2.5 PFAS Uses and Products

This section provides information on PFAS uses (Section 2.5.1), potential PFAS use or occurrence in some specific products (Section 2.5.2), and PFAS certifications (Section 2.5.3). Each section includes a table summarizing available information. The tables are not exhaustive.

The Priority Topics for History, Use, and Naming Conventions include information about less-publicized PFAS Sources (see Section 1.1.2) including hydraulic fluids and pesticides. Other less-publicized sources are presented in Table 1-1, which supplements Table 2-7. The Priority Topics for Human and Ecological Health Effects include information about potential PFAS exposures from consumer products (see Section 1.4.2). The Priority Topics for Sampling and Analysis include information about testing consumer products for PFAS (see Section 1.5.4).

2.5.1 PFAS Uses

PFAS have been produced on a commercial scale since the 1950s, and production continues today. The unique physical and chemical properties of PFAS impart oil, water, stain, and soil repellency, chemical and temperature resistance, friction reduction, and surfactant properties to a wide range of products, some of which are considered essential to health, safety, or modern life (Glüge et al. 2020). Glüge et al. (2020) categorized PFAS by uses according to industry application and practical use and identified more than 200 uses for more than 1,400 individual PFAS.

Table 2-6 provides a general (not exhaustive) introduction to some of the uses of PFAS chemistries that are, or have been, marketed or used (3M Company 1999; Poulsen et al. 2005; OECD 2006; Washington State Department of Ecology 2021; OECD 2011; OECD 2013; Fujii, Harada, and Koizumi 2013; OECD 2015; Performance Fluoropolymer Partnership 2021; Henry et al. 2018). The specific applications for all PFAS are not well documented in the public realm. For example, of the 2,000 PFAS identified in a 2015 study, only about half had an associated listed use (KEMI 2015). Further discussion of select uses that may be associated with potentially significant environmental releases are provided in Section 2.6.

As discussed in Section 2.2.2.1, most polymer PFAS are considered to pose relatively less risk to human health and the environment than some nonpolymer PFAS. For this reason, Table 2-6 distinguishes between these two major classes of PFAS and where they are used in various industries and products. Glüge et al. (2020) provided a detailed listing of PFAS by use category/subcategory, function, and properties; however, it is not organized according to polymer versus nonpolymer PFAS used in these instances.

The major industries and applications summarized in the table are described in more detail in Section 2.6.1.

Table 2-6. Sample historical and current uses of PFAS

Industry/Application	PFAS Type	Documented Use and Examples of Some PFAS
Aviation and Aerospace	Polymer	Mechanical components made of fluoropolymers (such as PTFE and Perfluoroalkoxy tubing, piping, seals, gaskets, cables, and insulators)
	Nonpolymers	Hydraulic fluid additives made from PFSA salts (such as PFOS at about 0.1%) to prevent evaporation, fires, and corrosion
Automotive	Polymer	Mechanical components made of fluoropolymers, including wiring and cable, fuel delivery tubing, seals, bearings, gaskets and lubricants, and some polymer coatings on carpets
	Nonpolymers	Surface treatment for textiles, upholsteries, carpets, leather and exterior surfaces

Industry/Application	PFAS Type	Documented Use and Examples of Some PFAS
Biocides (Herbicides and Pesticides)	Polymer	None reported
	Nonpolymers	Active ingredients such as short-chain sulfonamides in plant growth regulators and herbicides, and EtFOSA (sulfluramid) in ant and termite baits; inert enhancing ingredients in pesticides; PFPAs and PFPiAs as anti-foaming agents in solutions
Biotechnology	Polymer	Polymers used for reaction vessels, stirrers, and other components, filtration, and moisture barrier
	Nonpolymers	Cell cultivation by delivery of oxygen and other gases and ultrafiltration and microporous membranes to prevent bacterial growth.
Building and Construction	Polymer	Fluoropolymer membranes and coatings (such as PTFE, PVDF, and/or side-chain fluorinated polymers) in architectural materials (like fabrics, roofing membranes, metals, stone, tiles, concrete, radomes); adhesives, seals, caulks; additives in paints (for example, low- and no-VOC latex paints), varnishes, dyes, stains, sealants; surface treatment agent and laminates for conserving landmarks
	Nonpolymers	Additives in paints, coatings, and surface treatments (PASF- and fluorotelomer-based compounds, ammonium salt of PFHxA)
Cable and Wiring	Polymer	Coatings and jacketings made of fluoropolymers (such as PTFE and PVDF) for weathering, flame, and soil resistance, with cables used in many applications, including communication facilities, antennae, and computer networks
	Nonpolymers	None reported
Chemical Industry	Polymer	Fluoropolymers used to coat chemical tanks and pipes to enhance corrosion and high temperature resistance, as sealing and gasket materials for chemical processing, and for filtration media used in chemical manufacturing processes and emissions controls
	Nonpolymers	Fluoropolymer processing aids, stabilization and binder for certain chemicals, elimination of imperfections, and provide inert reaction media
Cosmetics/Personal Care Products	Polymer	Dental floss, toothpaste, dental creams, tooth powders, throat lozenges, chewing gums, sunscreens, cosmetics, and micro powders used in creams and lotions.
	Nonpolymers	Cosmetics, shampoos, nail polish, eye makeup, denture cleaners, eye drops, contact lenses, and others
Electronics	Polymer	Fluoropolymers (such as PVDF and PTFE) used in insulators, solder sleeves, printed circuit boards, cell phones, computers, speakers, and transducers
	Nonpolymers	Flame retardants for polycarbonate resin (such as the potassium salt of PFBS)
Energy	Polymer	Fluoropolymer films (such as FEP, PVDF) to cover solar panel collectors, electrolyte fuel cells, PTFE expansion joint materials for power plants, filtration of fly ash from stack emissions
	Nonpolymers	Fuel cell and battery electrolyte (such as the lithium salt of PFAAs)
Explosives, Propellants, Guns, and Ammunition	Polymer	Fluoropolymers (PTFE) applied to guns for lubrication and antidegradation during long term storage, tungsten-iron-fluoropolymer shot alloys (replacement for lead in hunting waterfowl and coots), fluoropolymer use in visual flares, warheads, incendiaries, and others
	Nonpolymers	PFCAs used in energetics, infrared flares, ignitor pyrolant, coating of reactive metallic powders, combustion behavior modification and other processes

Industry/Application	PFAS Type	Documented Use and Examples of Some PFAS
Firefighting/Safety	Polymer	Fluoropolymers used in firefighting equipment and protective clothing (such as those woven with PTFE). Other polymer coatings using side-chain fluorinated polymers
	Nonpolymers	Coatings and materials used as water repellents and some Class B foam (may contain PFCAs, PFSAs, and fluorotelomer-based derivatives), vapor suppression for flammable liquids (for example, gasoline storage)
Food Processing	Polymer	Fluoropolymer fabrication materials (such as PTFE) (liners for trays, ovens, grills)
	Nonpolymers	May be used as coatings on food packaging
Household and Cleaning Products	Polymer	Nonstick coatings (fluoropolymers such as PTFE); aftermarket treatment for textiles, upholsteries, carpets, and leather (such as Fluorotelomer-based side-chain fluorinated polymers); sewing machine presser feet; glass
	Nonpolymers	Aftermarket treatment for textiles, upholsteries, carpets, and leather (such as PASFs; floor polishes (such as the ammonium salt of PFDA), coatings, and floor finishes (PFPAs and PFPiAs) and cleaning agents and alkaline cleaners; automobile waxes; may include PFAAs, PASF- and fluorotelomer-based derivatives, anti-reflective coatings, dry cleaning agent (PureDry®) replacement for perchloroethylene
Medical Products	Polymer	Fluoropolymers (such as PTFE) used in surgical patches, cardiovascular grafts, raw materials for human body implants (such as catheters, stents, sutures, device surface coatings, needles, and other) given biocompatibility and extremely low coefficient of friction, dialysis membranes, anesthesia, machine components (o-rings, filters, tubing, and other)
	Nonpolymers	X-ray film, stain- and water-repellent protective medical fabrics (like surgical drapes and gowns) created from PASF- or fluorotelomer-based (meth)acrylate polymers and polyurethanes, burn wound care cleaning product, oxygen and oxygen carriers used to improve therapeutic outcomes
Metal Plating	Polymer	None reported
	Nonpolymers	Wetting agent, mist suppression for harmful vapors, and surfactants (may include potassium, lithium, diethanolamine and ammonium salts of PFOS or 6:2 FTS)
Oil Production	Polymer	Lining of gas pipes
	Nonpolymers	Marketed for and potential instances of use in oil well production
Mining	Polymer	None reported
	Nonpolymers	Instances of surfactants used in ore mining flotation and leaching, improve separation of materials, and concentration of ore by destruction of mineral structure
Nuclear Industry	Polymer	Lubricants used for valves and centrifugal bearings in enrichment processes
	Nonpolymers	None reported
Oil and Gas Industry	Polymer	Lining of gas pipes and insulation of cable and wire during drilling, and membranes for filtration
	Nonpolymers	Marketed for and potential instances of use in oil well production to change the permeability of the target formation, reduce viscosity for transport, prevent evaporative loss during storage, tracers

Industry/Application	PFAS Type	Documented Use and Examples of Some PFAS
Paper and Packaging	Polymer	Oil and grease and water repellent to paper, paperboard, molded pulp products (including food contact materials), and LDPE bags; examples include side-chain fluorinated polymers in which the PASF- or fluorotelomer-based alcohols or their acrylate or methacrylate esters are attached on side chains; PFPEs
	Nonpolymers	Phosphate ester salts (esterification of PASF or Fluorotelomer-based alcohols with phosphoric acid
Pharmaceutical Industry	Polymer	Polymers used for reaction vessels, stirrers, and other components, filtration, and moisture barrier
	Nonpolymers	Processing aids in the manufacture of microporous particles, additives and ingredients in certain types of medicine for drug delivery
Photographic Industry	Polymer	None reported
	Nonpolymers	Photographic processing aids to reduce air bubbles and prevent foaming, wetting agents, stabilizers, and antistatic agents, prevent spots, and create uniform edge in multilayer coatings, anti-reflective agents
PFAS Production	Polymer	None reported
	Nonpolymers	Emulsion polymerization processing aids for fluoropolymers (such as PTFE, FEP, PFA, PVDF), (co)monomer of side-chain fluorinated polymers; (co)monomer of fluoropolymers and to make fluoroelastomers; may use salts of long-chain PFCAs (such as PFOA and PFNA), salts of short-chain PFCAs (such as PFHxA), or PFECAs
Photolithography & Semiconductor	Polymer	Equipment raw materials (such as PFA) for molded wafer baskets to handle corrosive liquids and gases, use as fluids in mechanical vacuum pumps
	Nonpolymers	Photolithography (such as using PFOS) in manufacture of semiconductor chips
Plastics and Rubber	Polymer	Fluoropolymers (such as PTFE) are used as processing aids, as a raw material in plastics and rubber production, and as an intermediate material. Used in molded material production to enable easy release and reduce imperfections, polymer processing aids
	Nonpolymers	Surface tension reduction for foams, etching of plastic, and production of rubber
Recreational and Musical Equipment	Polymer	Fluoro waxes used to reduce wear and abrasion on: stringed sports equipment (for example, tennis racquets) and stringed instruments; fishing rods and reels; lubricants; piano keys; ski wax
	Nonpolymers	None reported
Recycling and Material Recovery	Polymer	None reported
	Nonpolymers	Fluorosurfactants are used to recover metals, including rare earth metals, and n-hexane from waste gases
Refrigerants	Polymer	None reported
	Nonpolymers	Perfluorocarbons (PFCs), a subset of PFAS, used in refrigerant fluid and compressor systems for both heat transfer and lubrication
Textiles (Upholstery, Carpets), Leather, and Apparel	Polymer	Fluoropolymers (such as PTFE) are used in the construction of outdoor gear, clothing, and housewares; side-chain fluorinated polymers (such as PASF- or fluorotelomer-based (meth)acrylate polymers and -polyurethanes) may be used in oil- and water-repellent and stain release finishing and treatment coatings
	Nonpolymers	PFOA-based chromium treatment for paper and leather. Nonpolymer coatings used to treat textiles to provide oil- and water- repellent and stain release finishes

Industry/Application	PFAS Type	Documented Use and Examples of Some PFAS
Wood Industry	Polymer	Polymeric PFAS fabric used during bleaching process, clear coating of wood substrate
	Nonpolymers	Adhesive resin on wood particle board

Information presented in this table captures potential instances of use but is not intended to indicate universal use. In addition, the table is not exhaustive of PFAS use in various industries.

2.5.2 Potential PFAS Use or Occurrence

Growing awareness of PFAS has led to both research and speculation about the use and occurrence of PFAS associated with an increasing number of consumer and commercial products, and whether such occurrences may constitute a risk to human health and the environment. Table 2-7 provides a high-level technical assessment of such recent claims, some of which have been popularized in the news media. Section 1.1.2 includes information about less-publicized PFAS sources, such as hydraulic fluids and pesticides. Other less-publicized sources are presented in Table 1-1, which supplements Table 2-7.

Table 2-7. Summary of Claims of PFAS Use and Occurrence

Potential Use or Occurrence	Technical Basis	Documentation	Conflicting Perceptions on Presence of PFAS and Significance of PFAS
Cosmetics and Personal Care Products	Higher dermal absorption of PFOA from sunscreen than was previously reported for dermal absorption of PFOA: 1.6% of the applied dose was absorbed over time in a human volunteer.	Journal Articles, Abraham and Monien 2022; Whitehead et al. 2021, 2021	One study demonstrates significant uptake of a PFAA via transdermal absorption in humans may occur via PFOA mixed into sunscreen, indicating past occurrence of PFAS in some cosmetics may have contributed to this route of exposure. Other article discusses the use of PFAS in North American cosmetics to increase their durability and water resistance.
Face Masks	Chemical analysis of PFAS in face masks and calculations of leaching to landfill leachate.	Journal Article, Muensterman et al. 2022	Nine varieties of masks were tested. Homologous linear PFCAs and 6:2 FTOH indicated a fluorotelomer origin. Wearing masks treated with high levels of PFAS for extended periods can be a notable source of exposure with potential human health risk. Modeled annual disposal of ~29–91 billion masks assuming 100% leaching of individual PFAS into landfill leachate indicates mask disposal would contribute an additional 6% of annual PFAS mass loads and less than 11 kg of PFAS discharged to U.S. wastewater.

Potential Use or Occurrence	Technical Basis	Documentation	Conflicting Perceptions on Presence of PFAS and Significance of PFAS
Fluorinated HDPE Containers	Testing of a limited number of fluorinated and non-fluorinated HDPE containers for presence of PFAS by EPA's Analytical Chemistry Laboratory at Fort Meade (initial and follow-up testing). Leaching of PFAS from container walls to liquid contents (methanol and water) was demonstrated for fluorinated containers. Degree of leaching relates to the brand of fluorinated containers and duration of liquid storage in container. Higher amounts of PFAS were detected in methanol solvent versus water.	USEPA Memos USEPA 2021; USEPA 2022	Through the fluorination process of HDPE containers, PFAS may be formed and then partly leach into the products inside the containers. These containers are believed to explain the occurrence of PFAS in mosquito control insecticide tested by an environmental group and published by news outlets.
Food Packaging	Consumer Reports (CR) tested total organic fluorine content in multiple samples collected from 118 paper food packaging products from 24 restaurants and grocery chains. A subset of 50 products was tested by a method only identified as being "regularly used by industry, regulators, and researchers."	Consumer Reports, Loria 2022	The organic fluorine levels were averaged for each product. Thirty-seven products had an average organic fluorine concentration above 20 ppm, and 22 products had an average above 100 ppm. PFBA was found at the highest concentrations in the subset of 50 products analyzed by an alternate method.
Pesticides	Fluorinated pesticides may meet certain definitions of PFAS and therefore would be considered PFAS-containing.	Scientific American, Wilcox 2022	Article notes at least three active pesticide ingredients currently allowed by the USEPA—broflanilide, pyrifluquinazon and noviflumuron—meet its definition for a PFAS.
Pesticides	A university laboratory tested pesticide products. PFAS were detected in some of the products.	Lasee et al. 2022; USEPA 2023	USEPA's Analytical Chemistry Branch repeated the analyses for PFAS and conducted additional analyses. In USEPA's results no PFAS were detected above the method detection limits.

Potential Use or Occurrence	Technical Basis	Documentation	Conflicting Perceptions on Presence of PFAS and Significance of PFAS
Synthetic Turf	Media reports describe testing by non-profit organizations that detected PFOS on backing of older discarded turf material and 4 PFAS (PFOS, PFOA, PFHxS and 6:2-FTS) in nearby wetland water, 6:2 FTS on backing of newer turf material, and fluorine in 8 samples of grass blades acquired directly from distributors.	Fact Sheet, TURI 2020 CT DPH Review, CT DPH 2022 Lab analyses of PFAS in turf and wetland waters, Eurofins 2019 PEER Letter of Complaint to MassDEP, PEER 2019 Massey and Pollard 2023 City of Portsmouth, NH Evaluation of PFAS in Synthetic Turf, City of Portsmouth 2022 Project report, Tetra Tech 2021 Journal article, Lauria et al. 2022	Staff at Connecticut Department of Public Health (CT DPH) have retrieved and reviewed the original lab reports that were the basis of the media reports for PFAS detected in newer and older fields (and nearby wetland water) and determined that the available data do not provide scientific evidence that the detected PFAS originate from the artificial turf itself; their presence in turf may be attributable to other sources of PFAS, including sample contamination. The PFAS concentrations detected in turf and in nearby waterways are within the range of "background" levels of PFAS detected in soils in remote areas and in surface waters collected near urban areas. The Portsmouth, NH study evaluated analyses of synthetic turf samples utilizing standard PFAS analyses and TOP Assay; low-levels of select PFAS detected were determined to not represent a human health risk to users of the turf. Staff at CT DPH were unable to identify lab reports of the detection of fluorine in grass blades. Negligible PFAS leachate concentrations were also noted well below applicable criteria associated with synthetic turf at the Martha's Vineyard Regional High School Athletic Fields. A study of artificial turf in Sweden determined that PFAS were detected intermittently and at low concentrations in backing (<LOD−0.63 ng of F/g; 71% DF) and filling (<LOD−0.15 ng of F/g; 18% DF) and were completely absent in blades. Studies reviewed did not show risk but not all manufacturers and products evaluated thus far.

2.5.3 PFAS Certification and Acceptability of Products

Numerous labels and certifications related to reduction or elimination of PFAS in products exist in the marketplace but there is great variation in the terms used to indicate PFAS content in products. Commonly used PFAS-related terms for products include: PFAS-free, PFOS-free, PFOA-free and Fluorine-free. However, many certifications allow a minimum limit to be present. The USEPA Sustainable Marketplace website (USEPA 2023) provides a useful compilation of PFAS-specific product certifications that lists the basis of the required and optional criteria. Many of the certifying organizations offer labels and criteria that may cover a wide range of chemicals and other sustainability considerations. The user should check the primary certifying organization's documentation to verify their requirements for obtaining PFAS-specific certifications.

Table 2-8 provides examples of some of the most commonly-used product labels and certifications for intentionally-added PFAS. Several definitions exist for the term "intentionally added" in legislation and regulation. Examples of "intentionally added" definitions include:

- Maryland: H275/S273 "(C) Intentionally added means the act of deliberately using a chemical in the formation of a product where the chemicals continued presence is desired in the product to provide a specific characteristic."

- Colorado: H1345(12) (a) “Intentionally added PFAS chemicals” means PFAS chemicals that a manufacturer has intentionally added to a product and that have a functional or technical effect on the product. (b) “intentionally added PFAS chemicals” includes PFAS chemicals that are intentional breakdown products of an added chemical.
- Hawaii: HB1644/S3000 “Intentionally introduced” means deliberately utilizing PFAS in the formulation of a package or packaging component where the continued presence of the PFAS is desired in the final package or packaging component to provide a specific characteristic, appearance, or quality.”
- California: A2771 “(c) Intentionally added PFAS means either (1) PFAS chemicals that a manufacturer has intentionally added to a product and that have a functional or technical effect on the product; or (2) PFAS chemicals that are intentional breakdown products of an added chemical.”

Many countries and states also have enacted individual bans for PFAS, or intentionally added PFAS, in products and some trade groups have developed product-specific certifications (for example, furniture, floor care products). Due to the dynamic and evolving nature of these labeling programs and requirements, users should consult the primary reference to get the most current information.

Certifications for unintentionally added PFAS have also been issued. The European Union’s ECHA program requires that PFOA cannot exceed 25 ppb and PFOS cannot exceed 10 ppm as impurities (See Annex 1, Part A, European Union 2019).

Table 2-8. Examples of Certifications – Intentionally Added PFAS

Institution	Products	Criteria	Reference
USEPA Sustainable Marketplace	Comprehensive web site of multiple product categories	Links to multiple Standards and Ecolabel	https://www.epa.gov/greenerproducts/how-epas-recommended-standards-and-ecolabels-address-and-polyfluoroalkyl-substances
USEPA – Safer Choice	Industrial and consumer products	PFAS not specifically prohibited but EPA has determined that PFAS no longer meet the Safer Choice standard; **Exceptions** allowed; will be specifically called out as not meeting the standard in March of 2023 **Other** labels also listed	https://www.epa.gov/greenerproducts/how-epas-recommended-standards-and-ecolabels-address-and-polyfluoroalkyl-substances
FDA	Food-contact equipment & packaging	Authorized **limited** PFAS use for certain categories of food contact products	https://www.fda.gov/food/chemical-contaminants-food/authorized-uses-pfas-food-contact-applications
Green Screen	PFAS-free AFFF, cleaners and degreasers, furniture and fabrics, food service ware, and textiles	Separate limits for intentionally added PFAS **(0-100 ppm)** versus contamination as Total Organic Fluorine **(1-100 ppm)**, which vary by product category.	https://www.greenscreenchemicals.org/resources/entry/pfas-free-preferred-products

Institution	Products	Criteria	Reference
Biodegradable Products Institute (BPI)	Compostable products and packaging	No intentionally added PFAS; Limit of **100 ppm** total fluorine; SDS review; BPI-approved lab testing	https://bpiworld.org/fluorinated-chemicals https://www.epa.gov/greenerproducts/how-epas-recommended-standards-and-ecolabels-address-and-polyfluoroalkyl-substances
EWG	EWG-Verified Program for consumer products	Products cannot contain the PFAS that are on "Unacceptable" list of ingredients; Right to perform **random testing**	https://www.ewg.org/ewgverified/get-the-mark.php https://www.ewg.org/ewgverified/standards-cleaning.php
PFAS-Central	Referrals to PFAS-free products	Based on declared **company policy**, no independent verification	https://pfascentral.org/perch/resources/products/pfas-free-products-list-eligibility-one-pager.pdf

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