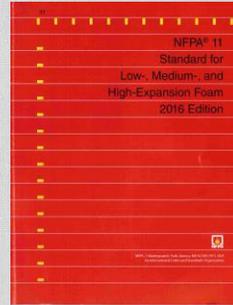


# Environmental Issues of Firefighting Foam

## NFPA 11 Standard for Low, Medium, and High Expansion Foam – 2016 Edition



- Contains useful information regarding environmental issues but is primarily focused on the uses of foams for flammable liquid fire protection

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## Annex E.1 Environmental Issues Overview

Fire fighting foams as addressed in this standard serve a vital role in fire protection throughout the world. Their use has proven to be essential for the control of flammable liquid fire threats inherent in airport operations, fuel farms, and petroleum processing, highway and rail transportation, marine applications, and industrial facilities. The ability of foam to rapidly extinguish flammable liquid spill fires has undoubtedly saved lives, reduced property loss, and helped minimize the global pollution that can result from the uncontrolled burning of flammable fuels, solvents, and industrial liquids.

However, with the ever-increasing environmental awareness, recent concern has focused on the potential adverse environmental impact of foam solution discharges. The primary concerns are toxicity, biodegradability, persistence, treatability in wastewater treatment plants, and nutrient loading. All of these are of concern when the end-use foam solutions reach natural or domestic water systems.

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## NFPA-11 Foam Standard Environmental Guidance

- Annex E added to NFPA-11 standard in early 1990s to provide foam users with helpful information regarding environmental issues
- Primary focus on foam discharge scenarios and how to deal the foam streams produced by fire fighting operations, training, foam equipment/system testing, and accidental foam releases
- Suggested use of “training foams”, engineered containment for systems, alternate test methods, and disposal alternatives

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## Progression of NFPA11 Annex E Regarding Fluorochemicals

- 2002, 2005, and 2010 Editions focused more on environmental issues related to U.S. EPA regulations regarding glycol ethers, ethylene glycol, and fluorochemical type surfactants used in FFFF, AFFF and AR-AFFF foams
- Starting in 2002 section E-9 describes the environmental concerns related to fluorochemical surfactants used in foams and identifies specific issues like toxicity, problems at treatment plants due to foaming, persistence in the environment, mobility, and bioaccumulation by living organisms
- 2010 Edition E.9.5 discusses environmental regulation of fluorochemical surfactants and references 3M company's electrochemical fluorination (ECF) manufacturing process that resulted in PFOS containing products

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## 2016 Edition NFPA11

- Annex E expanded to contain far more information regarding fluorochemical surfactants
- Para. E.9.6 provides specific recommendations to minimize the environmental affects from foam solution discharge
- Section D.5 Foam Injection Rate Tests expanded to provide new testing methods based on using surrogate test liquids instead of foam discharge
- New methods for testing foam proportioning systems using portable laptop computer based data acquisition equipment introduced

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## So, How Did Firefighting Foam Become An Environmental Issue?

- In essence, it has always been an issue, as Mother Nature needs to deal with anything discharged or spilled to the environment
- Things like: Toxicity, Biodegradability, BOD Loading and POTW Treatability have always been a concern
- New concerns have arisen over fluorochemicals in the environment – This has become the topic of discussion around the world

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## PFOS Started the Current Concern over Fluorochemicals in the Environment

- In 2000, 3M Company announced that they were exiting all markets that used PFOS including “Lightwater” brand fire fighting foam
- This was triggered by finding PFOS in the blood of mammals throughout the world including areas where no PFOS based products had ever been used.
- PFOS was found to be PBT
  - Persistent
  - Bioaccumulative
  - Toxic

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## FLUROSURFACTANTS IN AFFF

- Fluorosurfactants are the key ingredient in Film Forming Foams i.e. AFFF, AR-AFFF, FFPF, AR-FFFP
- They bring two important characteristics to the foam:
  - A. Film forming capabilities
  - B. Fuel sheading characteristics (oleophobicity)

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## Two ways to make the fluorochemicals used in Firefighting Foam

- Electrochemical Fluorination
  - This is the process that forms PFOS
  - Used by 3M Corporation to make “Lightwater” brand AFFF – phased out in 2002
- Telomerization
  - This is the process used by most other foam manufacturers throughout the world
  - Does not produce PFOS
  - Has been used since 1970’s

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## AFFF – Environmental Legacy

- Fluorosurfactants are “the” active ingredient in AFFF’s
- **PFOS** (perfluorooctyl sulfonate) Product formed in the manufacture of fluorochemicals by the electrofluorination process or through degradation of chemicals produced through the electrofluorination process.
- **PFOS** is considered Persistent, Bio-accumulative, & Toxic (PBT)
- **PFOA** – (Perfluorooctanoic acid) Chemical used in the production of fluoropolymers . Also found as a byproduct in some fluorosurfactants and as a byproduct of decomposition of some C<sub>8</sub> and higher fluorochemicals.
- Commonly referred to as C<sub>8</sub> Chemistry
- **PFOA** is considered Persistent, Bio-accumulative, & Toxic (PBT)

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## The Vehicle for Change

USEPA 2010 / 2015 Stewardship Program



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## Fluorochemical Supply Chain



EPA 2015 Stewardship Program is signatory by the raw material suppliers ;ip

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## Transition to Short-chains



- US EPA PFOA Stewardship Program 2010/15
  - Started in 2006 with 8 fluorochemical manufacturers
  - Goal to reduce C8 and longer chains by 95% at end of 2010
  - By the end of 2015, "work towards the total elimination..."
- Most fluorochemical manufacturers ended production of long-chain chemicals (≥C8) during or before 2015
- In response, most foam manufacturers have transitioned to the use of pure short-chain (C6) fluorosurfactants in Class B foams
- Environmental authorities consider perfluorinated chemicals containing less than eight carbons to have a lower potential for toxicity and bioaccumulation

## Transition to Short-chains

Is short-chain chemistry new?

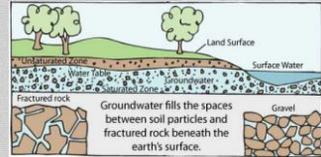


No, key component of some foams since the 1970s

- AFFFs with >95% short-chain fluorosurfactants have been on market for >30 years and exceed the most challenging industry standards
- AFFFs with >95% short-chain fluorosurfactants have been primary foams used for last decade by US, Australian, and European armed services
- New mil-spec AFFF agents from ICL, National Foam, Solberg, and Tyco containing only short-chain fluorosurfactants

## Foam Legacy Issues

- Groundwater and soil studies from fire training areas show multiple releases over many years resulting in long-term contamination
- Major issue at US military bases



Source: "What is Groundwater?" by The Groundwater Foundation, 2016

- Any facility where uncontrolled discharges of foam have taken place could have groundwater and soil contamination
- Growing issue in US, Europe, Australia, Canada

## Military Sites Under Review

- US Military is checking military sites throughout the US for possible ground water contamination due to PFOS and PFOA contamination



Source: EPA, 2015 - The Pentagon, USA and Department of Defense

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## EPA Establishes PFOS and PFOA Drinking Water Health Advisories

- In 2016 EPA published a Lifetime Health Advisory on PFOS and PFOA
- Set limits for PFOS and PFOA at 70 Parts Per Trillion
- When both are present the **combined** limit is 70 Parts Per Trillion
- “Designed to provide Americans, including the most sensitive populations, with a margin of protection from a lifetime of exposure to PFOS and PFOA from drinking water.”
- This is advisory only and is not legally binding unless adopted as law by States or other Authority Having Jurisdiction.

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## Environmental Action U.S.



- New York State
  - NY State DEC Notice of Emergency Adoption and Proposed Rule Making to classify PFOA, PFOS (and their salts) as hazardous substances. 6 NYCRR Part 597
- New Hampshire
  - NHDES is investigating the presence of perfluorochemicals (PFCs) in drinking water in the towns of Merrimack and Litchfield, New Hampshire.
- South Carolina
  - Beginning search of records to determine extent of foam's use in the state.
- Alaska, Minnesota, New Jersey, Vermont, Wisconsin
  - Tracks chemicals used in fire foams and from other sources through ongoing water monitoring or looking for contaminated sites.

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## Regulatory Update



- Emergency Adoption and Proposed Rule: 6 NYCRR Part 597
- Hazardous Substances Identification, Release Prohibition, and Release Reporting
- DEC filed a Notice of Emergency Adoption and Proposed Rule Making to classify PFOA and PFOS as hazardous substances at the request of the New York State Department of Health

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## A Closer Look: 6NY CRR Part 597



- Looks at specific chemical compounds
  - PFOS (CAS# 2795-39-3)
  - PFOS Ammonium Salt (CAS#3825-26-1)
  - PFOA (CAS# 335-67-1)
  - PFOA Sulfonic Acid (CAS#1763-23-1)
- Sets 1 pound as reportable quantity

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## Regulatory Update



Environmental authorities in Canada, the European Union and the United States have proposed regulations that would ban or restrict the use of long-chain perfluorinated chemicals for most applications, including foam

Australia is developing a National Standard for Industrial Chemicals that proposes to address perfluorinated chemicals as a first step in their program

## US Environmental Protection Agency

- US Environmental Protection Agency (EPA) has proposed a Significant New Use Rule (SNUR) on long-chain perfluoroalkyl chemicals (LCPFACs)
- SNUR is intended to provide a regulatory backstop to the US EPA 2010/2015 PFOA Stewardship Program
- As proposed, the SNUR would be expected to have minimal impact on the production and use of fire fighting foams



<b>Prohibits</b>	manufacture and import of LCPFACs for new uses and existing uses that are not ongoing
<b>Permits</b>	sale and use of LCPFACs

## Environment Canada

EC has proposed regulations on PFOA and LCPFCAs (long-chains)



<b>Prohibits</b>	manufacture of foams containing LCPFCAs
<b>Permits</b>	use, sale and import of LCPFCAs foams

- FFCC provided comments supporting a time limit on the exemption for import and sale of foams containing LCPFCAs
- Expect Environment Canada will include limit on long-chains in foam similar to EPA and EU

## Reformulating to Environmentally Improved AFFF - C<sub>8</sub> to C<sub>6</sub>

PFOS	PFOA
3M Light Water	Found in Trace Amounts of AFFF Formulations with C <sub>8</sub> Surfactants
Created from the ECF process	By product of degradation process when using C <sub>8</sub> and higher long chain homologues
PBT (Persistent, Bioaccumulative, Toxic)	PBT (Persistent, Bioaccumulative, Toxic)
Cannot be formed from C <sub>6</sub> surfactants	Cannot be formed from C <sub>6</sub> surfactants
Hazardous Waste in EU, Canada and New York	

**NO-PFOA/PFOS-6 Carbon Molecule**

- Meets EPA 2002/03 Stewardship program goals
- Solberg AFFF has same application rates as other C<sub>6</sub> formulated products
- Other manufactures products, application rates, and approvals should be verified

## Reformulating to Environmentally Improved AFFF

### Changing to C<sub>6</sub> Chemistry

- UL/FM recertification testing is required
- Changing from C<sub>8</sub> to C<sub>6</sub> formulations provides for improved environmental profile with shorter chain molecule
- Reformulation results in the challenge to maintain performance which typically results in increased fluorinated surfactant (about 10% more)

## Fire Fighting Foam Advancements The Next Generation



## Fluorine Free Foams

- Most foam manufacturers have developed fluorine-free (FF) foams that provide an alternative to fluorinated foams in many applications
- Some do not have fire performance across all fuels and in all operational circumstances equal to fluorinated products. Look for UL or FM foams – not emulsifiers or wetting agents.
- 2011 paper by Naval Research Labs showed that AFFF agents extinguished gasoline and heptane fires about 70-80% faster than FF

## Proven Firefighting Performance

✓	Same Design Application as AFFF
✓	Rapid Knockdown
✓	Vapor Suppression
✓	Enhanced Securement
✓	Firefighter Protection
✓	Global Acceptance
✓	Multiagency Certified

## Foam Legacy Issues

- Key points
  - Contamination from foam use is the result of past practices for testing and training, before the potential environmental impact of foam discharges was known to most users or manufacturers
  - Over the past decade there has been an increased focus on minimizing discharges of fire fighting foams to the environment
  - Current best practice calls for the containment and treatment of foam discharges, and the use of alternative fluids and methods for testing and training



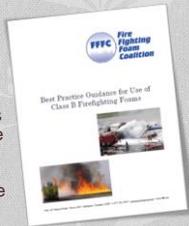
## Minimize Emissions

- The vast majority of foam discharges result from the use of foam for training or testing of systems and equipment
- FFFC has developed best practice guidance that focuses on using alternative fluids and methods for testing and non-fluorosurfactant foams for training
- Also contains detailed guidance on containing and treating foam discharges
- Included as additions to NFPA 11, In Annex E



## FFFC Best Practice Guidance

- Use fluorinated Class B foams only in situations that present a significant flammable liquid hazard
- Before deciding to use fluorinated Class B foam for a specific hazard, investigate whether other non-fluorinated foams or techniques can achieve the required extinguishment and burnback resistance
- Look for specific Approvals or Listings for Fluorine Free Foams consistent with the intended application. Look for UL and FM



## FFFC Best Practice Guidance

- Use **training foams** that do not contain fluorosurfactants for training and testing purposes
- Provide for **containment**, treatment, and proper disposal of foam solution – do not release directly to the environment
- Develop firewater **runoff collection plans** if not already in place
- Plan system testing so as to properly contain and dispose of foam solution effluent generated by the tests
- With a live fire there are an unlimited number of circumstances, therefore, any and all actions should consider fire fighter and public safety first
- Develop plans for dealing with unplanned releases of foam concentrate or foam solution so as to minimize the environmental impact

## Summary

- Fluorinated fire fighting foams are the most effective agents currently available to fight flammable liquid fires
- Fluorosurfactants provide exceptional extinguishing capability, but also an additional environmental challenge – persistence
- Environmental impact is being reduced further with the transition to short-chain (C<sub>6</sub>) fluorosurfactants
- Regulatory agencies in Canada, Europe, and the United States have proposed regulations on the use of long-chain perfluorinated chemicals (≥C8)
- Fluorine Free Foams provide excellent performance when used properly and on the proper hazards
- Foam legacy contamination issues are likely to be a growing concern
- Industry is promoting use of best practice to reduce environmental impact of foam

[www.fffcc.org](http://www.fffcc.org)

***A thank you to the Fire Fighting Foam Coalition (FFFC) for supplying some of the materials used in this presentation!***

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## Foam Legacy Issues

- 3M or other PFOS-based foams degrade into:
  - PFOS, PFHxS (C6 homologue of PFOS)
  - PFOA, PFHxA (C6 homologue of PFOA)
- Fluorotelomer-based foams degrade into :
  - 6:2 Fluorotelomer Sulfonate (6:2 FTS), 8:2 FTS
  - PFOA, PFHxA (minor breakdown products)
  - Do not contain or breakdown to PFOS or PFHxS
  - Misconception to refer to fluorotelomer-based foams as "PFOA foams"
  - Not made with PFOA, PFOA is not an ingredient in the foam, only contain trace quantities of PFOA as a contaminate of the surfactant manufacturing process

## Transition to Short-chains

- US EPA PFOA Stewardship Program 2010/15
  - Started in 2006 with 8 fluorochemical manufacturers
  - By the end of 2015, "work towards the total elimination..."
- Most fluorochemical manufacturers ended production of long-chain chemicals ( $\geq$ C8) during or before 2015
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Thank You

