



PFAS IN MILITARY TEXTILES

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WHAT IS PFAS?



PFAS stands for **per- or polyfluoroalkyl substances**, a group of chemicals that have been manufactured and used since 1940

Excellent chemical resistance and repellent properties due to the C-F bond

Referred to as “Forever Chemicals” due to widespread persistence in the environment

PFAS is an umbrella term for a class of organic chemicals that include nearly 9,000 different substances, including **any chemical with a carbon atom bonded to two or more fluorine atoms**


Industry is phasing out PFAS use and production

EPA requested information from Textile Manufacturers (including importers) on PFAS activities from 2011 to 2022 (11 years!):

PFAS use

Manufacturing and plant processes

Waste-water processes



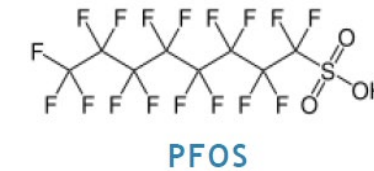
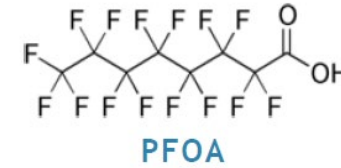
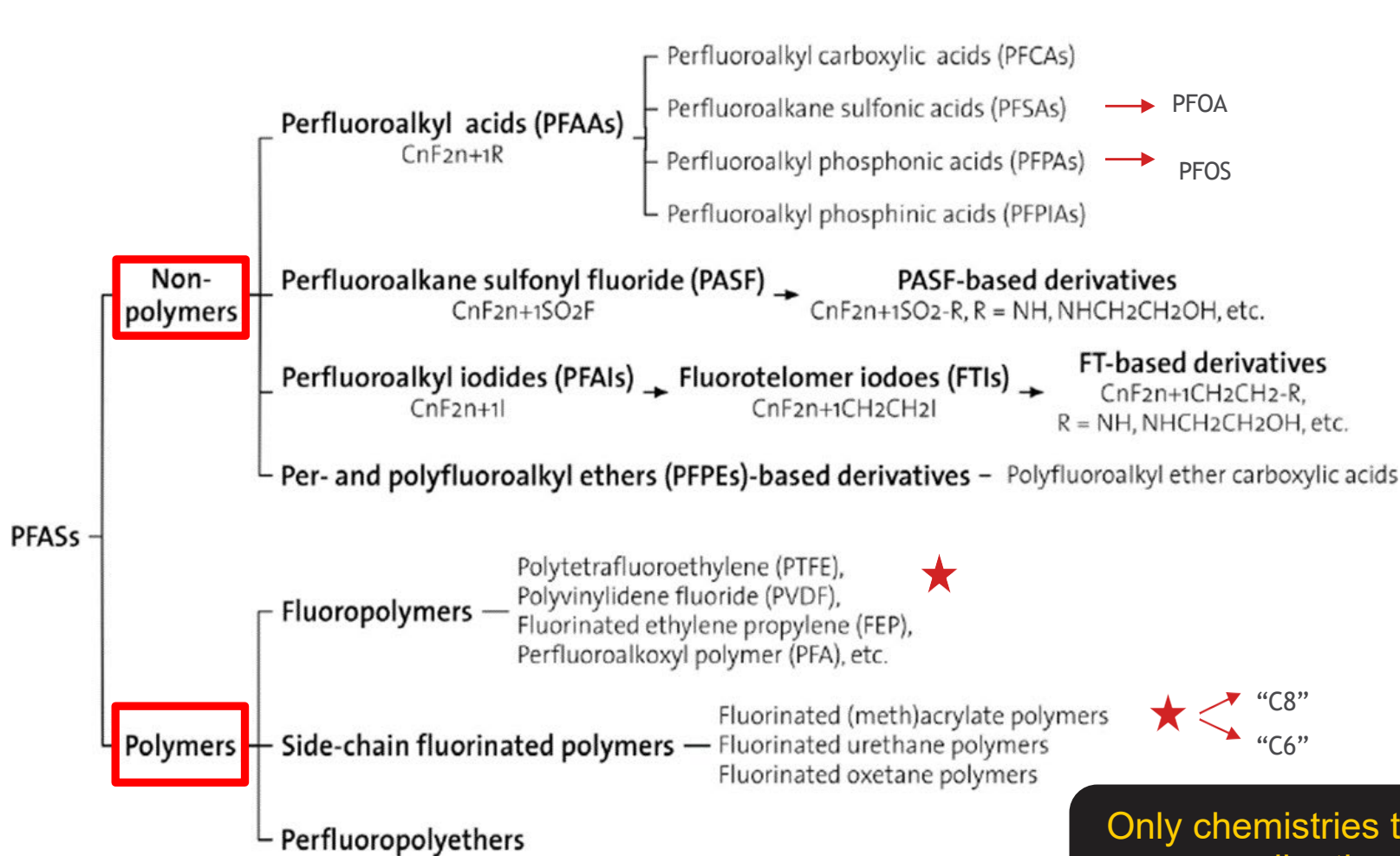
1,462 PFAS are
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2011

A yellow starburst graphic with a jagged, sunburst-like border. Inside the starburst, the text reads: '1,462 PFAS are known to have been made or used in the U.S. since 2011'.

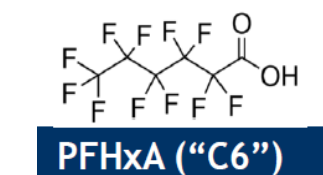
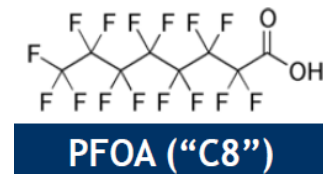
WHAT IS PFAS?



Per- and polyfluoroalkyl substances (PFASs)



Firefighting foams



Textile & equipment Applications

Only chemistries that pass oil rating requirements

OECD(2013), OECD/UNEP Global PFC Group, Synthesis paper on per- and polyfluorinated chemicals (PFCs), Environment, Health and Safety, Environment Directorate, OECD.



STATE OF THE INDUSTRY

- Civilian textile industry has largely divested from PFAS
- Market for PFAS based finishes is small and shrinking
 - Limited to military and medical textiles
 - FDA is struggling to find alternatives that meet IPA/water requirement
- EPA mandated reporting requirements for all companies working with PFAS
 - Industry considers the requirements confusing and labor intensive
- EPA enacted federal water levels
 - Water entering textile facility is often above EPA limits (45% of US water is contaminated)
 - Treating PFAS waste is expensive
 - Five years to comply
- Litigation concerns, pressure from state and local governments
- Vendors actively enquiring about waivers on oil rating requirement (shorthand for working with PFAS)
- **Many PFAS finish manufacturers have divested & continue to divest, focusing on the higher demand for non-PFAS based finishes. This leaves textile finishers with sudden supply chain issues.**

CRITICAL USES OF PFAS IN MILITARY CLOTHING & EQUIPMENT



Two major uses of PFAS

1.) Fabric Finishes

- To provide water, liquid, & oil repellency and soil (stain) resistance on clothing and equipment items (including footwear, shelters, etc.) along with reduced friction on parachute components

2.) Breathable, waterproof membranes and films

- To provide a barrier against wind, rain, and snow/ice hence providing protection in extreme environments to prevent hypothermia
- Chemical/Biological (CB) Protective barriers

HOW IS DEVCOM SC ADDRESSING PFAS CHALLENGES?



- **PFAS S&T IPT** – Cross-service collaborative IPT devoted to addressing PFAS replacement and remediation technologies, tracking state-of-the-art alternatives, research and legislation affecting supply chain issues
- **Impacted Items PFAS IPT** – Cross-service IPT focused on impacts to fielded items and mitigation strategies
- **Standardized Test Method Development**
 - AATCC** – Developing standards and test methods for PFAS detection
 - ASTM** – Developing guides on PFAS



SCOPE OF THE CHALLENGE



Courses of Action to understand the challenges we were facing:

1.) What textiles-based items utilize PFAS? Where is it located? In what form?

A.) Textile finishes for repellency

B.) Barriers for Protection

C.) PFAS used in the manufacturing process but NOT intended in the final product

For Example: Used as part of solvent to disperse particles for coatings / textile finishes / etc.

2.) Why? What is its purpose?

Many current performance specifications can NOT be met without the use of PFAS

3.) If PFAS was to be removed what is the impact?

Bucket 1: Low impact to function and protection

Bucket 2: Medium impact

Bucket 3: Critical impact



BUCKET 1: LOW IMPACT ITEMS

Army Green Service Uniform (AGSU)/Dress uniforms/Army Physical Fitness Uniform/canopy cloth/static lines

- PFAS finishes used for water repellency, stain/soil release, reducing friction
- Oil rating often used as a stand-in for stain/soil release properties
- Non-PFAS finishes need more investment to reach water resistance performance of PFAS finishes for water repellency and prevent impact to other properties
- Can likely be worked through with little impact to performance
- Could consider replacing oil rating test Stain/soil release tests, non-PFAS coatings do have stain/soil release
- AATCC 130, stain/soil release: apply the stain, wash, rate it



BUCKET 2: MEDIUM IMPACT ITEMS



Cold weather/environmental protection

- Purpose of oil rating is similar to Bucket 1
- Dynamic absorption requirement often can't be met with non-PFAS equivalent, sometimes hydrostatic resistance is lessened
- Durability of spray rating more critical to protection
- Unknown impacts on soldier physiology
- Needs more investment, potential decrease in performance



BUCKET 3: CRITICAL IMPACT ITEMS

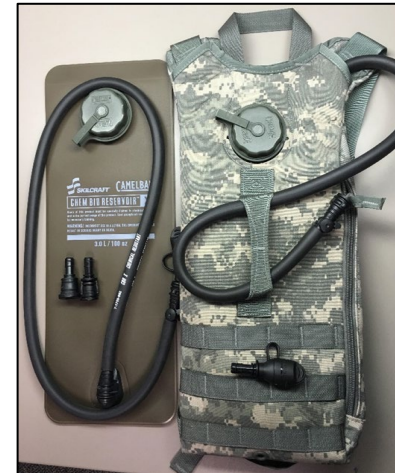


Fuel protection/Flame Resistance, CB protective gear

- Oil rating requirement used to gauge retention of FR during/after exposure to fuels
- Estimate ability to repel chemical warfare agents

HOLY GRAIL!
1 to 1 replacement of current
PFAS finish

Non-PFAS Alternative is 10+ years
away



SPEC ALTERATIONS



Currently in progress:

- MIL-DTL-32439 (used widely across the DoD, including airdrop)
 - Undergoing a full revision: Stipulates numerous 4 Types of deniers, with 3-4 Classes of each Type
 - All Classes with a water repellent finish include the oil rating (AATCC 118) as a requirement, which necessitates the use of a PFAS based finish
 - Revision will include identical, equivalent Classes **without** the oil rating, allowing for the use of non-PFAS based finishes
 - This will enable end item users to determine if the oil rating is necessary for their product without forcing them to abandon it
 - Replacing the obsolete ASTM D 747 test is delaying the revision, but it is in progress
- MIL-DTL-43128 (heavily used by airdrop)
 - Undergoing a full revision, using the same approach
- End item specifications: work in progress, determining if tests more operationally relevant to end item use can replace the oil rating

GENERAL MATERIAL CHALLENGES



Windproof/Waterproof Liners
Water Repellent Finish
Durable Stain Release
Petroleum/Oil/Lubricant/Flame Resistance
CB Agent Resistance
CB Protective Barriers

IDENTIFYING PFAS ALTERNATIVES OVERVIEW



Natick PFAS S&T Working group is tracking currently funded efforts:

- Partnerships with academic institutions (HEROES, JSNN)
- Environmental Programs: SAFR, SERDP
- SBIR & STTR efforts both Army and JSTO-DTRA funded
- ARO BAA includes PFAS replacements as a major thrust in the reactive chemistry program

Broad Technical Approaches:

- Modeling
 - AI/ML
- Repellency
 - Surface Chemistry or Morphology
 - Synthetic Biology
- Chemical Barriers
 - Selectively Permeable Membranes
 - Impermeable
- Hydration/Drinking Water
 - Sensing/Detection
 - Remediation

REPELLENT FINISHES



PFAS finishes provide durable water, liquid, soil and oil repellency on any fabric regardless of weave, fiber or fiber blend throughout the garment lifecycle

Currently, PFAS alternative finishes

- Cannot provide oil repellency in accordance with AATCC 118 to meet DoD specifications
- Don't provide PFAS levels of durability – performance is end-use dependent & must be optimized based on fiber content and fabric construction

Path forward:

- For applications that only need stain/soil release – change to Stain Release Testing vs. Oil Rating
- Look at each system individually & as a whole– Engineering Solution
 - i.e. remove the repellent finish and add protection in another layer / section of the system
- Still pushing for the one-to-one replacement for oil repellency
 - 10 + years away!

MEMBRANES & BARRIER FILMS



Perfluorinated materials as

- 1.) Membranes for semi / selectively permeable materials - for chemical, wind, cold, and environmental protection allow water vapor to pass through for Soldier comfort while blocking other threats
- 2.) Barrier materials to achieve very high, broad levels of protection in chemical/biological applications

Selectively permeable materials

- Trade space between protection and comfort
- Difficult to meet with non-PFAS solutions currently

The role of as a barrier is critical

- In a chemical/biological application, barriers in an impermeable garment provides ALL protection
- Materials with PFAS compounds provide high levels of protection from TICs and chemical agents
- PFAS may not be necessary, but is used for the exceptional chemical resistance of the C-F bonds

LIFE CYCLE MANAGEMENT



At end-of-use, any residual chemistry needs to be handled in the relevant material recovery method, regardless of whether it is recycling, incineration, or landfilling. Contamination can occur in:

- Ground/Water
 - Carpet & clothing are most likely sources of PFAS in landfill leachate.
- Air
 - During manufacturing air emissions from volatile substances
 - Polymerized PFAS & integrated into the textile, when thermally decomposed such as in burn pits
 - Burning waste in pits can create more hazards compared to controlled high-temperature burning (commercial incinerator)
- Water
 - Processing/manufacturing of textiles containing PFAS
 - Water emulsions during application to fabrics, effluent water
 - Many textile manufacturers (Milliken, DuPont, 3M, and Mount Vernon Mills) have been sued for contaminating US public drinking water.

PATH FORWARD



- Continue to seek funding to identify and develop alternatives to PFAS which will not be considered "regrettable solutions"

- Continue to evaluate tradeoffs and modify requirements to tests specific to end item use to remove the oil rating (which necessitates a PFAS based finish) when possible

- Modify or identify new test methods that are more operationally relevant than the oil rating that will demonstrate the required capability in fielded items

- Collaborate and share information and findings among DoD partners, academia, & industry
 - Understand areas of research and finding overlapping areas for future collaboration/info sharing

Points of Contact



THANK YOU.

Environmental Programs

ASTM F15.81 Per-and Polyfluoroalkyl Substances

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DOD PFAS Site/Task Group

<https://www.acq.osd.mil/eie/eer/ecc/pfas/index.html>

Natick PFAS S&T IPT

Protect Working Group (CBR MOU):
Task 8 – Fluorine Free Approaches to Dermal
Liquid Protection

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Impacted Items PFAS IPT

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