# Information Bulletin

IB 06

## Selection and use of firefighting foams

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FIRE PROTECTION ASSOCIATION AUSTRALIA

# Selection and use of firefighting foams

*Leading and supporting a professional industry to minimise the impact of fire on life, property and the environment, for a safer community*

## 1.0 Purpose statement

The purpose of this document is to increase awareness of the issues surrounding the selection and use of firefighting foams based on their:

- Firefighting performance;
- Environmental impact; and
- System and equipment compatibility.

## 2.0 Audience

This Information Bulletin is intended for:

(i) FPA Australia members;

(ii) Users of firefighting foams, including owners of facilities protected by foam-based systems and response agencies who use firefighting foams; and

(iii) Other stakeholders involved in the selection and use of firefighting foams, including manufacturers, suppliers, installers and maintainers of fire protection systems and equipment that use firefighting foams.

## 3.0 Background

Firefighting foam is a suppression medium known for its effectiveness in preventing, extinguishing or controlling fires involving flammable liquids (Class B fuels). Firefighting foams are used in fixed and portable fire extinguishing systems as well as fire brigade apparatus. Firefighting foam is produced by mixing foam concentrate with water to produce foam solution. This solution can either be applied:

- Non-aspirated (through water nozzles, sprinklers or deluge nozzles—provided the foam is suitable for application through these devices); or
- Aspirated (when the foam solution is mixed with air through dedicated foam making devices including foam branchpipe, top pourer, foam cannon, foam sprinkler, medium expansion pourer or high expansion generators).

The application of firefighting foams suppresses liquid fuel fires by suppressing the release of flammable vapours, separating flames from the fuel, blocking the supply of oxygen to the fuel and cooling the fuel.

The environmental acceptability of different firefighting foam classes, based on their chemical composition has been an issue of global debate in recent years and varying information is available in the public domain on the different environmental and firefirefighting performance of fluorinated and fluorine-free foams.

FPA Australia has observed that the information that is available is increasingly focussed on environmental issues in isolation of other key issues such as firefighting performance, firefighter safety and system compatibility.

FPA Australia recognises the need for fire protection to be environmentally responsible and this is a key component of the Association's Vision. Good fire protection outcomes are not attributable to any single component and must be considered holistically as a combination of factors. In relation to firefighting foams, FPA Australia contends that the selection and use of different foam types should be determined after consideration of:

- Firefighting performance (including the impact of performance on firefighter and community safety)
- Potential adverse environmental impacts
- Compatibility with the fixed or portable fire systems in which they are to be used
- Compatibility with existing foam concentrate in storage
- Potential tank/pipework corrosion
- Proportioning accuracy issues
- Cost impacts

This document is intended to provide a balanced overview of the key issues which impact on the selection and use of firefighting foams. Only by considering all of these key criteria collectively can foam users make an informed decision as to which type of foam is most suitable for their current and future needs.

# 4.0 Factors impacting on selection and use

## 4.1 Firefighting performance

Firefighting foams are used to prevent, control and extinguish fires. The effectiveness of a type of firefighting foam in achieving these goals must be a prime consideration in its selection and use.

The types of liquid fuels and associated fires that firefighting foams have been developed to respond to, are not effectively controlled by other suppression agents. Firefighting foams must:

- Cool the fuel surface
- Resist mixing with specific fuels
- Resist attack or breakdown by specific fuels (such as, polar solvents)
- Suppress the release of flammable vapours

- Control fire spread and provide progressive extinguishment
- Provide protection from re-ignition

The performance of firefighting foam is important in order to protect life and property.

Firefighting foams must have effective firefighting performance in order to reduce the potential for fire spread, reduce the products of combustion and reduce the risk to life safety of responding firefighters and the community.

Demonstrated firefighting performance to recognised standards is essential in the selection and use of firefighting foams. Reduced firefighting performance may result in fires burning longer and therefore releasing larger volumes of the products of combustion that will impact on the environment—such as contaminated water run-off and smoke. Reduced firefighting performance also adversely affects the life safety of firefighters and the community.

There are a range of test methods available to determine the firefighting performance of foams and the relevant test method or standard varies depending upon the system application in which the foam is to be used.

FPA Australia considers that demonstrated firefighting performance for a particular application is critical in the selection and use of firefighting foams.

## 4.2 Environmental impact

FPA Australia supports efforts to reduce the adverse impacts that fire and firefighting activities have on the environment. Appropriate selection and use of firefighting foams is important as some firefighting foams have a greater environmental impact than others by virtue of their chemical composition.

The different chemical compositions of firefighting foams can have varying impacts when they come into direct contact with the environment. As discussed in this Information Bulletin there are scientific criteria available that can be used to assess the environmental impact of different firefighting foams.

The immediate environmental impact from individual fires is also important to consider. Whilst it is difficult to quantify the environmental impact of individual fire events, improved firefighting foam performance will help to reduce environmental impacts as extinguishing fires quicker will result in less contaminated water run-off and products of combustion.

Although environmental impact is important, failure to also consider the firefighting performance aspects of foams, may result in selection of a foam that is ineffective for the intended application.

### 4.3 System and equipment compatibility

Use of a firefighting foam which has not passed the specified fire testing protocol applicable to the fire protection system or equipment that it is to be used in, places life, property and the environment at risk. Furthermore, it can also have serious implications for product/system approvals and insurance cover.

Firefighting foams form only one part of a system and a decision to change the type of foam cannot be made without considering the impact on the complete system. Foam compatibility is critical to achieving expected firefighting performance. For each system, careful consideration and consultation with key fire protection stakeholders, especially foam system designers and manufacturers, is required prior to taking a decision to change the type of foam used, so as not to adversely affect the performance of the system. Important factors include:

- Viscosity
- Proportioning accuracy
- Corrosivity
- Sedimentation
- Cross bonding
- Materials and component compatibility
- Suitability for use on the flammable liquids in question

System compatibility is an issue which must be considered for each individual application. Using a firefighting foam which is incompatible with the system or fuels in question will adversely affect the performance of the system.

## 5.0 Measuring environmental impact and performance

A number of measures have been developed to assess the environmental impact and performance of firefighting foams.

### 5.1 Environmental Indicators

From a direct environmental exposure perspective, the Stockholm Convention on Persistent Organic Pollutants (POPs)—an international treaty signed in 2001 and effective from May 2004—aims to eliminate or restrict the production and use of POPs. Australia is one of 179 parties who are signatories to this convention. Australia ratified the Convention on 20 May 2004 and became a party to it on 18 August 2004.

The POP Review Committee established by the Convention developed a procedure for the consideration of individual substances. To qualify as a POP, a substance must meet all four of the following criteria:

- (P) Persistence in the environment
  - (i) Evidence that the half-life of the chemical in water is greater than two months, that its half-life in soil is greater than six months, or that its half-life in sediment is greater than six months; or
  - (ii) Evidence that the chemical is otherwise sufficiently persistent to justify its consideration within the scope of the Convention.
- (B) Bioaccumulation
  - (i) Evidence that the bioconcentration factor or bioaccumulation factor in aquatic species for the chemical is greater than 5000 or, in the absence of such data, that the $K_{ow}$ is greater than 5;
  - (ii) Evidence that a chemical presents other reasons for concern, such as high bioaccumulation in other species, high toxicity or ecotoxicity; or
  - (iii) Monitoring data in biota indicating that the bioaccumulation potential of the chemical is sufficient to justify its consideration within the scope of the Convention.
- (T) Toxicity
  - (i) Evidence of toxicity or ecotoxicity data that indicates the potential for damage to human health or to the environment
- (LRET) Potential for Long-Range Environmental Transport
  - (i) Measured levels of the chemical in locations distant from the sources of its release that are of potential concern;
  - (ii) Monitoring data, modelling or environmental fate properties showing that long-range environmental transport of the chemical, with the potential for transfer to a receiving environment, may have occurred via air, water or a migratory species

If a substance meets each of the above criteria, the Committee undertakes risk profiling to evaluate whether, as a result of its LRET, a substance is likely to lead to significant adverse human health and/or environmental effects and therefore warrants global action. If global action is warranted, a risk management evaluation is undertaken reflecting socioeconomic considerations associated with possible control measures and the substance is listed under the appropriate annex of the Convention. Annexes include:

- Annex A – Elimination
- Annex B – Restriction
- Annex C – Unintentional production

In addition to these criteria, another scientific measure of the environmental impact of firefighting foams is full environmental testing to determine the Biological Oxygen Demand (BOD)/Chemical Oxygen Demand (COD) and the impact of this on aquatic toxicity. BOD/COD profiling identifies the biodegradability of firefighting foams in the environment and can categorise the acute (short term) and/or chronic (long term) impact for firefighting foams.

## 5.2 Firefighting performance indicators

As discussed above, it is important to also consider the firefighting performance of foams and the safety and engineering compatibility implications which need to be addressed when considering the use of a different foam to that currently used.

There are a number of local and international standards that rate the firefighting performance of foams, these include, but are not limited to:

(i) Australian Standards

- AS/NZS 1850, *Portable fire extinguishers – Classification, rating and performance testing*
- AS 5062, *Fire protection for mobile and transportable equipment*
- DEF(AUST)5706, *Foam Liquid Fire Extinguishing, 3 percent and 6 percent concentrate*

(ii) International Standards

- EN 1568, *Fire Extinguishing Media – Foam Concentrates* (Parts 1, 2, 3 *& 4*)
- EN 13565, *Fixed Firefighting Systems – Foam Systems* (Parts 1 & 2)
- International Civil Aviation Organisation (ICAO) Fire Test Method, Doc 9137 — *Airport Services Manual,* Part 1 — *Rescue and Fire Fighting*
- NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*
- UL 162, *Standard for Safety for Foam Equipment and Liquid Concentrates*
- Mil-F-24385F(SH), *Fire Extinguishing Agent, Aqueous Film Forming Foam (AFFF) Liquid Concentrate, for Fresh and Sea Water*

In addition to these standards, there are a number of listing or product certification schemes that recognise the firefighting performance of fire protection products, including foams. When considering the use of product that has been listed or accredited, it is important to check the basis for listing or accreditation and that this included testing to a relevant standard, representative of the expected environment that the foam is intended to protect.

The performance parameters identified by testing to these standards can include extinguishment, burnback resistance, viscosity and consideration of surface tension and spreading coefficient of a particular foam type.

For fixed and portable firefighting equipment using foam, it is important that foams pass appropriate performance and characteristic testing and internationally or locally recognised approvals to demonstrate compatibility with system designs. In all circumstances, evidence of suitability should be sought to demonstrate foam performance.

Unfortunately, there is no simple way to guarantee that equivalent firefighting performance will be retained when changing the type of foam used. Testing of new formulations to internationally or locally recognised test protocols is required to demonstrate performance. Changing a foam type will also require review of the compatibility of the foam with the associated firefighting systems or equipment and, again, evidence of suitability should be sought.

## 6.0 Different types of firefighting foam

Firefighting foams can be broken into two broad categories:

- Foams which contain fluorinated surfactants; and
- Foams which are fluorine free.

However there are also individual foam types within these two broad categories.

Commonly used firefighting foam types are better known by the following terms:

- Fluorinated Foams
  - AFFF—aqueous film-forming foam
  - FFFP—film forming fluoroprotein
  - AR-AFFF—alcohol-resistant aqueous film-forming foam
  - AR-FFFP—alcohol-resistant film-forming fluoroprotein
  - FP—fluoroprotein foam
- Fluorine Free Foams
  - F3—fluorine-free foams

## 6.1 Fluorinated firefighting foams

Historically, fluorinated firefighting foams include perfluorinated and polyfluorinated chemicals (PFCs).

Perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) are two of the best know PFC-based firefighting foams.

Fluorinated firefighting foams that contain PFOS and PFOA have good firefighting performance but have been identified as having a negative effect in the environment due to their chemical composition. PFOS and PFOA fluorosurfactants are manufactured by a process called electrochemical fluorination (ECF). Other fluorosurfactants can be made with a different process known as telomerisation and are known as fluorotelomers or telomer-based fluorosurfactants.

Fluorinated firefighting foams that contain fluorotelomers do not contain PFOS and only trace levels of PFOA. Not all fluorinated foams have the same chemical composition or environmental impact.

### PFOS

In 2004 the first 12 POPs were listed in annexes to the Stockholm Convention. In 2010, PFOS was one of 9 new substances added as an Annex B Restricted substance in accordance with the Stockholm Convention with the expectation that every four years progress on its elimination is reported. It should be noted that Australia's National Implementation Plan - Stockholm Convention on Persistent Organic Pollutants, dated July 2006, was published by the Commonwealth Department of the Environment prior to the addition of PFOS as a POP.

Australia is yet to ratify this addition of PFOS as an Annex B Restricted substance and update the National Implementation Plan to reflect this. Australia is considering ratification of PFOS as a POP but must go through a domestic treaty process that the Commonwealth Department of the Environment is responsible for. FPA Australia considers that the Australian Government should ratify PFOS as a POP in accordance with the Stockholm Convention.

With the goal of reducing and ultimately eliminating production and use of PFOS, the Stockholm Convention encourages:

- Phase out of use when suitable alternative substances or methods are available;
- Producers or users of PFOS to develop and implement an action plan for elimination; and

- Producers or users, within their capabilities, to promote research on development of safe alternative substances to reduce human health risks and environmental implications.

The European Union (EU) has prohibited the marketing and use of PFOS since 27 June 2008 as it met the PBT criteria relating to persistence (P) and toxicity (T) and very high bioaccumulation (B) in aquatic organisms has been proven. PFOS was banned from use in 28 European countries in 2011, requiring high temperature incineration (above 1,100°C) to destroy it.

However, it is misleading and untrue to suggest that other fluorinated chemicals (produced by a different, telomerisation process producing fluorotelomer surfactants) may behave in a similar way.

## PFOA

Whilst a substance of high concern, PFOA is orders of magnitude lower in its bioaccumulation and toxic effects than PFOS. Scientific research has shown that C8 and longer chain fluorochemicals are larger more complex molecules which are more likely to breakdown to substances which become toxic, potentially bioaccumulate, and remain in mammalian organisms for longer periods of time.

PFOA is found as an unintended by-product of the fluorotelomer reaction process as trace quantities in eight carbon chain (C8) or longer fluorotelomer surfactants. In 2005, concerned about the known persistence of PFOA in the environment, detection in human blood and effects in animal studies, the US Environmental Protection Agency (EPA) and eight important fluorotelomer manufacturers launched a voluntary PFOA Stewardship Program to phase out these small amounts of PFOA, and the precursor chemicals that can break down to PFOA, from their production processes, waste streams and finished products by the end of 2015. Most Australian distributors of foam are aligned to this stewardship program.

In 2013, the Danish Environmental Protection Agency compiled a survey of PFOS, PFOA and other perfluoroalkyl and polyfluoroalkyl substances. It confirmed that the technologically best alternatives to long-chain fluorinated chemicals are short-chain chemicals with a carbon chain length of ≤C8 for perfluoroalkyl carboxylates and ≤C6 for perfluoroalkyl sulfonates. The short-chain fluorinated alternatives are still rather persistent but much less bioaccumulative and toxic than the long-chain homologues.

The Danish EPA's overall conclusions confirmed that the US EPA PFOA Stewardship Program will result in significantly lower environmental concentrations and human exposure to these chemicals in the future.

The short-chain homologues have a better toxicological profile and do not bioaccumulate to the same extent as the long-chain substance as they are excreted more rapidly from both humans and organisms in the environment, but they are still persistent in the environment. The short-chain homologues and their precursors (e.g. fluorotelomers based on short-chain fluorochemistry) generally seem to have a better human health and environmental profile than the substances based on long-chain fluorochemistry.

The French Food Safety Agency and Norwegian Institute of Public Health have evaluated the potential human health risks related to the residual presence of PFOA in non-stick coatings for cookware, concluding that the consumer health risk is negligible.

## Fluorotelomers

Scientific research into six carbon atom and shorter (≤C6) chain fluorotelomer surfactants and their primary breakdown products of 6:2 fluorotelomer sulfonate (6:2 FTS) and perfluorohexanoic acid (PFHxA), have shown that although still persistent, firefighting foams containing C6 fluorotelomer surfactants are neither bioaccumulative, nor genotoxic, nor developmental toxins. They are not mutagenic, nor have they been shown to exhibit harmful effects. They have been preferentially found in aquatic sediments, are generally an order of magnitude less toxic to aquatic life than fluorine-free foam (F3) alternatives, with lower Chemical Oxygen Demands (COD) during biodegradation. Accordingly, foam manufacturers have recently begun producing fluorinated firefighting foams containing fluorosurfactants that have only 4 to 6 carbon atoms, improving environmental properties and complying with the US EPA PFOA Stewardship Program.

C6 fluorotelomer-based foams:

- Do not break down into chemicals currently listed or suspected of being POPs and are not listed by the Stockholm Convention or European Chemicals Agency current (2014) list of substances of very high concern (VHC)
- Do not contain or break down into PFOS

- Are not made with PFOA or any PFOA-based products
- Are not made with chemicals currently considered to be, bioaccumulative or toxic by environmental authorities

Importantly, fluorotelomer surfactant based firefighting foams retain strong firefighting performance.

Most fluorotelomer surfactants have chemical composition, breakdown products and environmental impacts that are very different from PFOS without the far reaching bioaccumulative and toxic environmental impacts. This is evident in the shorter chain C6 fluorotelomer surfactants increasingly used in modern fluorinated foams.

Given the above information, it is clear that fluorinated firefighting foams should not be grouped as a single class in terms of their environmental properties. Foams containing PFOS, PFOA and fluorotelomers have distinctly different environmental characteristics and these sub-groups must be considered separately on the basis of these characteristics.

In any case, evidence of suitability for purpose must be demonstrated.

## 6.2 Fluorine-free firefighting foams

In recent years, driven by the European and US reforms, fluorine-free foam technology has advanced in order to counter concerns raised with PFOS and PFOA fluorinated foams. Fluorine-free foams are now available in the Australian and international market.

It is important to note, however, that just like fluorinated foams, not all fluorine-free foams are the same. For example, where hydrocarbon surfactants have been used to replace fluorosurfactants, some fluorine-free foams have been shown to be an order of magnitude higher in acute aquatic toxicity than fluorotelomer-based foams.

FPA Australia supports the use of more environmentally responsible foam formulations. However, firefighting foams must only be used in applications where they provide acceptable firefighting performance and safety.

Historically, there are a number of important applications for which fluorine-free foams have not been suitable. These include:

(i) Portable fire extinguishers

(ii) Non-aspirated pre-engineered foam/water spray systems used to protect large mining machines.

Use of foam in these applications in Australia requires the extinguisher/system to pass specific fire test protocols detailed in Australian Standards AS/NZS 1850, *Portable fire extinguishers – Classification, rating and performance testing* and AS 5062, *Fire protection for mobile and transportable equipment*, respectively. Past testing has demonstrated that fluorine-free foams have been ineffective on the fires specified in the test protocols and hence have been unsuitable for use in these applications. Regardless of the type of foam, fluorinated or fluorine-free, foams should not be used in any application unless the required fire test protocols have been successfully passed or completed.

As with fluorinated firefighting foams, fluorine-free firefighting foams should not be grouped as a single class in terms of their environmental properties or performance. High detergent content in some fluorine free foams can make them vulnerable to edge flickers, sudden flashbacks and re-involvement which can put the safety of firefighters at unnecessary risk. Some fluorine-free foams have proven firefighting performance, but just like fluorinated foams, evidence of suitability for purpose must be demonstrated.

## 7.0 Recommendations

FPA Australia's recommendations on the selection and use of firefighting foam are as follows:

1. The use of foams containing PFOS should be banned.
2. Existing stocks of foams containing PFOS should be removed from service and sent for high temperature incineration at an approved facility.
3. Foam manufacturers should reduce and eliminate the production of foams containing PFOA in accordance with the US EPA PFOA Stewardship Program.
4. Regardless of whether the foam under consideration is a fluorinated or fluorine-free foam, evidence of suitability must be provided to demonstrate its ability to achieve the required firefighting performance for the fuel in question having been subjected to appropriate and recognised testing. Evidence of suitability must also be used to demonstrate that the foam is compatible with associated systems and equipment.
5. Whilst important, the environmental performance of a foam should not be used as the sole selection criteria. In addition to recommendations 1 to 4 above the following additional key selection criteria must be considered in addition to environmental impacts:
    (a) Firefighting performance
    (b) Life safety
    (c) Physical properties and suitability for use on known hazards
    (d) Compatibility with system design and approvals
6. Any proposal to change the type of foam used in a system requires careful consideration and must take fire safety and engineering factors into account. The type of foam used should not be changed without completing a detailed review of the design, performance and operation of the system as a whole. Such design reviews should include consultation with fire system designers, foam and foam hardware suppliers, and the relevant authority having jurisdiction.
7. Choosing the most responsible firefighting foam, the best one to protect people, property and the environment, involves selecting one that provides a combination of firefighting performance, reliability and life safety, balanced with minimal toxicological and environmental impacts.

## 8.0 References

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11. FPA Australia Technical Advisory Committee (TAC) 11/22 Special Hazard Fire Protection Systems

## 9.0 Disclaimer



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