EA Engineering, Science, and Technology, Inc., PBC (EA) is on the forefront of the burgeoning field of emerging contaminants–committed to advancing the science and successfully executing projects. Every day, we are working on behalf of our clients to mitigate the health and environmental risks posed by emerging contaminants.

Advancing the Science

For more than 14 years, EA has been conducting research on the safety and toxicology of a variety of industrial and military compounds, as well as consumer product constituents, evaluating their potential to enter the environment and cause adverse ecological or human health impacts. EA has also been actively involved in demonstrating the feasibility of technologies to treat emerging contaminant waste streams.

Executing Projects

EA is determinedly addressing potential environmental and public health risk posed by emerging contaminants in the environment. With projects in 25 states, all market sectors, and 5 EPA regions, EA has successfully tackled the unique issues and challenges associated with characterization and treatment of these contaminants. EA routinely applies a site-specific, risk-based assessment methodology to ensure successful completion of these projects.

EA is meeting the challenge of remediating emerging contaminants, and in the process, advancing the state of the science on the understanding of environmental degradation mechanisms and breakdown pathways.

About EA Engineering, Science and Technology, Inc., PBC

EA is a 100% employee-owned public benefit corporation that provides environmental, compliance, natural resources, and infrastructure engineering and management solutions to a wide range of government and industrial clients. Headquartered in Hunt Valley, Maryland, EA employs more than 500 professionals through a network of 25 commercial offices across the continental United States, as well as Alaska, Hawaii, and Guam. In business for more than 46 years, EA has earned an outstanding reputation for technical expertise, responsive service, and judicious use of client resources. EA is a small business under NAICS Codes: 562910: Environmental Remediation Services and 541715: Research and Development

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Reference Guide: PFAS Family Heirarchy

Advancing PFAS Science

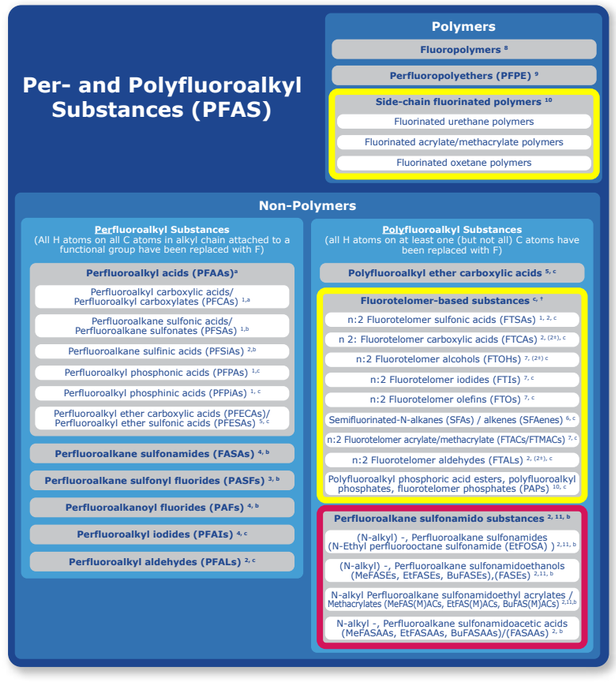
EA developed this **PFAS Family Hierarchy** as a reference guide for those conducting PFAS inventories, site characterization, and remediation activities.

PFAS are a complex family of more than **4,000 manmade flourinated organic chemicals** with differing chemistry and behavior.

This **reference guide** deals with those PFAS most prolific in the environment and associated with the most common sources.

It includes information regarding the manufacturing history, as well as past and current uses, which is critical in the identification of potential sources, possible release mechanisms, and associated pathway-receptor relationships. It also includes an **analytical method summary table.**

Developed based on more than **14 years of PFAS experience,** including substantial research and development, as well as participation on several national working groups, EA is proud to make this available to PFAS practitioners.



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Reference Guide: PFAS Family Heirarchy

Advancing PFAS Science

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PFAS Family Heirarchy

Per- and Polyfluoroalkyl Substances (PFAS)

Polymers

- **Fluoropolymers** [8]
- **Perfluoropolyethers (PFPE)** [9]
- **Side-chain fluorinated polymers** [10]
  - Fluorinated urethane polymers
  - Fluorinated acrylate/methacrylate polymers
  - Fluorinated oxetane polymers

Non-Polymers

Perfluoroalkyl Substances
(All H atoms on all C atoms in alkyl chain attached to a functional group have been replaced with F)

- **Perfluoroalkyl acids (PFAAs)**[a]
  - Perfluoroalkyl carboxylic acids/ Perfluoroalkyl carboxylates (PFCAs) [1,a]
  - Perfluoroalkane sulfonic acids/ Perfluoroalkane sulfonates (PFSAs) [1,b]
  - Perfluoroalkane sulfinic acids (PFSiAs) [2,b]
  - Perfluoroalkyl phosphonic acids (PFPAs) [1,c]
  - Perfluoroalkyl phosphinic acids (PFPiAs) [1, c]
  - Perfluoroalkyl ether carboxylic acids (PFECAs)/ Perfluoroalkyl ether sulfonic acids (PFESAs) [5, c]
- **Perfluoroalkane sulfonamides (FASAs)** [4, b]
- **Perfluoroalkane sulfonyl fluorides (PASFs)** [3, b]
- **Perfluoroalkanoyl fluorides (PAFs)** [4, b]
- **Perfluoroalkyl iodides (PFAIs)** [4, c]
- **Perfluoroalkyl aldehydes (PFALs)** [2, c]

Polyfluoroalkyl Substances
(all H atoms on at least one (but not all) C atoms have been replaced with F)

- **Polyfluoroalkyl ether carboxylic acids** [5, c]
- **Fluorotelomer-based substances** [c, †]
  - n:2 Fluorotelomer sulfonic acids (FTSAs) [1, 2, c]
  - n 2: Fluorotelomer carboxylic acids (FTCAs) [2, (2‡), c]
  - n:2 Fluorotelomer alcohols (FTOHs) [7, (2‡) c]
  - n:2 Fluorotelomer iodides (FTIs) [7, c]
  - n:2 Fluorotelomer olefins (FTOs) [7, c]
  - Semifluorinated-N-alkanes (SFAs) / alkenes (SFAenes) [6, c]
  - n:2 Fluorotelomer acrylate/methacrylate (FTACs/FTMACs) [7, c]
  - n:2 Fluorotelomer aldehydes (FTALs) [2, (2‡), c]
  - Polyfluoroalkyl phosphoric acid esters, polyfluoroalkyl phosphates, fluorotelomer phosphates (PAPs) [10, c]
- **Perfluoroalkane sulfonamido substances** [2, 11, b]
  - (N-alkyl) -, Perfluoroalkane sulfonamides (N-Ethyl perfluorooctane sulfonamide (EtFOSA)) [2,11, b]
  - (N-alkyl) -, Perfluoroalkane sulfonamidoethanols (MeFASEs, EtFASEs, BuFASEs),(FASEs) [2,11, b]
  - N-alkyl Perfluoroalkane sulfonamidoethyl acrylates / Methacrylates (MeFAS(M)ACs, EtFAS(M)ACs, BuFAS(M)ACs) [2,11,b]
  - N-alkyl -, Perfluoroalkane sulfonamidoacetic acids (MeFASAAs, EtFASAAs, BuFASAAs)/(FASAAs) [2, b]

Legends and Other Useful Information

PFAS Family Heirarchy

- **Family**
  - **Class**
    - **Sub Class**
      - **Group**
        - Sub Group

Precursor Key

- **Potential PFCA Precursors**
- **Potential PFSA and PFCA Precursors**

Analytical Method Summary Table

Method	Matrices/Analytes
EPA Method 537.1 (2018)	Drinking Water (DW) 18 PFAS
EPA Method 533 (2019)	DW; 24 PFAS
ISO/DIS 21675 (2019)	Aqueous
ASTM D7979-17 (2017)	Non DW Aqueous and sludge; 39 PFAS*
ASTM D7968-17a (2017)	Soil; 31 PFAS*
EPA SW-846 Method 8327 (draft)	Non potable aqueous; 24 PFAS
ISO Method 25101 (2009)	Aqueous; PFOS/PFOA
EPA 1600 Series (in development)	Aqueous, solids, tissue; 29 PFAS

*Method covers 21 PFAS, but others may be identified

PFAS Use

(1) Surfactants

(2) Intermediate environmental transformation product

(3) Principal raw material for perfluoroalkanesulfonyl-based products including surfactants and surface protection products

(4) Raw material for surfactants and surface protection products

(5) Includes some fluoropolymer polymerization aids such as PFOA

(6) Ski wax, medical applications

(7) Raw material for fluorotelomer-based surfactants and surface protection products

(8) High molecular weight polymeric plastics such as PTFE

(9) A broad class of polymers used largely as lubricants

(10) Used for surface protection

(11) Major raw material for perfluoroalkanesulfonyl based surfactant and surface protection products

Manufacturing Process

(a) Manufactured by either ECF or Fluorotelomer Process

(b) Manufactured by ECF Process

(c) Manufactured by Fluorotelomer Process

Notes

† N:3 saturated/unsaturated acids subfamily (intermediate transformation product) not shown under this family

‡Unsaturated derivatives are intermediate transformation products