WESTCAS Fall Conference
24 October 2019
Tucson, Arizona

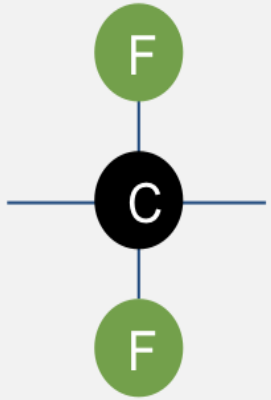
PFAS Overview

Per- and Polyfluoroalkyl Substances

American® Chemistry Council

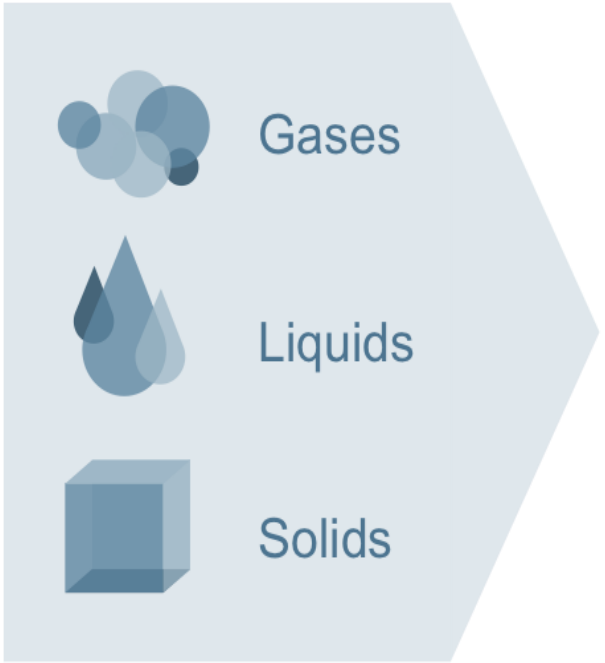
Overview: PFAS includes thousands of substances with *very different* properties

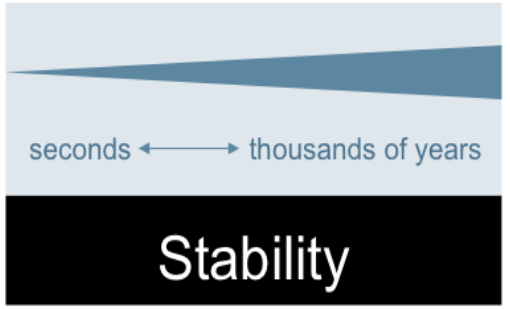
Similarities

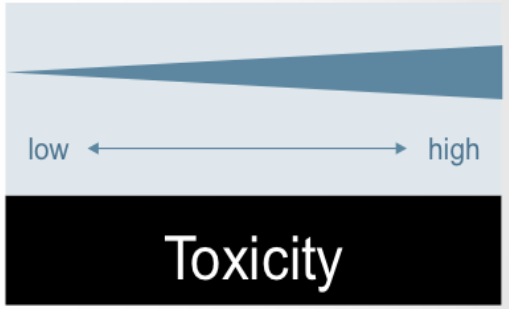


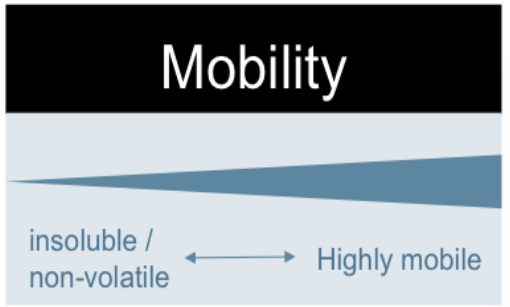
1 fully fluorinated carbon

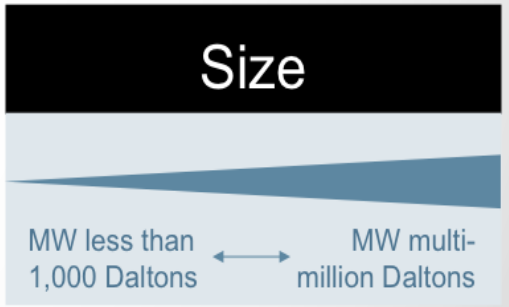
Differences





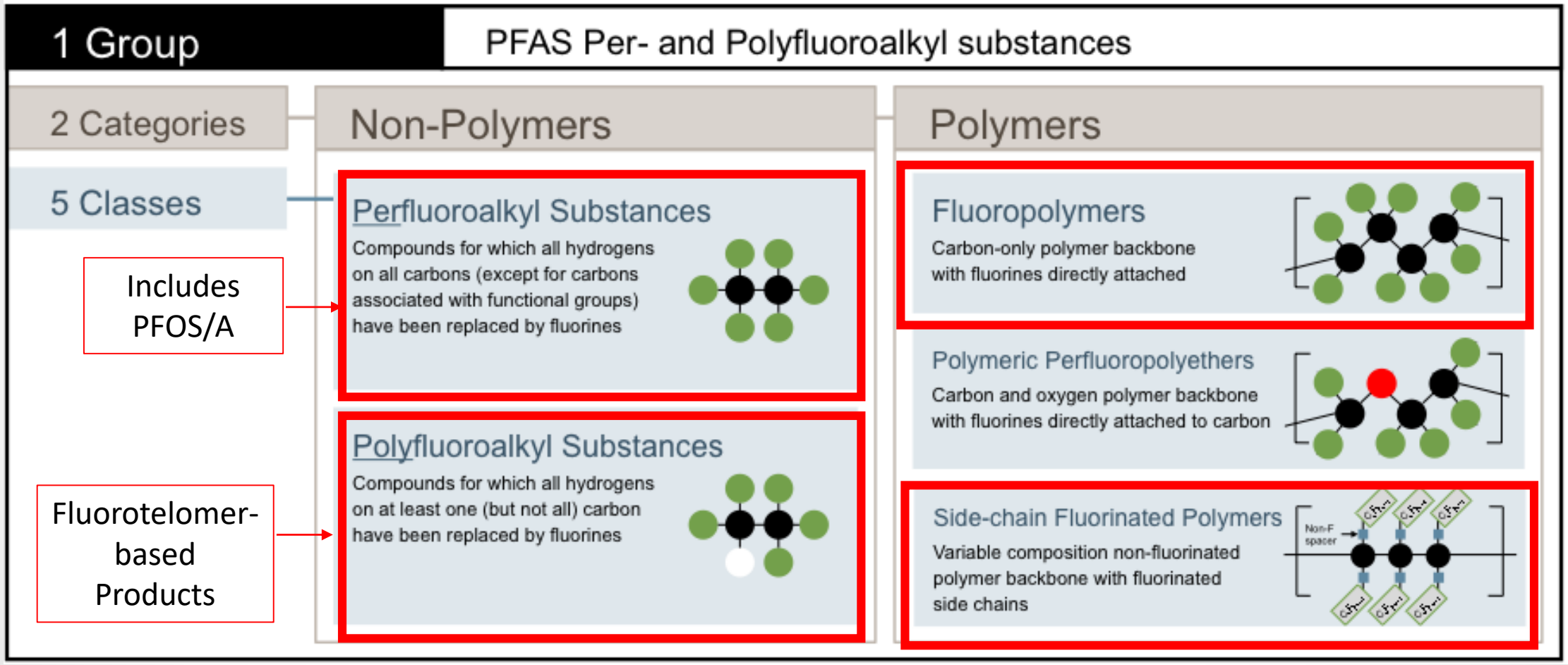






PFAS Overview

Fluorine
Carbon
Oxygen
Hydrogen

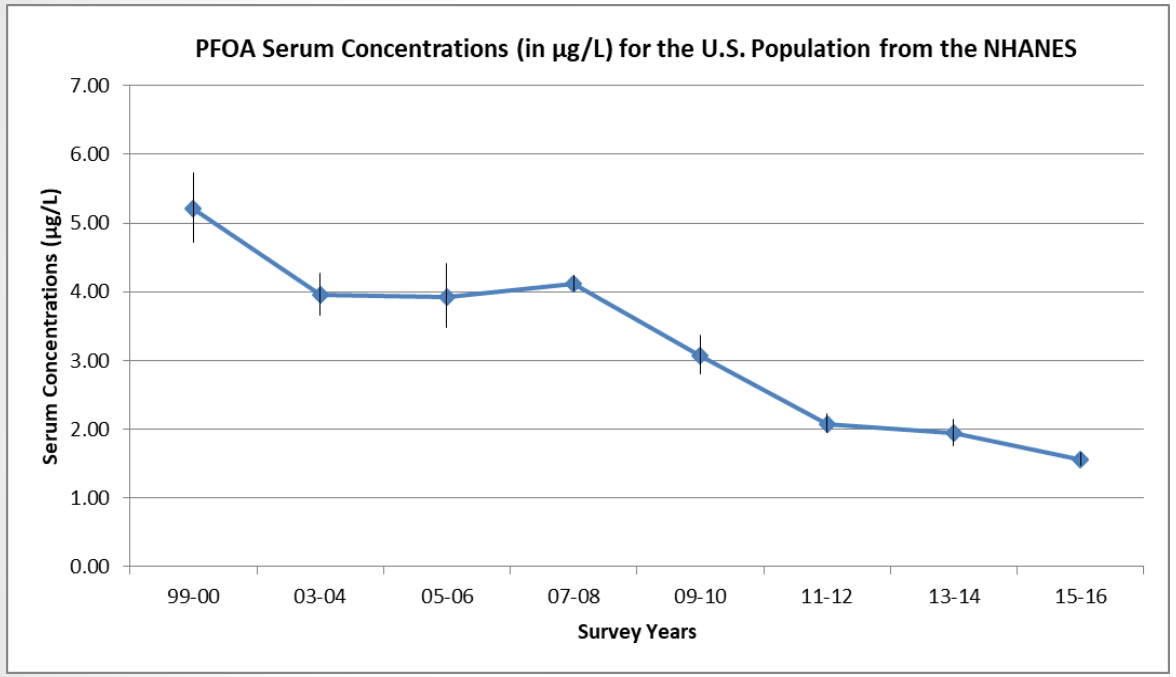


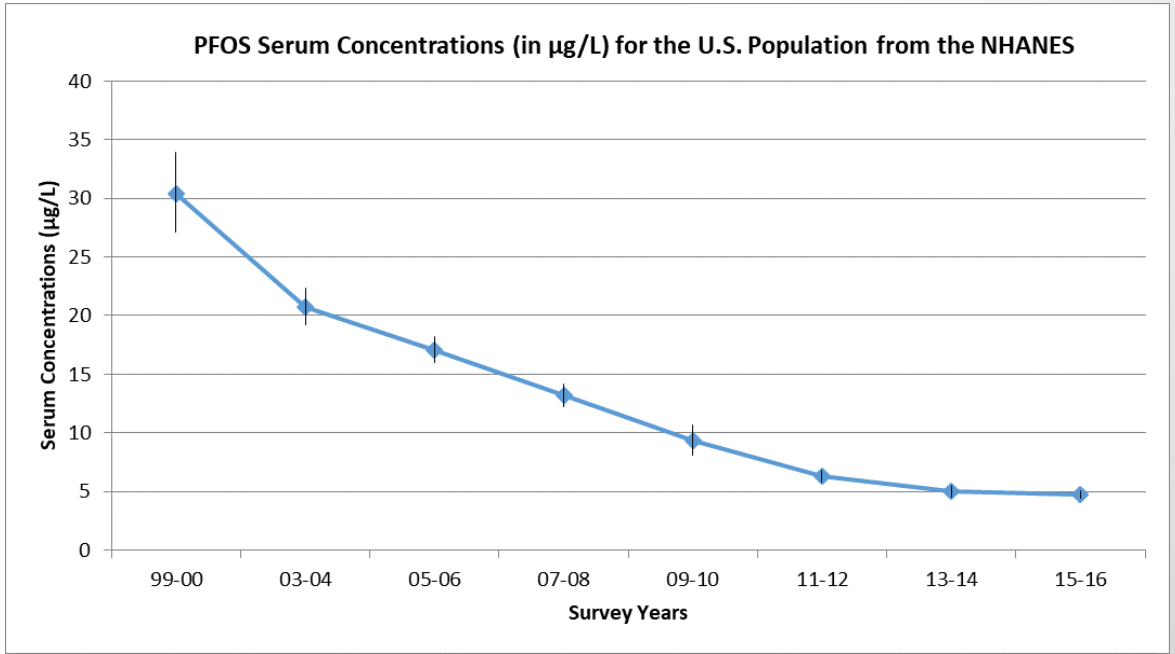
Perfluoroalkyl and polyfluoroalkyl substances in the environment: Terminology, classification, and origins. *Integrated Environmental Assessment and Management* **2011**, *7*, (4), 513-541. http://dx.doi.org/10.1002/ieam.258

History of PFAS – PFOS & PFOA

- Properties & Use
  - Stable, hydrophobic (water) & lipophobic (oil and grease), superior surfactants
  - Used as a stain/water repellant, surfactant in class B fire-fighting foams (AFFF), polymerization aid in fluoropolymer manufacturing
  - Voluntarily phased out in U.S., Europe, and Japan by major manufacturers in conjunction with EPA
    - As a result, blood levels have dropped by 60 – 80%
    - Manufacturing continues in other countries and can be imported to the U.S.
- Issues
  - Persistent and bioaccumulative
    - Biological half-lives of 2-3 years
  - Associated with multiple health effects in animal testing
    - Including developmental effects
  - Mobile in water
- Federal Actions
  - Various use restrictions (*i.e.*, SNURs) imposed
  - Lifetime health advisories (@70 ppt) for drinking water issued in 2016

Blood Levels of PFOA and PFOS Have Declined Dramatically





NHANES – National Health and Nutrition Examination, Center for Disease Control and Prevention (CDC)

Exposure to PFOA and PFOS is Generally Low

- US EPA survey of public drinking water systems (2013-2015)
  - All large systems + representative sample of small systems
  - PFOA and PFOS were detected in **less than 2** percent of the systems tested.

- MI Department of Energy, Great Lakes, and Environment (EGLE) – 2018 Survey
  - All community, school, child care, and tribal water supplies
    - PFOA and PFOS **not detected** in 90 percent of the samples
    - An additional 7 percent of the samples <10 parts per trillion (ppt)
  - EGLE estimates that only 22 small water suppliers* would exceed the state's proposed standards for 7 PFAS – out of a total of 2700 suppliers (<1%)

*suppliers include churches, trailer parks, schools, private businesses, and 2 small towns

What Other States Have Found

- VT PFAS Testing in Public Water Systems
  - So far, all public drinking water systems sampled for PFAS shows that the water in each system currently meets state DW advisory level
    - The advisory level is 20 ppt for the sum of five PFAS
  - Testing all public drinking water systems by December 1, 2019

- CA Public Water Supply Well Sampling
  - Testing for >600 water system sites adjacent to airports with fire training areas and municipal solid waste landfills
  - PFOS/PFOA detected at half of the sites, even though sampling was targeted at sites where contamination was expected

Potential PFOA/PFOS Exposure

- Disparity in guidance established by U.S. EPA, other federal agencies, various states, and international organizations has created significant confusion about the potential health risk of exposure to PFOA and PFOS
  - Values range from ~10 to 200+ ppt for PFOA; ~10 to 600 ppt for PFOS

- USEPA and MI DEQ surveys suggest that exposure to these two substances is generally below levels that have been identified as presenting potential health concerns

Regarding Water Standards for PFAS

- ACC supports a science-based rulemaking process for developing standards
  - Focused on PFOA and PFOS
  - Considers best available scientific information
    - Animal and human evidence for health effects
    - Latest information on biological half-lives
  - Standards should apply to individual substances
    - No single standard for multiple PFAS

Fluoropolymers

Material Properties:	• Chemical resistance, thermal stability, resilience
Toxicity	• High molecular weight polymers that are not bioavailable and do not present a significant risk to human health or the environment
Polymerization aids	• Major manufacturers phased out use of PFOA/long-chains and moved to alternatives that regulators have approved with conditions (e.g., strict limits on emissions)

Fluoropolymers meet OECD Polymer of Low Concern Criteria

13 Criteria

Polymer composition

MW, M_n, MWD

wt% oligomer

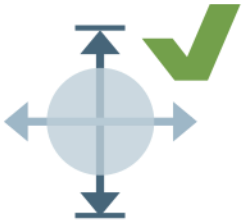
Electrical charge

Reactive Functional Groups (RFG)

Functional Group Equivalent Weight (FGEW)

Low MW leachables

Water / lipid solubility, octanol water partition



Particle size

Polymer stability

Thermal stability

Abiotic stability

Biotic stability

Example Fluoropolymer Applications

Electronics

High frequency signal transmission; smudge-resistant touch screens

Textiles

Membranes in outdoor apparel, providing a breathable barrier against wind and rain

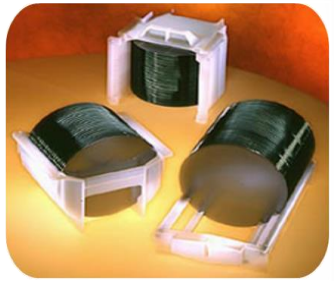
Medical Devices

High dielectric insulators in medical equipment that relies on high frequency signals

Aerospace/Auto

Weight reducing fuel lines; heat/chemical resistant wire coatings

Semiconductor Manufacturing



Providing pure environments to transport/store harsh chemicals

Alternative Energy

Insulation properties, durability, and safety enabling lithium batteries, fuel cells and photovoltaic solar panels

Fluorotelomer-based Products

Properties Provided

- Surface modification & protection
- Water & oil repellency
- Soil resistance and release
- Wetting and spreading

Chain Length

- Major manufacturers moved to short-chain fluorotelomer-based products

Example Fluorotelomer-based Product Applications

Healthcare

Garments/Drapes that Protect Against Disease Transmission

First Responder Gear

Treatments and Bulletproof Vests that Maintain Performance in Extreme Conditions

Specialty Paper

Oil/Grease Resistant Food Packaging that is Recyclable, Increases Shelf-Life, Reduces Packaging

Upholstery

Textiles with Water/Oil Repellency, Stain Resistance and Soil Release and Longer Useful Life

Paints and Varnishes

Durable construction materials coatings

Fire Fighting Foam

Class B (Flammable Liquid) Foams with Shorter Extinguishing Time and Burnback Resistance

About Short-Chain Fluorotelomer-based Products

- Accepted for use in consumer products by regulators globally
- Recognized as meeting relevant regulatory standards
- Polymers widely understood not to present toxicity concerns
  - Not bioavailable; not a focus of regulators
- Hazard is characterized by their degradation products (namely PFHxA)
- Supported by a robust body of data
- Studies show short-chain fluorotelomer-based products do not present significant adverse impacts

PFHxA Toxicity Summary

- Does not represent a reproductive, developmental or neurobehavioral hazard
- Not carcinogenic
- Not mutagenic
- Does not bioaccumulate in fish
- Quickly eliminated from living organisms
- Not an endocrine disruptor

* PFHxA is an impurity/degradation product

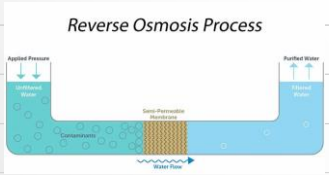
Analytical Methods

- US EPA Method 537.1 (DW)
  - Measures 18 distinct analytes
  - Expanding to 25 analytes to cover certain short-chain PFAS

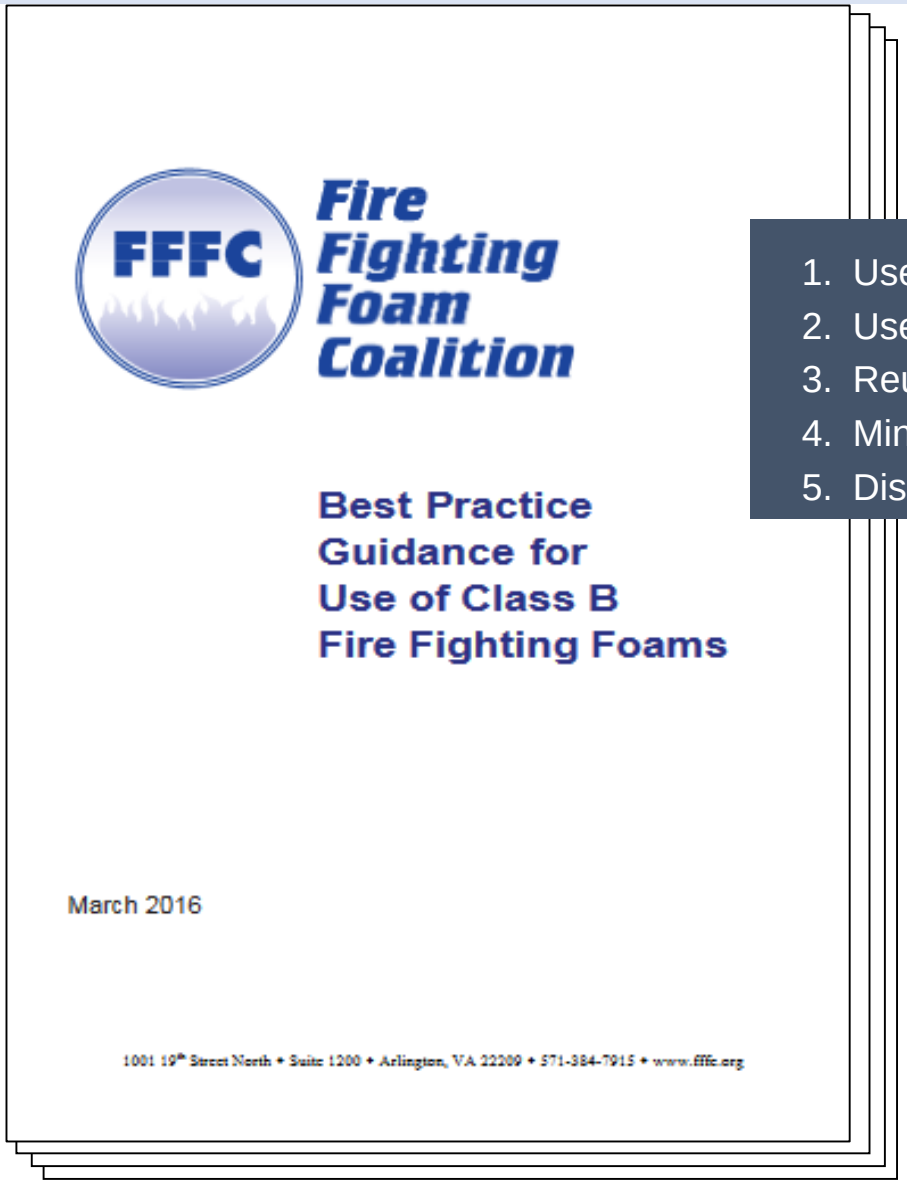
- Proposed US EPA Method 8327 (non-DW)
  - Draft released for public comment in June 2019
  - Intended to detect 24 PFAS analytes
  - Non-potable water (e.g. SW, GW, WW)

PFAAs can be removed from source water to meet drinking water standards

PFAS Removal from Water

Technology	How it Works	Issues	End of Life
GAC - Granular Activated Carbon 	Molecules adsorb onto surface of carbon particle pores Least Expensive Option	Pores not selective to just PFAS; short-chains not as effectively removed via GAC	Spent GAC either landfilled or regenerated via high temperatures
IX - Ion-exchange Resins 	Granular form can be packed in beds like GAC. Charged particles bind charged PFAS molecules as they pass through bed	Resins need to designed to be specific to PFAS and thus increase effectiveness New resins are more efficient	If single-use: landfilled Can regenerate resins with solvent flush. Flush needs to be managed/disposed of
RO - Reverse Osmosis 	Contaminated water forced via pressure through semipermeable membrane filtering out PFAS selectviely	RO is energy intensive and may filter out other molecules such as minerals in drinking water. Potential pipe corrosion control issue as a result	A concentrated liquid PFAS waste stream is generated and needs proper disposal

Industry Best Practices – Reduces Environmental Release and Potential For Exposure



1. Use the product only when necessary
2. Use only what you need
3. Reuse/recycle residual liquids if possible
4. Minimize waste and emissions
5. Dispose of all chemicals properly

Links: https://fluorocouncil.com/PDFs/Guidance-for-Best-Environmental-Practices-BEP-for-the-Global-Apparel-Industry.pdf
https://fluorocouncil.com/PDFs/Best-Practice-Guide-for-Use-of-Class-B-Fire-Fighting-Foams-PDF.pdf

Questions, Discussion