Fluorinated Fire Suppression Products

Briefing pursuant to Senate Report 118-188, page 112, accompanying S.4638, the National Defense Authorization Act for Fiscal Year 2025

September 2025

The estimated cost of this report or study for the Department of Defense is approximately $27,000 for the 2025 Fiscal Year. This includes $12,000 in expenses and $16,000 in DoD labor.
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Purpose

Senate (Armed Services Committee) Report 118-188 (p.112),[1] accompanying S.4638, the National Defense Authorization Act for Fiscal Year 2025, requested a briefing on DoD uses of fluorinated gas fire suppression products:

> "The committee understands that fluorinated gas (F-gas) fire suppression products are currently used in cockpits, ships, and other confined spaces to provide lifesaving emergency fire suppression. Additionally, F-gas fire suppression products neither conduct electricity nor impair visibility upon discharge like other fire extinguishing agents, making them useful across a wide variety of applications for the Department of Defense (DoD).
>
> The committee is interested in learning more about how DoD may or may not be impacted by the definition of per- and polyfluoroalkyl substances (PFAS) as it relates to F-gas fire suppression products. Accordingly, the committee directs the Secretary of Defense to brief the Senate Armed Services Committee, not later than January 1, 2025,[2] on the identification of any lifesaving products that use F-gas and any potential mission impacts as a result of any changing definitions regarding PFAS."

[1] https://www.congress.gov/congressional-report/118th-congress/senate-report/188/1.
[2] OASD(EI&E) request granted to extend due date to 31 July 2025.

Briefing Outline

- **Boundaries of Briefing**
- **Life Saving Fluorinated Fire Suppressants**
  - Fluorinated Fire Suppressants
  - Fluorinated Fire Suppressants used by DoD and Defense Industrial Base (DIB) – Supply Chain Vulnerabilities
  - Non-Fluorinated Fire Suppressant Alternatives
- **Impacts to DoD from Differing Various Regulations and PFAS Definitions**
  - Regulation of Fluorinated Fire Suppressants
  - Trends Among PFAS Definitions
  - Broad PFAS Definitions Creating Supply Chain Risk
  - Impacts to DoD from Differing PFAS Definitions
- **Conclusions**

Boundaries of Briefing

Bottom Line Up Front (BLUF): This briefing will use the term "fluorinated fire suppressants" to be inclusive of products stored as liquid but discharged as gas.

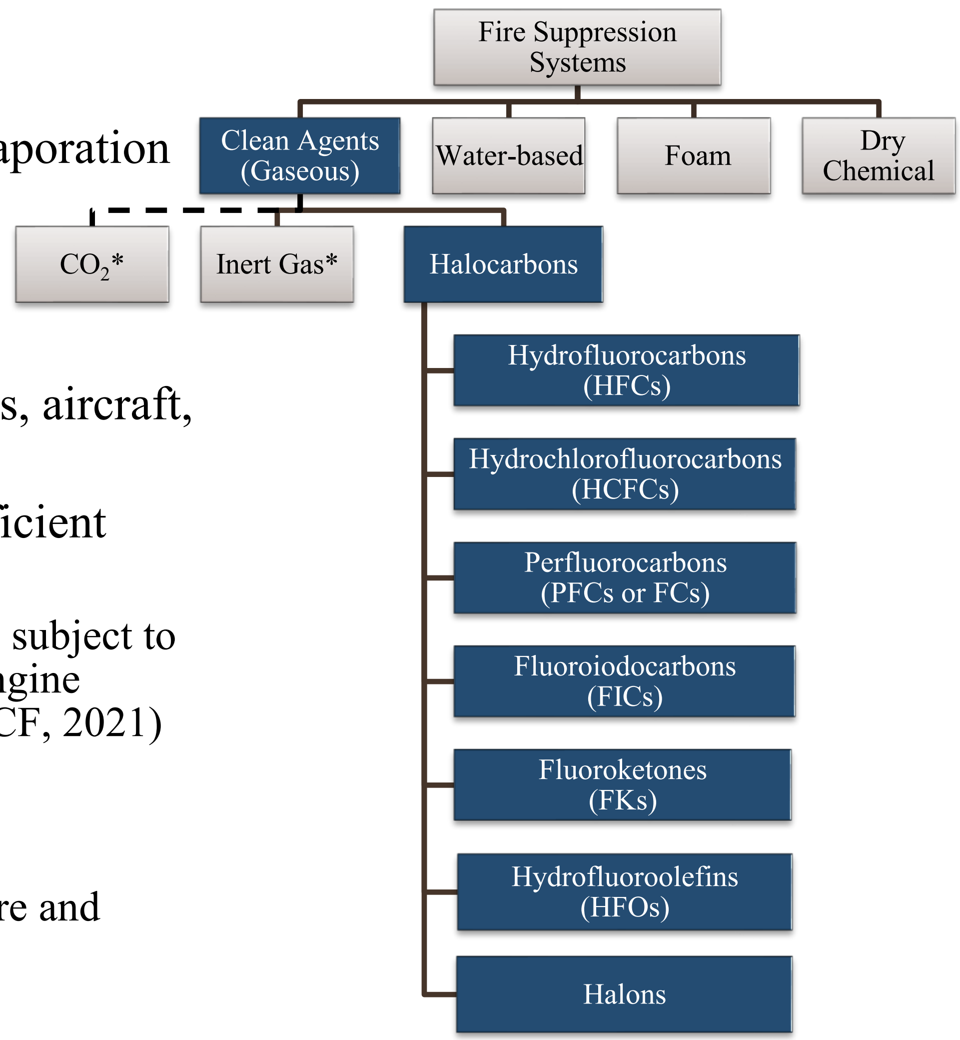
- Congress requested a briefing on "**fluorinated gas (F-gas) fire suppression products**."
- The most common definitions of F-gases (e.g. EU 2024/573) are limited to fluorinated greenhouse gases (GHGs), and do not include all of the fluorinated fire suppressants that DoD uses that could meet various PFAS definitions.
- DoD critical fluorinated fire suppressants can be both gases and liquids in their initial state. Both can fall under various PFAS definitions.
- For the purposes of this briefing, we will use the term "**fluorinated fire suppressants**" to address Congress's question regarding F-gas criticality.

Fluorinated Fire Suppressants

BLUF: This briefing focuses on clean agent fluorinated fire suppressants (in blue boxes below), which are critical for the protection of weapon systems and safety of warfighters to maintain lethality of force.

Clean Agent Fluorinated Fire Suppressants

- Gaseous fire suppressants that are electrically nonconducting and do not leave residue upon evaporation (O'Connor, 2022)
- Extinguish fires without damaging equipment
- Multiple military and industry standards
- Preferred in DoD weapon systems such as vessels, aircraft, and ground combat vehicles (DoD, 2023)
- Provide superior extinguishing capacities and efficient integration into high performance systems:
    - Use in crew spaces and unoccupied compartments subject to flammable/combustible liquid fuel fires such as engine modules and hazardous material storage spaces (ICF, 2021)
    - Rapidly vaporize to fill compartment space
    - Compress to liquids, requiring less storage space
    - Offers optimal protection to warfighters against fire and explosions caused by combat threats



*Not feasible for certain DoD applications based on considerations listed on Slide 7.

Fluorinated Fire Suppressants Used by DoD and DIB – Supply Chain Vulnerabilities[1]

BLUF: DoD has sole source and Foreign Ownership, Control or Influence (FOCI) risks with many critical fluorinated fire suppressants. China has emerged as the primary alternative source.

Product	Weapon Systems and Platforms	Relevant Spec	Product Manufacturer(s)	Country Source
HFC-227ea (CASRN 431-89-0)	• Ground / Amphibious Vehicles (Crew and Engine) • Aviation Systems • Marine Vessels • Onboard space vehicles	ASTM D6064	• Chemours (FM-200™) *to be discontinued • Domestic recycled sources (i.e., A-Gas, Wesco) • Multiple from China (e.g. Waysmos Fine Chemical Company)	
HFC-236fa (CASRN 690-39-1)	• Aircraft	ASTM D6541	• Multiple from China (e.g. Waysmos Fine Chemical Company)	
HFC-125 (CASRN 354-33-6)	• Aircraft (Engine nacelle & Auxiliary Power Unit) • Ground / Amphibious Vehicles (Engine)	ASTM D6231	• Chemours (FE-25™)	
FK-5-1-12 (CASRN 756-13-8)	• Flightline fire extinguishers, turbine engine test cells • Marine Vessels • Drone Control Centers • Electronic Control Rooms	ASTM WK75827	• 3M (Novec 1230™) • Multiple from China; some packaging/ distribution from other Asian countries and limited European countries	
Halon 1301 (CASRN 75-63-8)	• Aircraft • Marine Vessels • Legacy Ground Combat Vehicles (Crew)	ASTM D5632	• *No Domestic Production: Recycled:* A-Gas, Wesco etc.	

Other fluorinated fire suppressants used by industry include HFC-23 (CASRN 75-46-7), 2-BTP (CASRN 1514-82-5), Halon 1211 (CASRN 353-59-3), Trifluoroiodomethane (CF_3I) (CASRN 2314-97-8), Halocarbon Blend 55 (HB-55), and certain HCFCs.

[1]Informed through DoD subject matter expert (SME) engagement.

Non-Fluorinated Fire Suppressant Alternatives[1]

BLUF: For many DoD- and certain critical civil- applications, non-fluorinated fire suppressant alternatives are not viable.

- **Though some non-fluorinated alternatives (e.g., water mist, inert gases, sodium or potassium bicarbonate dry chemical suppressants) may exist for specific applications, alternatives are generally not suitable due to:**
  - Safety Concerns (e.g., flammability potential) and Toxicity/Byproduct Concerns
  - Size/Weight/Form Factor Requirements, which can make alternatives difficult to integrate in small, mobile systems
  - Retrofitting Needs (e.g., dry chemical requires modified distribution) and Operational Concerns (e.g., clean up, corrosivity, obscuration)
- **Several weapon system platforms have technical requirements that commercially available alternatives cannot satisfy (SERDP and ESTCP, 2022).**
  - Gaseous low global warming potential (GWP) alternatives are more reactive and may create explosive hazards.
  - Lower GWP chemicals also generate much higher levels of toxic byproducts resulting in higher exposure to warfighter, as compared to more stable, higher GWP chemicals.
- **Despite 30-years of efforts, DoD and the world-wide civil aviation industry have not identified technically feasible, safe, effective non-fluorinated alternatives for critical in-flight applications.**
  - In fact, aviation has not been able to replace ***halon***, which went out of production in 1993; All civil airliner aircraft still use halon for critical in-flight engine and cargo fire suppression.
  - International Civil Aviation Organization (ICAO) representatives have notified the UN Fire Suppression Technical Option Committee that the aviation industry may manufacture the next generation of airliner aircraft with halon – requiring a Montreal Protocol Essential Use Exemption for at least 50 years (ICAO, 2022).
- **Retrofitting assets to utilize alternatives would be necessary in ground vehicles, ships, and cargo planes.**
  - For non-occupied compartments, non-fluorinated alternatives are technically feasible and available; however, would require significant retrofit.
  - Weapon system redesign or retrofit to use alternatives may not be technically or economically feasible.
- **Finding appropriate alternatives will require time for research, development, test, and evaluation (RDT&E) to qualify new products for case-by-case substitutions.**
  - RDT&E efforts to find, qualify, and approve alternatives takes 10-15 years before an alternative candidate is identified.
  - No alternatives have been approved for occupied compartments.

[1]Informed through DoD SME engagement.

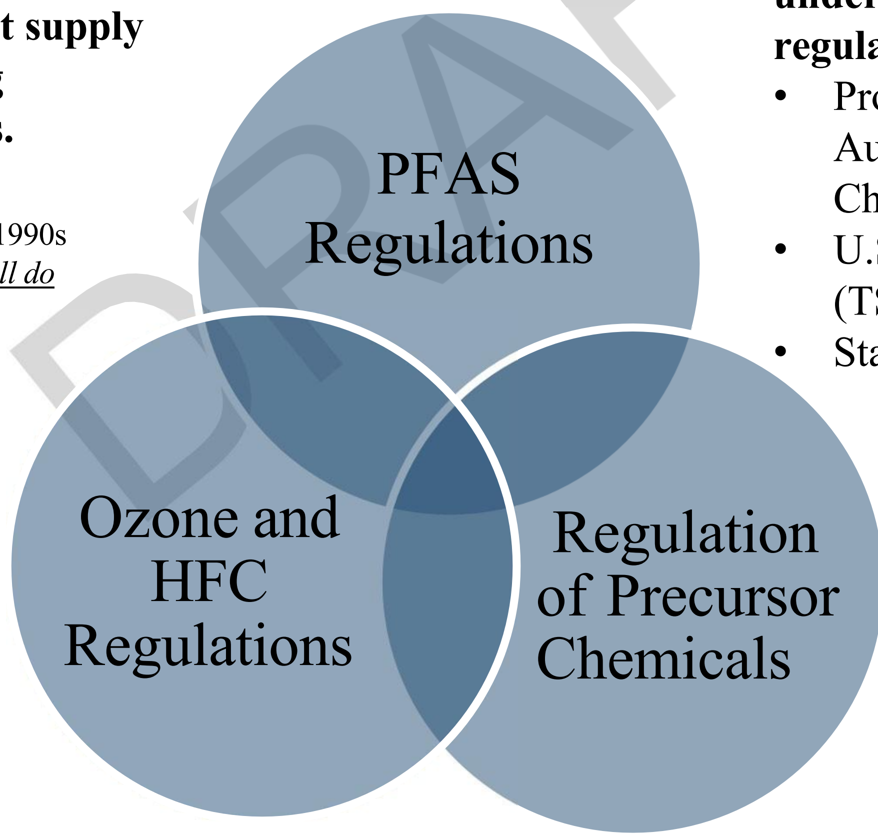
Regulation of Fluorinated Fire Suppressants

BLUF: Federal, state, and international regulations of manufacture and use of fluorinated fire suppressants can cause supply chain vulnerabilities and affect availability of lifesaving products.

Regulations that impact fluorinated fire suppressants can include phasedowns to reduce GHG emissions, PFAS-containing product bans, PFAS manufacturer discharge limits (e.g. state National Pollutant Discharge Elimination System (NPDES) permits), and restrictions on feedstock chemicals.

Most fluorinated fire suppressants are already under significant supply chain pressure from existing phase-outs and phase-downs.

- Montreal Protocol
  - Halon production phase-out in the 1990s
  - Some critical halon applications _still do not_ have technically feasible replacements
- U.S. American Innovation and Manufacturing (AIM) Act (and Kigali Amendment to Montreal Protocol)
  - 40% reduction in 2024
  - 85% reduction by 2036
- EU F-Gas Regulation
- EU Ozone-Depleting Substances Regulation
  - Phase out critical uses of halons from 2025 to 2040



Fluorinated fire suppressants can fall under PFAS definitions for emerging regulations.

- Proposed EU Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH) PFAS Restriction
- U.S. Toxic Substances Control Act (TSCA) PFAS Reporting Rule
- State Regulations

Regulations of precursor chemicals could impact the production of fluorinated fire suppressants.

- U.S. TSCA Section 6 (e.g. perchloroethylene (PCE) used to produce HFC-125)

Trends Among PFAS Definitions in Regulations

BLUF: Varying PFAS definitions in emerging regulations, especially in States, are creating regulatory uncertainty for industry and end-users of PFAS.

PFAS definitions vary among international, federal, and state regulations.

- OECD definition* is widely adopted, but regulations may carve out specific exemptions.
- At least 24 states have adopted the same definition "at least one fully fluorinated carbon atom", which is consistent with the OECD definition (Safer States, n.d.).
- EPA has relied on various PFAS definitions, depending on the program.

Trend to include exemptions for fluoropolymers and critical uses.

- New Mexico[1] included exemption for fluoropolymers.

  Canada[2] considered fluoropolymers out of scope.
- Maine[3] and New Mexico[1] have Currently Unavoidable Use (CUU) determinations for specific product categories.

  Minnesota[4] will do the same beginning in 2032.

Arguments remain about whether fluorinated gases should be similarly regulated as other PFAS.

- Overlap in substances subjected to proposed EU PFAS REACH Restriction[5] and EU F-Gas Regulation[6].

*See next slide for additional detail.

[1] New Mexico PFAS Protection Act (HB 212) (2025)

[2] Canada PFAS Risk Management Approach (2025)

[3] Maine Public Law, Chapter 630 (2024)

[4] Minn. Stat. § 116.943 (2024)

[5] EU PFAS REACH Restriction Proposal (2023)

[6] EU F-Gas Regulations (2024)

Interpretation and Practical Use of the 2021 OECD PFAS Definition

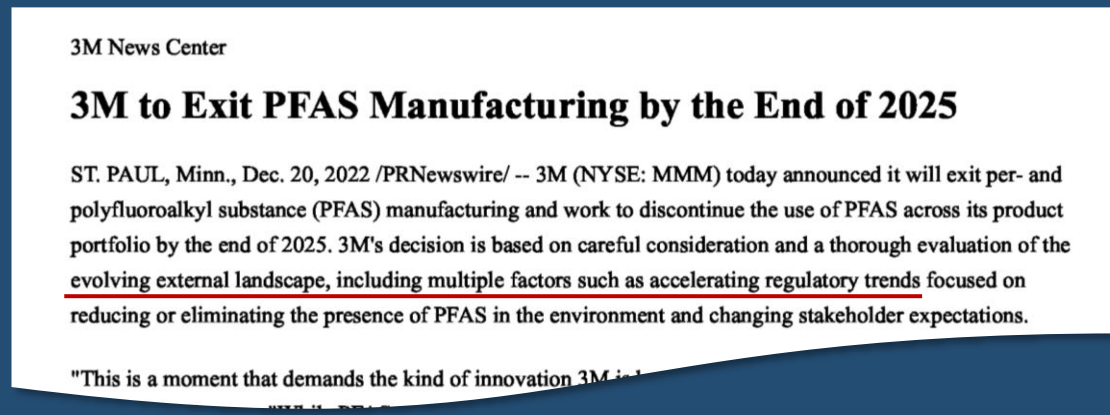
BLUF: The OECD states that their "*general definition is based only on chemical structure, and….is* ***not connected to decisions on how PFAS should be grouped and managed in regulatory and voluntary actions****.*" (OECD, 2021)

- In 2021, the Organization for Economic Cooperation and Development (OECD) defined PFAS as *"fluorinated substances that contain at least one fully fluorinated methyl or methylene carbon atom (without any H/Cl/Br/I atom attached to it), i.e. with a few noted exceptions, any chemical with at least a perfluorinated methyl group (–CF3) or a perfluorinated methylene group (–CF2–)."*
- OECD states that their PFAS term *"is a broad, general, non-specific term, which* ***does not inform whether a compound is harmful or not****, but only communicates that the compounds under this term share the same trait for having a fully fluorinated methyl or methylene carbon moiety."*
- The OECD definition "*does not include…any considerations beyond chemistry. It also* ***does not conclude that all PFASs have the same properties, uses, exposure, and risks****."*
- OECD provides "*practical guidance to governments and other stakeholders on how to use the PFAS terminology starting from the* ***distinction between the general definition and user-specific working scopes of PFASs****.*"

Overly Broad Definitions of PFAS Create Risk in the Defense Supply Chain

PFAS definitions used for legislation at state, federal, and international levels are not consistent, creating regulatory uncertainty.

- Creates logistical supply chain challenges for companies selling into different countries (and into different states).
- Drives manufacturers to exit the market or move manufacturing overseas.



3M News Center

3M to Exit PFAS Manufacturing by the End of 2025

ST. PAUL, Minn., Dec. 20, 2022 /PRNewswire/ -- 3M (NYSE: MMM) today announced it will exit per- and polyfluoroalkyl substance (PFAS) manufacturing and work to discontinue the use of PFAS across its product portfolio by the end of 2025. 3M's decision is based on careful consideration and a thorough evaluation of the evolving external landscape, including multiple factors such as accelerating regulatory trends focused on reducing or eliminating the presence of PFAS in the environment and changing stakeholder expectations.

"This is a moment that demands the kind of innovation 3M i...

https://news.3m.com/2022-12-20-3M-to-Exit-PFAS-Manufacturing-by-the-End-of-2025

- Regulatory restrictions/bans, reporting rules, and liability concerns associated with broad class-based PFAS definitions are leading to:
  - U.S. manufacturers ceasing production of mission critical fire suppressants
  - FOCI and supply chain risks
  - Growing Chinese chemical sector
    - Manufacturers in China face less stringent regulatory barriers

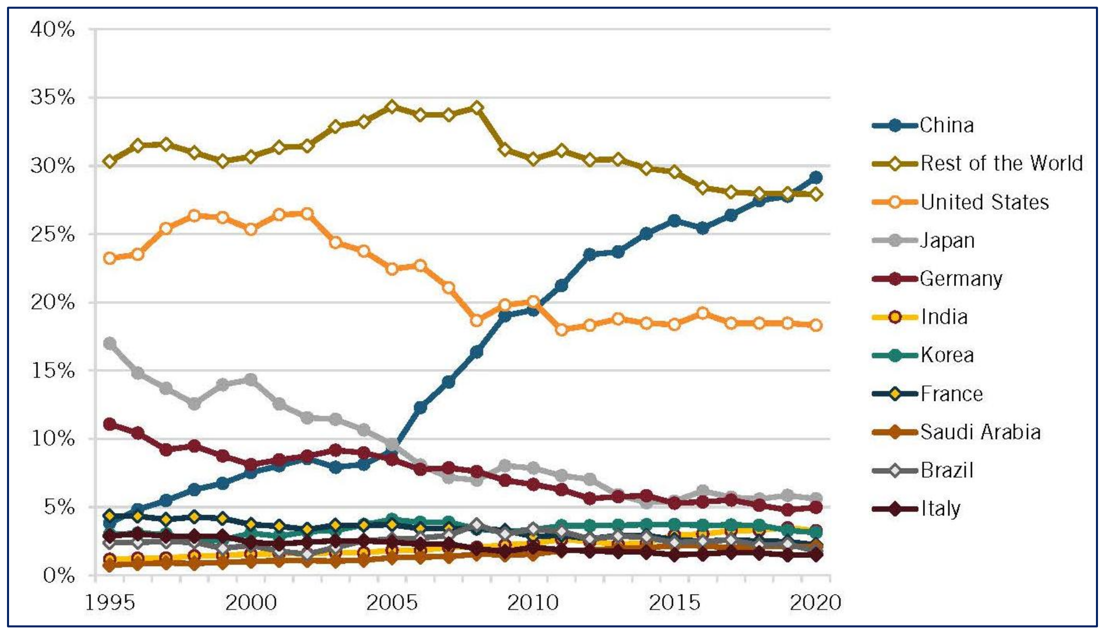


Figure: Top 10 producers' historical shares of global value-added output in chemicals (from Atkinson, 2024).

Impacts to DoD from Differing PFAS Definitions

What we have learned:

- Fluorinated products provide lifesaving emergency fire suppression.
  - DoD requires clean agent fire suppressants that are **safe for the Warfighter**.
- PFAS definitions could impact the availability of fluorinated fire suppressant products as well as other critical/lifesaving products and applications:

Refrigeration and Air Conditioning, Cooling, and Electronics Thermal Control	Semiconductor Manufacturing	Medical Applications (propellent)	Precision Cleaning/ Degreasing Applications	Manufacturing Processes of Lifesaving Products	Insulation and Foam Blowing

What we have found:

- Regulation based upon a broad structural definition of PFAS (e.g., the proposed EU REACH PFAS restriction, various state regulations) may disrupt the fluorinated fire suppressant supply chain and adversely impact the DoD and DIB. Disruptions may result in:
  - Sole-source suppliers and diminishing manufacturers in the industrial base
  - Sourcing mission critical PFAS from China and other foreign entities of concern
  - Chemical obsolescence that drives product obsolescence, impacting niche defense-related products
  - Unmonitored product reformulation or counterfeit products that inadvertently impact military performance
  - Delay or impounding of DoD chemical product supply shipments across international borders
  - Adverse impacts to the Foreign Military Sales program
  - Interoperability disconnects with NATO partners

Risk-Based Approach to PFAS Definition

BLUF: Using a fit-for-purpose risk-based approach to defining PFAS allows regulators to focus on the most significant risks to society (e.g., higher hazard, higher likelihood of exposure) for regulatory management.

- Establishing a risk-based definition for regulatory purposes considers key parameters such as chemical/physical properties and toxicological effects to inform overall risk.
- Fluorinated chemistries differ significantly in their behavior based on molecular size, structure, perfluorinated chain length, water solubility, vapor pressure, and functional group charges (Secundo et al, 2025).
- Fluoropolymers and fluorinated gases differ from other fluorinated chemistries in their exposure and hazard profiles.
  - Fluoropolymers are large molecules, generally insoluble in water, unlikely to have environmental transport, and unlikely to bioaccumulate.
  - Fluorinated gases such as HFCs are unlikely to bioaccumulate.

Benefits of a Risk-Based Approach

$$Risk = Hazard \; x \; Exposure$$

- Allows regulators to target the greatest risks to human health and the environment tailored to the specific statute and focus efficient use of resources on mitigating risks.
  - Ensures that proper exposure controls / workplace protection are in place for continued critical uses to limit pathways of exposure.
  - Allows for flexibility in regulatory responses, adapting to the changing industry practices.
- Data-informed digital technology approaches will help better understand and manage risks.
- Considers essential / critical use and availability of alternatives.
- Reduces economic harm.
- Provides greater regulatory certainty to manufacturers and end-users (such as the DoD).

Conclusion

- Many fluorinated fire suppressants have irreplaceable mission critical applications.
- Global and U.S. regulations that limit availability are impacting the domestic supply chain of fluorinated fire suppressants, leading to increased risk of supply chain disruption and dependence on non-allied foreign sources (e.g. China).
- Technical challenges in finding alternatives increases the need to establish and maintain a supply of fluorinated fire suppressants for these applications.
- Using a risk-based, fit-for-purpose approach to defining PFAS in regulations will provide for added regulatory certainty and encourage domestic manufacturing of critical chemistries.
  - An example of a such a definition that takes into account hazard and exposure profiles:

    Non-polymeric perfluoroalkyl and polyfluoroalkyl substances that are a group of man-made chemicals that contain at least 2 fully fluorinated carbon atoms excluding:

    a. *gases and*
    b. *liquids with a Henry's Law Constant for water as a solvent at 25 °C and 1 atm exceeding 0.001 atm m3 mol-1, as determined experimentally using accepted test methods (e.g. OECD Test Guideline 104 for vapor pressure and 105 for water solubility) or derived from accepted modeling methods.*

- The DoD will continue to identify critical chemical applications within the DoD and DIB and encourage domestic availability of critical chemicals and their precursors.
- Use of a risk-based, fit-for-purpose definition of PFAS supports appropriate risk management of fluorinated fire suppressants, though other existing regulations and market drivers will continue to impact the end-to-end supply chain.

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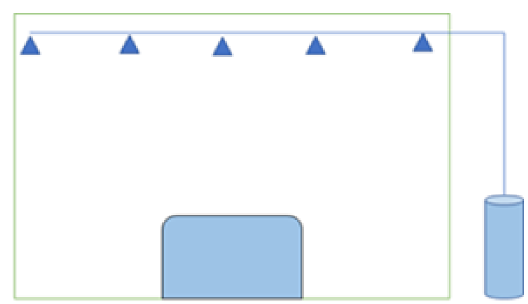
Supplemental Information

End-Use for Fire Suppression

- **Many fire suppression applications have previously used halons, but halon production was phased out in the United States due to their strong ozone depletion potential (ODP).**
  - Certain halons are still used, but recycled halons are the only source of supply in the United States (ICAO, 2022).
- **Clean agents provide protection through “total flooding” or “streaming” applications (O’Connor, 2022).**

Total Flooding Agent

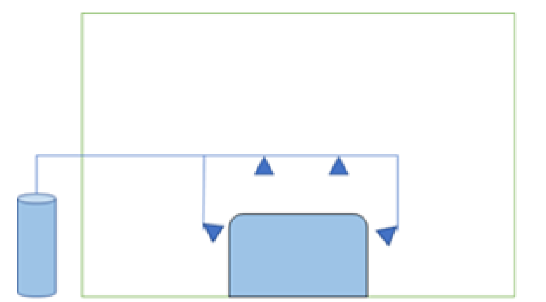


Total flooding systems are designed to automatically discharge an extinguishing agent and achieve a specified minimum agent concentration throughout a confined space.

Streaming Agent

Streaming fire extinguishers are portable and can be manually manipulated to discharge in a specific direction and release a specific quantity of extinguishing agent at the time of a fire.

Local Streaming Agent



Local streaming systems discharge extinguishing agent, so the burning object is surrounded locally by a high concentration of agent to extinguish the fire.

Alternatives are not simple drop in solutions and do not provide certainty needed for maintaining warfighter safety

Current funding is insufficient to develop alternatives for all affected items, which jeopardizes military readiness and lethality of the force.

- While the Army initiated a project in 2024 to find alternatives to fluorinated gases in tactical vehicles, all future projects are on hold due to budget uncertainty.
- While mission critical end use exemptions provide the ability for DoD to operate, exemptions create market dynamics that can result in obsolescence and does not address mission concerns.

The Army has been looking at commercial alternatives for at least a decade and there are no current non-fluorinated alternatives that meet Warfighter safety needs.

- Army continues to evaluate "non-clean" agents for suitability in fire suppression performance and safety.

The Navy continues to move to alternative fire suppression technologies where suitable in new U.S Naval ship designs.

- However, there is no "drop-in" replacement for HFC agents in existing ships (DoD, 2023).

There are no non-fluorinated alternatives for aviation applications. The worldwide aviation fire suppression category requires fluorine.

- The DIB have exhausted many possible alternatives and gathered much data on this concern (UNEP, 2022).

Broad structural definitions of PFAS do not support fit-for-purpose risk management and regulation

- Current approaches to PFAS regulations are at odds with the Executive Order on *Restoring Gold Standard Science*, which cautions regulatory agencies on using overly precautionary assumptions and scenarios.
- Structural definitions (non-regulatory and regulatory examples below) only communicate that the substances share common structural traits and do not inform whether a substance is or is not harmful.
  - Broad definitions of PFAS create the misperception that the thousands of PFAS chemicals within the category are equally hazardous.
- Broad structural definitions therefore may not be fit for the purposes of regulatory risk management.

Source	PFAS Definition	# Substances
OECD (2021)	Contains aliphatic and saturated –CF2-	**38,382** (1)
	Contains aliphatic and saturated -CF3	**32,940** (1)
EPA Safe Drinking Water Act (SDWA) Contaminant Candidate List (CCL) 5 Final List (2022)	PFAS includes at least one of these structures: 1) R-(CF2)-CF(R′)R″, where both the CF2 and CF moieties are saturated carbons, and none of the R groups can be H 2) R-CF2OCF2-R′, where both the CF2 moieties are saturated carbons, and none of the R groups can be H 3) CF3C(CF3)RR′, where all the carbons are saturated, and none of the R groups can be H	**10,246** (2)
EU REACH PFAS Restriction Proposal (2023)	Contains at least one fully fluorinated methyl (CF3-) or methylene (-CF2-) carbon atom (without any H/Cl/Br/I attached to it) (with few exceptions)	**~10,000**
TSCA 8(a)7 Reporting and Recordkeeping Rule (2023)	PFAS includes at least one of these structures: 1) R-(CF2)-CF(R')R", where both the CF2 and CF moieties are saturated carbons; 2) R-CF2OCF2-R', where R and R' can either be F, O, or saturated carbons; 3) CF3C(CF3)R'R", where R' and R" can either be F or saturated carbons.	**13,054** (3)

(1) Williams, et al. 2022. Assembly and Curation of Lists of Per- and Polyfluoroalkyl Substances (PFAS) to Support Environmental Science Research. Front. Environ. Sci. https://doi.org/10.3389/fenvs.2022.850019.
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(3) "PFAS8a7" list in EPA Comptox. https://comptox.epa.gov/dashboard/chemical-lists.

PFAS Definitions – Federal

Regulation	Approach	Impacted by Regulation			
		HFC-227ea	HFC-236Fa	HFC-125	FK-5-1-12
TSCA 8(a)7 Reporting and Recordkeeping Rule (2023)	• Reporting requirement on certain companies to disclose info on any PFAS manufactured between 2011-2022, including production volumes, uses, byproducts, disposal, worker exposures, and environmental and health effects • See slide 19 for PFAS definition that covers 13,054 substances, including some fluorinated gases.	**Yes**	No	**Yes**	**Yes**
Final CCL 5 (2022)	• List of substances that are known or anticipated to occur in public water systems and are not currently subject to EPA drinking water regulations. • See slide 19 for PFAS definition that covers 10,246 substances.	No	No	No	No

Certain fire suppressants may be doubled-regulated through HFC phasedown regulations

The AIM Act of 2020 directs the U.S. EPA to phase down the production and consumption of HFCs in a stepwise manner by 2036 through allowance allocations. EPA issues allowances for six approved applications (EPA, 2024).

- DoD currently has 66.9% of the total application-specific allowances provided by EPA in 2025 for **mission-critical military end uses, including armored vehicle crew and engine and shipboard fire suppression systems** (EPA, 2025).
- Another application-specific allowance includes **onboard aerospace fire suppression**, including commercial-derivative aircraft for military use, rotorcraft, and space vehicles.

The European Union (EU) F-Gas Regulation adopted new regulations on 7 February 2024 to completely phaseout the consumption of HFCs by 2050. The production of HFC will be phased down to a minimum 15% by 2036 (European Council of the EU, 2024).

- The text permits the use of ozone-depleting substances (ODSs) under strict conditions for fire protection in special applications such as military equipment and airplanes.

IMPACT: Even with mission-critical military end use allowances, commercial entities may voluntarily exit the market due to low profitability and regulatory uncertainty on PFAS. This may impact the availability of mission-critical products and force reliance on foreign suppliers.

PFAS Definitions – International

Regulation / Guidance	Approach	Impacted by Regulation			
		HFC-227ea	HFC-236Fa	HFC-125	FK-5-1-12
OECD (2021)	• Guidance that proposed a PFAS definition (not a regulation) • Definition covers over 38,000 substances, including fluorinated gases and fluoropolymers (see slide 19).	Yes	Yes	Yes	Yes
EU PFAS REACH Restriction Proposal (2023)	• Proposed EU-wide restriction ban on PFAS (submitted by Germany, Netherlands, Norway, Denmark and Sweden) • Used same definition as OECD (2021) that covers over 38,000 substances, including fluorinated gases and fluoropolymers.	Yes	Yes	Yes	Yes
Canada PFAS Risk Management Approach (2025)	• Phased regulations to prohibit specific PFAS uses ▪ Phase I: firefighting foams and additional types of PFAS not presently regulated ▪ Phase II: PFAS not needed for the protection of health, safety or the environment ▪ Phase III: PFAS that require further evaluation of the role of PFAS due to the lack of currently existing feasible alternatives or socio-economic considerations (including F-gas applications, like clean agent fire suppression) • Adopted same definition as OECD (2021) but is excluding fluoropolymers from regulation scope.	Yes[1]	Yes[1]	Yes[1]	Yes[1]
EU F-Gas Regulations (2024)	• Regulations aimed at reducing HFC emissions • Introduced EU-wide phasedown of HFCs in 2014 • Noted "some fluorinated greenhouse gases subject to this Regulation are Per- and Polyfluorinated Substances (PFAS) or are proven to or suspected to degrade into PFAS... In 2023 a proposal under Regulation (EC) No 1907/2006 of the European Parliament and of the Council to restrict the manufacture, placing on the market and use of PFAS, including fluorinated greenhouse gases, was submitted to the European Chemicals Agency"	Yes	Yes	Yes	No

[1] Meets OECD (2021) definition, but Canada will consider if exemptions will be necessary "with attention to feasible alternatives and socio-economic factors" in each phase of risk management.

PFAS Definitions – State

Regulation	Approach	Impacted by Regulation			
		HFC-227ea	HFC-236Fa	HFC-125	FK-5-1-12
Maine Public Law, Chapter 630 (2024)	• Phased prohibitions of products with intentionally added PFAS and reporting program for product categories with a Currently Unavoidable Use (CUU) determination. ▪ Exemption for "products required to meet standards or requirements of the DOT, FAA, NASA, DOD, or DHS". • **PFAS Definition**: any member of the class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom.	Yes[1]	Yes[1]	Yes[1]	Yes[1]
Minnesota Amara's Law (Minn. Stat. § 116.943) (2024)	• Phased prohibitions of products containing intentionally added PFAS. ▪ Prohibited unless the commissioner use of PFAS in the product is deemed CUU. • Adopted same PFAS definition as Maine (2024).	Yes	Yes	Yes	Yes
New Mexico PFAS Protection Act (HB 212) (2025)	• Phased prohibition of products containing intentionally added PFAS unless the use of the PFAS is designated as a CUU. Exemptions include: ▪ Products containing certain fluoropolymers. ▪ Products that contains intentionally added PFAS with uses that are currently approved under the EPA SNAP Program. ▪ Products containing intentionally added PFAS, where that PFAS is being used as a substitute for ozone-depleting substances under specified federal rules. • Adopted same PFAS definition as Maine (2024) but introduced exemptions that excludes fluoropolymers.	Yes[2]	Yes[2]	Yes[2]	Yes[2]
West Virginia PFAS Protection Act (2023)	• Requirement to perform statewide study on PFAS in drinking water • **PFAS Definition**: non-polymeric perfluoroalkyl and polyfluoroalkyl substances that are a group of man-made chemicals that contain at least 2 fully fluorinated carbon atoms, excluding gases and volatile liquids.	No	No	No	No
Delaware, Chapter 253, § 1 (2025)	• Requirement to perform statewide survey on PFAS in drinking water under Delaware's Drinking Water Protection Act • Adopted same PFAS definition as West Virginia (2023).	No	No	No	No

[1] Meets Maine PFAS definition, but may meet exemption under DoD standards/requirements provision.
[2] Meets New Mexico PFAS definition, but may meet exemption under SNAP provision.

Definitions of fluorinated chemistries should be fit-for purpose with the desired risk management outcome

- **Many peer reviewed scientific journal articles advocate for refining classification of fluorinated chemicals based on their physicochemical properties and toxicity profiles (Secundo et al, 2025).**
- **Generally, current definitions are too broad because they include chemistries with diverse physical and chemical properties and unrelated toxicological effects.**
  - Fluorinated chemistries differ significantly in their behavior based on molecular size, structure, perfluorinated chain length, water solubility, vapor pressure, and functional group charges, all of which influence cell membrane penetration, toxicity, and environmental fate (Secundo et al, 2025).
    - Fluoropolymers and fluorinated gases differ in their exposure and hazard profiles.

$$Risk = Hazard \ x \ Exposure$$

Intrinsic Physicochemical Properties
- Environmental half life
- Water solubility
- Mobility
- Boiling point/ vapor pressure

Toxicological Effects
- Pathways of exposure
- Modes and mechanisms of action
- Absorption, Distribution, Metabolism, Excretion

  - Anderson et al. highlighted the complexity of human health risk assessment for PFAS and recommended avoiding generalizations and specifying whether toxicity data applies to individual PFAS, subgroups, or the entire class (Anderson et al. 2022).