heptane	Gasoline	Kerosene Jet A-1
AFFF (1%)	1:03	0:38	0:22
AR-AFFF 1x3	2:11	1:25	1:25
Fluorine-free (1%)	2:14	3:36	3:12
Fluorine-free (1%)	2:21	2:21	3:21
Fluorine-free (3%)	None	None	1:00

Table 3: Spray Pan Fire Out Times (minutes)

Foam Type	$0.25m^2$	$0.785m^2$	$4.52m^2$	$7.06m^2$
AFFF (1%)	0:35	1:19	2:16	2:06
Fluorine-free (1%)	0:50	1:55	2:21	None

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 C6-based AFFF fluorosurfactants and their likely breakdown products are low in toxicity and not considered to be bioaccumulative or biopersistent.

Groundwater monitoring studies have shown the predominant breakdown product of the short-chain C_6 fluorosurfactants contained in telomer-based AFFF to be 6:2 fluorotelomer sulfonate (6:2 FTS)[5]. 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[6,7,8,9]. 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[10].

Aerobic biodegradation studies of 6:2 FTS in activated sludge have been conducted to better understand its environmental fate[11]. 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 telomer-based AFFF. Extensive data on PFHxA presented in 2006 and 2007 gave a very favorable initial toxicology (hazard) profile[12,13,14]. 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 is not carcinogenic in rats and its chronic toxicity was low[15].

Conclusions

Telomer-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 toxins. AFFF and fluorochemical manufacturers are in position to meet the goals of national stewardship programs with pure short-chain fluorosurfactants that provide the same fire protection characteristics with reduced environmental impacts.

References

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Information from the 2012 FFFC Fact Sheet

Fluorinated Surfactants

All AFFF fire fighting agents contain fluorinated surfactants (fluorosurfactants). They are key ingredients that provide AFFF with the required low surface tension (15 to 17 dynes/cm) and positive spreading coefficient that enables film formation on top of lighter fuels. It is this film formation capability that gives AFFF its name and its effectiveness against flammable liquid fires.

The chemicals used to produce fluorosurfactants can be manufactured by different processes and have different chemical structures. The fluorosurfactants used in AFFF have historically been produced from fluorochemicals manufactured by two methods: electrochemical fluorination and telomerization. AFFF agents manufactured by 3M contain fluorosurfactants produced by electrochemical fluorination. Virtually all other AFFF agents contain fluorosurfactants produced by telomerization.

PFOS

In 2002, 3M voluntarily stopped production of a number of products including AFFF agents because they contain and degrade into perfluorooctane sulfonate (PFOS). PFOS is considered by environmental authorities to be persistent, bioaccumulative and toxic (PBT). Regulations in the United States, Canada, European Union, Australia, and Japan act as a ban on new production of PFOS-based products including foams. These regulations do not currently restrict the use of existing stocks of PFOS-based foam in the US, Australia, or Japan. In the EU and Canada, existing stocks of PFOS-based foam must be removed from service in 2011 and 2013, respectively. Production and sale of PFOS foams continues in China.

Telomers

All modern AFFF agents (except some produced in China) contain telomer-based fluorosurfactants. Telomer-based AFFF agents do not contain or break down into PFOS and have about 30 - 60% less fluorine than PFOS-based AFFF. Telomer-based AFFF agents are not made with any chemicals that are currently considered by environmental authorities to be PBT.

The US Environmental Protection Agency (EPA) has indicated that some telomer-based fluorochemicals can break down in the environment into perfluorooctanoic acid (PFOA) or other perfluorocarboxylic acids (PFCAs). Further, EPA states that their concern is focused on long-chain perfluorinated chemicals (LCPFCs) containing eight carbons or more (C_8, C_{10}, C_{12}). Existing data shows that shorter-chain compounds (C_6 and below) have a lower potential for toxicity and bioaccumulation.

EPA PFOA Stewardship Program

Under the EPA 2010/15 PFOA Stewardship Program eight fluorochemical manufacturers have voluntarily agreed to reduce by 95% by year-end 2010 and work to eliminate by year-end 2015 both plant emissions and product content of PFOA, PFOA precursors, and related higher homologue chemicals. EPA intends to propose a regulation in 2012 that would close any loopholes in the Stewardship Program such as treated article imports.

EPA Program - Impact on AFFF

The EPA Stewardship Program is focused on eliminating telomers with eight or more carbons (C_8 or above). Historically, the majority of the fluorosurfactants used in telomer-based AFFF have been derived from six-carbon molecules (C_6). Some current AFFF formulations contain over 90% pure C_6 fluorosurfactants, but others contain a higher percentage of C_8 and above.

Over the next few years, AFFF manufacturers will be introducing reformulated products that contain only C_6 fluorosurfactants. Some of these fluorosurfactants are new and must be approved by EPA under the TSCA New Chemicals Program. There have been foam agents on the market for 25 years that contain more than 90% C_6 fluorosurfactants and meet the toughest industry specifications. This history makes manufacturers confident that the reformulated products will retain the same fire suppression capabilities as existing agents. Changes to formulations may require products to be re-qualified underthe various specifications such as UL and FM.