



BASEL CONVENTION

TECHNICAL GUIDELINES

Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride



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BASEL CONVENTION

TECHNICAL GUIDELINES ON THE
ENVIRONMENTALLY SOUND MANAGEMENT
OF WASTES CONSISTING OF, CONTAINING OR
CONTAMINATED WITH PERFLUOROOCTANE
SULFONIC ACID, ITS SALTS AND
PERFLUOROOCTANE SULFONYL FLUORIDE

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Abbreviations and acronyms

CAS	Chemical Abstracts Service
ECF	electrochemical fluorination
EPA	Environmental Protection Agency (United States of America)
ESM	environmentally sound management
FOSA	n-alkyl perfluorooctanesulfonamide
FOSE	n-alkyl perfluorooctanesulfonamido ethanol
HDPE	high-density polyethylene
ISO	International Organization for Standardization
OECD	Organisation for Economic Co-operation and Development
OEWG	Open-ended Working Group (of the Basel Convention)
PFBS	perfluorobutane sulfonate
PFC (PFAS)	perfluorinated compounds (perfluoroalkyl substances)
PFOA	Perfluorooctanoate
PFOS	perfluorooctane sulfonic acid
PFOSA	perfluorooctane sulphonamide
PFOSF	perfluorooctane sulfonyl fluoride
POP	persistent organic pollutant
PTFE	polytetrafluoroethylene
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization

Units of measurement

Mg	megagram (1,000 kg or 1 tonne)
mg	milligram (10 ⁻³ gram)
mg/kg	milligram(s) per kilogram. Corresponds to parts per million (ppm) by mass.

I. Introduction

A. Scope

1. The present technical guidelines provide guidance on the environmentally sound management (ESM) of wastes consisting of, containing or contaminated with perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOSF) pursuant to several decisions of two multilateral environmental agreements on chemicals and wastes.¹
2. PFOS, its salts and PFOSF were listed in Annex B to the Stockholm Convention in 2009, through an amendment that entered into force in 2010.
3. Along with PFOS, its salts and PFOSF, the present technical guidelines address other PFOS-related substances that are precursors of PFOS. In the guidelines, the term “PFOS-related substances” (also known as precursors) refers to substances that contain the PFOS carbon chain and moiety (defined as C₈F₁₇SO₂ or C₈F₁₇SO₃), that can degrade to PFOS in the environment, and that are or were produced with PFOSF as a starting or intermediate material. These chemicals are covered by the PFOSF listing in the Stockholm Convention.
4. The present document should be used in conjunction with the General technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants (UNEP, 2015) (hereinafter referred to as “general technical guidelines”). The general technical guidelines are intended to serve as an umbrella guide for the ESM of wastes consisting of, containing or contaminated with persistent organic pollutants (POPs) and provide more detailed information on the nature and incidence of wastes consisting of, containing or contaminated with PFOS and PFOS-related substances for purposes of their identification and management.
5. In addition, the use of PFOS in pesticides is addressed in more detail in the Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with the pesticides aldrin, alpha hexachlorocyclohexane, beta hexachlorocyclohexane, chlordane, chlordecone, dieldrin, endrin, heptachlor, hexachlorobenzene, lindane, mirex, pentachlorobenzene, perfluorooctane sulfonic acid, technical endosulfan and its related isomers or toxaphene or with hexachlorobenzene as an industrial chemical (UNEP, 2015a).

B. Description, production, use and wastes

1. Description

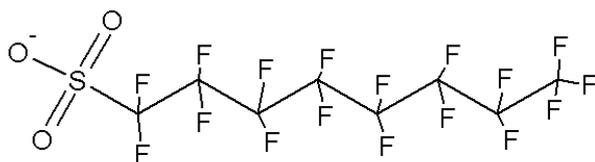
(a) PFOS

6. PFOS² is a fully fluorinated anion that is commonly used as a salt or incorporated into larger polymers. Fluorinated chemicals, such as PFOS, contain carbons that are completely saturated by fluorine. It is the strength of the C-F bonds that contributes to the extreme stability of perfluorinated compounds (PFCs) and gives them their distinctive properties.
7. While PFOS can exist in anionic, acid and salt forms, the PFOS anion is the most common form of PFOS found in the environment and the human body (Environment Canada, 2006). The basic structure of the PFOS anion is shown in figure 1 below and corresponds to the molecular formula C₈F₁₇SO₃⁻.

¹ Decisions BC-10/9, BC-11/3 and BC-12/5 of the Conference of the Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal; decisions OEWG-8/5 and OEWG-9/3 of the Open-ended Working Group of the Basel Convention; and decisions SC-4/17, SC-5/9 and SC6/11 of the Conference of the Parties to the Stockholm Convention on Persistent Organic Pollutants.

² Perfluorooctane sulfonate (PFOS) as an anion does not have a specific CAS number. The parent sulfonic acid has a recognized CAS number (CAS no: 1763-23-1). For the purpose of these guidelines, PFOS is used to describe the parent sulfonic acid as listed under the Stockholm Convention.

Figure 1: Structural formula of the PFOS anion



8. PFOS is persistent and has bioaccumulative and biomagnifying properties. PFOS substances do not follow the classic pattern of other chlorinated POPs, which are lipophilic and partition into fatty tissues. Instead, PFOS substances bind to the proteins in blood (UNEP, 2007) and in the livers of living organisms (Luebker et al., 2002). In the environment, PFOS tends to be adsorbed into sediment and sludge or to bind to particulate matter in the water column.

(b) PFOS-related substances

9. The term “PFOS-related substance” is used in the present guidelines to refer to any substance containing the PFOS moiety with the potential to degrade into PFOS in the environment. Since PFOS-related substances are considered PFOS precursors, it is assumed that those substances have the same POP characteristics as PFOS.

10. The majority of PFOS-related substances are polymers with high molecular weights of which PFOS is only a fraction (OECD, 2002). PFOS-related substances have been defined somewhat differently in different contexts and there are currently varying numbers of PFOS-related substances that are thought to have the potential to break down into PFOS.

11. Information on the degradation of PFOS-related substances into PFOS is limited. However, PFOS-related substances are expected to degrade through bacterial-mediated pathways and, over time, all PFOS-related substances are expected to degrade in the environment into PFOS (Environment Canada, 2006). As a result, it is recognized that all PFOS-related substances will ultimately contribute to the environmental load of PFOS.

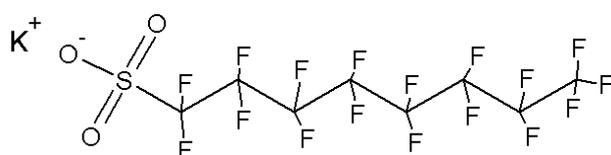
12. Several PFOS-related substances are considered to be volatile and may be subject to atmospheric transport from their sources to remote areas. While information on long-range atmospheric transport mechanisms and pathways is limited, the transport of PFOS-related substances may be partly responsible for the presence of PFOS in places, such as the Canadian Arctic, that are far from significant sources (UNEP, 2006; Environment Canada, 2006).

(i) PFOS salts

13. A PFOS salt is a PFOS-related substance and has the potential to degrade into PFOS in the environment. PFOS is commonly used as a simple salt. Examples of PFOS used as simple salts include: potassium perfluorooctane sulfonate (CAS No. 2795-39-3); lithium perfluorooctane sulfonate (CAS No. 2945772-5); ammonium perfluorooctane sulfonate (CAS No. 29081-56-9); diethanolammonium perfluorooctane sulfonate (CAS No. 70225-14-8); tetraethylammonium perfluorooctane sulfonate (CAS No. 56773-42-3); and didecyldimethylammonium perfluorooctane sulfonate (CAS No. 25109916-8).

14. The basic structure of the PFOS potassium salt is shown in figure 2 below and corresponds to the molecular formula $C_8F_{17}SO_3K$.

Figure 2: Structural formula of the PFOS potassium salt

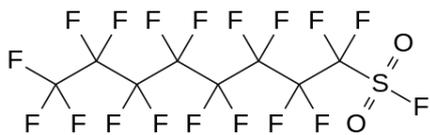


(ii) **PFOSF**

15. PFOSF (CAS No. 307-35-7) is the primary intermediate reactant for the chemical synthesis of PFOS and PFOS-related substances. PFOSF can degrade into PFOS (UNEP, 2006).

16. The basic structure of PFOSF is shown in figure 3 below and corresponds to the molecular formula $C_8F_{17}SO_2F$.

Figure 3: Structural formula of PFOSF



2. Production

17. Parties to the Stockholm Convention must restrict the production of PFOS, its salts and PFOSF, unless they have notified the Secretariat of their intention to produce those substances for an acceptable purpose or a specific exemption in accordance with part I of Annex B to the Convention. Information on the production of PFOS, its salts and PFOSF can be found in the registers of acceptable purposes and specific exemptions of the Stockholm Convention on the Convention website (www.pops.int). Information on the status of ratification by the parties of the amendment listing PFOS, its salts and PFOSF in the Stockholm Convention can be found on the website of the Treaty Section of the United Nations (<https://treaties.un.org/>).

18. PFOS, its salts and PFOSF are still being produced for acceptable purposes and exemptions listed in part I of Annex B to the Stockholm Convention, such as fire-fighting foams, insect baits, photo-imaging and aviation hydraulic fluids.

19. The actual production of PFOS and its related substances cannot be accurately quantified and confirmed due to a lack of reporting of production in many countries and accurate estimations of related substances degrading into PFOS. There is also uncertainty as to whether some of the reported amounts relate to PFOS alone, to PFOSF or to combined PFOS-related substances (Wang et al., 2009). PFOS, its potassium and ammonium salts and PFOSF were reported to be manufactured in 2008 (OECD, 2011).

20. Refer to table 1 below for an overview of the production, applications and environmental releases of PFOS and its related substances.

(a) PFOS

21. All industrial PFOS derivatives are prepared from PFOSF. Base-catalyzed hydrolysis of PFOSF results in PFOS or its related salts (Lehmler, 2005). It should be noted that industrial production of PFOSF yields about 25 per cent of PFOS as linear or branched isomers.

22. There are no known natural sources of PFOS and its presence in the environment is due solely to anthropogenic activity (Key et al., 1997). PFOSF is used as an intermediate in the commercial production of PFOS through hydrolysis (Lehmler, 2005). PFOS can also be formed by environmental microbial degradation or by metabolism by larger organisms of PFOS-related substances (Keml and Swedish EPA, 2004).

23. Although PFOS was produced in Asia (Lim et al., 2011), as well as in some developed countries between 2003 and 2008, PFOS production has dropped significantly since 2002, largely because of the voluntary phase-out of PFOS by the 3M Company (3M) starting in 2000. In 2008, it was reported that PFOS was still being produced (OECD, 2011). In 2011, production of PFOS was documented only in China (Lim et al., 2011).

24. PFOS is also formed from PFOS-related substances. The rate and the extent of PFOS formation from PFOS-related substances are, however, currently unknown. It is therefore not possible to evaluate the contribution of PFOS-related substances to the environmental load of PFOS (UNEP, 2007).

(b) PFOS-related substances

25. About 4,500 Mg of PFOS-related substances were produced worldwide annually up to 2002. Since then, some producers have moved to using alternate fluorine-based products, such as telomere alcohols and perfluorobutane sulfonate (PFBS) (Pistocchi and Loos, 2009).

(i) PFOS salts

26. PFOS salts are produced when PFOS reacts with bases. Its reaction with potassium hydroxide, for example, forms potassium perfluorooctane sulfonate (Lehmle, 2005). In 2008, it was reported that the ammonium and potassium salts of PFOS were still being manufactured for use in commercial products and industrial processes (OECD, 2011).

(ii) PFOSF

27. PFOSF is produced through electrochemical fluorination of octanesulfonyl fluoride, where organic feedstocks are dispersed in liquid anhydrous hydrogen fluoride and an electric current is passed through the solution, leading to the replacement of the molecule's hydrogen atoms (Brooke et al., 2004).

28. The 3M Company was the world's largest producer of PFOSF until the company phased out all PFOS-related products in 2002 (Paul et al., 2009). From 1970 to 2002, the total industrial production of PFOSF was estimated to be 122,500 Mg, of which 3M contributed 96,000 Mg. The largest production sites were in the United States of America (Decatur, Alabama) and Belgium (Antwerp).

3. Use

29. Parties to the Stockholm Convention must eliminate the use of PFOS, its salts and PFOSF unless they have notified the Secretariat of their intention to use them for an acceptable purpose or in accordance with a specific exemption listed in part I of Annex B to the Convention. Information on the current use of PFOS, its salts and PFOSF can be found in the registers of acceptable purposes and specific exemptions of the Stockholm Convention on the Convention website (www.pops.int). Information on the status of ratification by the parties of the amendment listing PFOS, its salts and PFOSF in the Convention can be found on the website of the Treaty Section of the United Nations (<https://treaties.un.org/>).

30. PFOS, its salts and PFOSF are still being used for acceptable purposes and exemptions listed in part I of Annex B to the Stockholm Convention, including fire-fighting foams, insect baits, photo-imaging and aviation hydraulic fluids.

31. PFOS and its related substances exhibit properties such as thermal and acid resistance and are both hydro- and lipophobic (i.e., water and fat repelling). For this reason, they have been used in a wide range of applications in consumer products and industrial processes, such as polymers, surfactants, lubricants, pesticides, textiles coating, non-stick coatings, stain repellents, food packaging and fire-fighting foams (Wang et al., 2013).

32. Table 1 below provides an overview of the production, applications and environmental releases of PFOS and its related substances.

(a) PFOS

33. In 2000, about 2,160 Mg, corresponding to 48 per cent of total PFOS production, was used to make apparel and leather, fabric, upholstery and carpets soil, oil and water resistant. About 1,490 Mg (33 per cent of the total) was produced for paper protection and about 891 Mg (18 per cent of the total) was produced for industrial applications such as mining and oil production (as well surfactants), metal plating (as acid mist suppressants and in electronic etching baths), photolithography, electronics and photography (in films) (OECD, 2002).

(b) PFOS-related substances

34. PFOS-related substances are used as surface-active agents. Their persistence makes them well suited for contact with high temperatures and strong acids or bases.

35. Ever since 3M announced its intention to cease the manufacture of PFOS-related substances in 2000, PFOS user patterns changed in the United Kingdom of Great Britain and Northern Ireland and in the

European Union as a whole, with users applying alternative substances that provided similar functions (Brooke et al., 2004).

36. Prior to the phase-out of most PFOS-containing products by 3M, PFOS-related substances were used in applications such as carpets, leather and apparel, textiles and upholstery, paper and packaging, coatings and coating additives, industrial and household cleaning products, and pesticides (including insecticides). Continued use of PFOS-related substances has been confirmed in the metal plating, photographic and aviation industries, in semi-conductors and photolithography, and in fire-fighting foams (Brooke et al., 2004; FOEN, 2009).

(i) PFOS salts

37. The various PFOS salts have been used, and in some cases are still being used, in a number of applications, including as surfactants in fire-fighting foams; as surfactants in alkaline cleaners; as emulsifiers in floor polish; as mist suppressants in metal plating baths; as surfactants for etching acids for circuit boards; and as pesticide active ingredients in baits against ants and beetles (Brooke et al., 2004).

(ii) PFOSF

38. PFOSF is used as the primary intermediate for the synthesis of PFOS and PFOS-related substances.

4. Wastes

39. Action aimed at waste streams of importance in terms of volume and concentration will be essential to eliminating, reducing and controlling the environmental load of PFOS from waste management activities. In that context, the following should be recognized:

- (a) It is likely that PFOS and its related substances are released into the environment throughout their life cycles (production, product assembly, consumer use, and disposal, including recycling);
- (b) Waste management activities have been identified as one route through which PFOS and its related substances can enter the environment, mainly through industrial and municipal wastewater discharges to surface waters and through leachate from landfills;
- (c) Wastes may contain variable concentrations of PFOS and its related substances, depending on the quantities in which those substances were originally present in specific products and the quantities released during product use and end-of-life management;
- (d) The primary media for the release of PFOS and its related substances from waste management activities are likely to be water, sediments and soils;
- (e) For wastes contaminated with PFOS and its related substances, important considerations occur where high volumes of such wastes are found and a high potential for exposure is present, as in the case of contaminated sewage sludge.

40. Wastes consisting of, containing or contaminated with PFOS and its related substances may be found in a number of physical forms, including:

- (a) Solid obsolete stockpiles of PFOS and its related substances in original packages which are no longer usable because their shelf life has been exceeded or the packaging has deteriorated;
- (b) Soil and sediments;
- (c) Solid waste (food packaging materials, paper, textiles, leather, rubber and carpets);
- (d) Production wastes from fluorinated chemicals;
- (e) Fire suppression equipment;
- (f) Wastewater from industrial and municipal processes;
- (g) Solid residues from wastewater cleaning such as activated carbon treatment;
- (h) Sludge, including sewage sludge;

- (i) Landfill leachate;
- (j) Liquid industrial and household cleaning products; and
- (k) Liquid fluids (aviation hydraulic fluids).

41. Waste streams of importance in terms of potential volume or concentration are as follows:

- (a) Sludge and wastewater from metal plating and photographic industrial activities;
- (b) Sludge and wastewater from municipal treatment plants;
- (c) Landfill leachate;
- (d) Leather and upholstery;
- (e) Carpets;
- (f) Fire-fighting foams equipment;
- (g) Hydraulic fluids; and
- (h) Obsolete stockpile.

42. PFOS wastes can be generated in a diverse range of applications, at different stages of the PFOS life cycle and through different release media. Knowledge of release media guides the analysis and choice of methods that may be required to manage these wastes. Table 1 provides an overview of the production and applications of PFOS and its related substances and the media through which they are released into the environment.

Table 1: Overview of the production and application of PFOS and its related substances and their environmental release media (Adapted from Kemi and Swedish EPA, 2004 and Lim et al., 2011)

Group	Substances Used	Applications	End Products	Release Media
Chemical Production	PFOSF, perfluorooctane sulfonamide (PFOSA), n-alkyl perfluorooctanesulfonamido ethanol (FOSE)	Chemical synthesis	Chemical intermediates	<ul style="list-style-type: none"> • Liquid industrial and household cleaning waste • Sludge • Air
Surface Treatment Applications	FOSE alcohols, silanes, alkoxyates, fatty acid esters, adipates, urethanes, acrylates, polyesters, copolymers	Treatment	Apparel/textiles	<ul style="list-style-type: none"> • Solid waste • Landfill leachate • Wastewater cleaning • Sludge • Air
			Fabric/upholstery	
			Carpets	
Automotive interiors				
		Treatment of metal and glass	Metal/glass	
	As above including PFOS amphoteric	Leather treatment (water/oil/solvent repellence)	Leather	
Paper Protection Applications	FOSE acrylates FOSE copolymers FOSE phosphate esters	Water/ oil grease/ solvent repellence	Plates and food containers	<ul style="list-style-type: none"> • Solid waste • Landfill leachate • Air
			Bags and wraps	
			Folding cartons	
			Containers	
			Carbonless forms	
			Masking papers	

Performance Chemical Applications	PFOS potassium (K ⁺), lithium (Li ⁺), diethanolamine (DEA) and ammonium (NH ₄ ⁺) salts	Mist suppressants Corrosion inhibitors	Metal plating baths	<ul style="list-style-type: none"> • Liquid industrial and household cleaning waste • Wastewater • Sludge • Air
		Surfactants	Surfactant in fire-fighting foams	
			Surfactant in alkaline cleaners	
			Mine and oil well surfactants	
		Cleaning agents	Denture cleaners	
			Shampoos	
			Carpet spot cleaners	
			Mould release agents	
	Waxes and polishes	Emulsifier in wax and floor polishes		
	Coatings	Coating additives		
	N-alkylperfluorooctanesulfonamide (FOSA) carboxylates	Photography	Antistatic agents; surfactants for paper, films, photographic plates	
		Photolithography	Coatings for semiconductors anti-reflective coatings	
	FOSA amides	Pesticides/ Insecticides	Pesticides (active ingredient)	<ul style="list-style-type: none"> • Stockpiles of obsolete chemicals • Wastewater • Sludge • Air
	PFOS amines		Ant bait traps (active ingredient)	
FOSA oxazolidones	Medical applications	Waterproofing casts/wound dressings	<ul style="list-style-type: none"> • Liquid industrial and household cleaning waste • Sludge 	
	Hydraulic fluids	Hydraulic agents	<ul style="list-style-type: none"> • Liquid fluids 	

II. Relevant provisions of the Basel and Stockholm conventions

A. Basel Convention

43. Article 1 (“Scope of the Convention”) defines the types of waste that are subject to the Basel Convention. Subparagraph 1 (a) of that article sets forth a two-step process for determining whether a “waste” is a “hazardous waste” subject to the Convention: first, the waste must belong to any category contained in Annex I to the Convention (“Categories of wastes to be controlled”), and second, the waste must possess at least one of the characteristics listed in Annex III to the Convention (“List of hazardous characteristics”).

44. Annexes I and II to the Basel Convention list some of the wastes that may consist of, contain or be contaminated with PFOS and its related substances. These include:

- (a) Y4: Wastes from the production, formulation and use of biocides and phytopharmaceuticals;

- (b) Y16: Wastes from production, formulation and use of photographic chemicals and processing materials;
- (c) Y17: Wastes from surface treatment of metals and plastics;
- (d) Y18: Residues arising from industrial waste disposal operations;
- (e) Y45: Organohalogen compounds other than substances referred to in this Annex (e.g., Y39, Y41, Y42, Y43, Y44);
- (f) Y46: Wastes collected from households.

45. Annex I wastes are presumed to exhibit one or more Annex III hazardous characteristics, which may include H6.1 "Poisonous (Acute)", H11 "Toxic (Delayed or chronic)", H12 "Ecotoxic", or H13 (capable, after disposal, of yielding a material which possess a hazardous characteristic) unless, through "national tests", they can be shown not to exhibit such characteristics. National tests may be useful for identifying a particular hazardous characteristic listed in Annex III until such time as the hazardous characteristic is fully defined. Guidance papers for Annex III hazardous characteristics H11, H12 and H13 were adopted on an interim basis by the Conference of the Parties to the Basel Convention at its sixth and seventh meetings.

46. List A of Annex VIII describes wastes that are "characterized as hazardous under Article 1, paragraph 1 (a) of this Convention" although "their designation on this Annex does not preclude the use of Annex III [hazard characteristics] to demonstrate that a waste is not hazardous" (Annex I, paragraph (b)). List A of Annex VIII includes a number of wastes or waste categories which have the potential to contain or be contaminated with PFOS and its related substances, including:

- (a) A3120: Fluff – light fraction from shredding;
- (b) A4030: Wastes from the production, formulation and use of biocides and phytopharmaceuticals, including waste pesticides and herbicides which are off-specification, outdated³ or unfit for their originally intended use;
- (c) A4060: Waste oils/water, hydrocarbons/water mixtures, emulsions;
- (d) A4130: Waste packages and containers containing Annex I substances in concentrations sufficient to exhibit Annex III hazard characteristics;
- (e) A4140: Waste consisting of or containing off specification or outdated chemicals corresponding to Annex I categories and exhibiting Annex III hazard characteristics;
- (f) A4160: Spent activated carbon not included on list B (note the related entry on list B B2060).

47. List B of Annex IX lists wastes that "will not be wastes covered by Article 1, paragraph 1 (a), of this Convention unless they contain Annex I material to an extent causing them to exhibit an Annex III characteristic". List B of Annex IX lists a number of wastes or waste categories that have the potential to contain or be contaminated with PFOS and its related substances, including:

- (a) B1180: Waste photographic film containing silver halides and metallic silver;
- (b) B1190: Waste photographic paper containing silver halides and metallic silver;
- (c) B1250: Waste end-of-life motor vehicles, containing neither liquids nor other hazardous components;
- (d) B2060: Spent activated carbon not containing any Annex I constituents to the extent they exhibit Annex III characteristics, for example, carbon resulting from the treatment of potable water and process of the food industry and vitamin production (note to the related entry on list A A4160);
- (e) B3010: Solid plastic waste;⁴
- (f) B3020: Paper, paperboard and paper product wastes;⁵

³ "Outdated" means unused within the period recommended by the manufacturer.

⁴ Refer to Annex IX to the Basel Convention for a full description of this entry.

⁵ Refer to Annex IX to the Basel Convention for a full description of this entry.

- (g) B3030: Textile wastes;⁶
- (h) B3035: Waste textile floor coverings, carpets;
- (i) B3090: Paring and other wastes of leather or of composition leather not suitable for the manufacture of leather articles, excluding leather sludges, not containing hexavalent chromium compounds and biocides (note the related entry on list A A3100);
- (j) B3100: Leather dust, ash, sludges or flours not containing hexavalent chromium compounds or biocides (note the related entry on list A A3090).

48. For further information, see section II.A of the general technical guidelines.

B. Stockholm Convention

49. The present document covers intentionally produced PFOS, its salts and PFOSF whose production and use are to be restricted in accordance with Article 3 and Annex B, part III to the Stockholm Convention.

50. Annex B, part III (“Perfluorooctane sulfonic acid, its salts, and perfluorooctane sulfonyl fluoride”), to the Stockholm Convention outlines specific requirements for PFOS and its related substances as follows:

1. “The production and use of perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOSF) shall be eliminated by all Parties except as provided in part I of this Annex for Parties that have notified the Secretariat of their intention to produce and/or use them for acceptable purposes. A Register of Acceptable Purposes is hereby established and shall be available to the public. The Secretariat shall maintain the Register of Acceptable Purposes. In the event that a Party not listed in the Register determines that it requires the use of PFOS, its salts or PFOSF for the acceptable purposes listed in part I of this annex, it shall notify the Secretariat as soon as possible in order to have its name added forthwith to the Register.
2. Parties that produce and/or use these chemicals shall take into account, as appropriate, guidance such as that given in the relevant parts of the general guidance on best available techniques and best environmental practices given in part V of Annex C to the Convention.
3. Every four years, each Party that uses and/or produces these chemicals shall report on progress made to eliminate PFOS, its salts and PFOSF and submit information on such progress to the Conference of the Parties pursuant to and in the process of reporting under Article 15 of the Convention.
4. With the goal of reducing and ultimately eliminating the production and/or use of these chemicals, the Conference of the Parties shall encourage:
 - (a) Each Party using these chemicals to take action to phase out uses when suitable alternatives substances or methods are available;
 - (b) Each Party using and/or producing these chemicals to develop and implement an action plan as part of the implementation plan specified in Article 7 of the Convention;
 - (c) The Parties, within their capabilities, to promote research on and development of safe alternative chemical and non-chemical products and processes, methods and strategies for Parties using these chemicals, relevant to the conditions of those Parties. Factors to be promoted when considering alternatives or combinations of alternatives shall include the human health risks and environmental implications of such alternatives.⁷
5. The Conference of the Parties shall evaluate the continued need for these chemicals for the various acceptable purposes and specific exemptions on the basis of available scientific, technical, environmental and economic information, including:
 - (a) Information provided in the reports described in paragraph 3;

⁶ Refer to Annex IX to the Basel Convention for a full description of this entry.

⁷ The use of alternatives eliminates the generation of wastes containing PFOS, its salts and PFOSF.

- (b) Information on the production and use of these chemicals;
 - (c) Information on the availability, suitability and implementation of alternatives to these chemicals;
 - (d) Information on progress in building the capacity of countries to transfer safely to reliance on such alternatives.
6. The evaluation referred to in the preceding paragraph shall take place no later than in 2015 and every four years thereafter, in conjunction with a regular meeting of the Conference of the Parties.
7. Due to the complexity of the use and the many sectors of society involved in the use of these chemicals, there might be other uses of these chemicals of which countries are not presently aware. Parties which become aware of other uses are encouraged to inform the Secretariat as soon as possible.
8. A Party may, at any time, withdraw its name from the Register of Acceptable Purposes upon written notification to the Secretariat. The withdrawal shall take effect on the date specified in the notification.
9. The provisions of note (iii) of part I of Annex B shall not apply to these chemicals.”
51. Further information on the register of acceptable purposes for PFOS, its salts and PFOSF is available from: www.pops.int.
52. For further information, see section II.B of the general technical guidelines.

III. Issues under the Stockholm Convention to be addressed cooperatively with the Basel Convention

A. Low POP content

53. The provisional definition of low POP content for PFOS, its salts and PFOSF is 50 mg/kg.⁸
54. The low POP content described in the Stockholm Convention is independent from the provisions on hazardous waste under the Basel Convention.
55. Wastes with a content of PFOS, its salts or PFOSF above 50 mg/kg must be disposed of in such a way that the POP content is destroyed or irreversibly transformed in accordance with the methods described in subsection IV.G.2 or otherwise disposed of in an environmentally sound manner when destruction or irreversible transformation does not represent the environmentally preferable option in accordance with the methods described in subsection IV.G.3.
56. Wastes with a content of PFOS, its salts or PFOSF at or below 50 mg/kg should be disposed of in accordance with the methods referred to in subsection IV.G.4 outlining other disposal methods when POP content is low and section IV.I.1 addressing pertinent to higher-risk situations.
57. For further information, see section III.A of the general technical guidelines.

B. Levels of destruction and irreversible transformation

58. For the provisional definition of levels of destruction and irreversible transformation, see section III.B of the general technical guidelines.

⁸ This provisional definition was proposed by the European Union for consideration at the ninth meeting of the Open-ended Working Group of the Basel Convention.

C. Methods that constitute environmentally sound disposal

59. See section IV.G below and section IV.G of the general technical guidelines.

IV. Guidance on environmentally sound management (ESM)

A. General considerations

60. For information, see section IV.A of the general technical guidelines.

B. Legislative and regulatory framework

61. Parties to the Basel and Stockholm conventions should examine their national strategies, policies, controls,⁹ standards and procedures to ensure that they are in agreement with the two conventions and with their obligations under them, including those that pertain to ESM of PFOS wastes.

62. Elements of a regulatory framework applicable to PFOS and its related substances should include measures to prevent the generation of wastes and to ensure the environmentally sound management of generated wastes. Such elements could include:

- (a) Environmental protection legislation establishing a regulatory regime, setting release limits and establishing environmental quality criteria;
- (b) Prohibitions on the production, sale, use, import and export of PFOS and its related substances;
- (c) Phase-out dates for PFOS and its related substances that remain in service, inventory or storage;
- (d) Transportation requirements for hazardous materials and waste;
- (e) Specifications for containers, equipment, bulk containers and storage sites;
- (f) Specification of acceptable analytical and sampling methods for PFOS and its related substances;
- (g) Requirements for waste management and disposal facilities;
- (h) Definitions of hazardous waste and conditions and criteria for the identification and classification of PFOS wastes as hazardous wastes;
- (i) A general requirement for public notification and review of proposed waste-related government regulations, policies, certificates of approval, licences, inventory information and national emissions data;
- (j) Requirements for identification, assessment and remediation of contaminated sites;
- (k) Requirements concerning the health and safety of workers; and
- (l) Other legislative measures on, e.g., waste prevention and minimization, inventory development and emergency response.

63. Legislation should establish a link between the phase-out dates for the production and use of PFOS and its related substances, including in products and articles, and the dates by which PFOS and its related substances should be disposed of once they have become waste. Legislation should also set a time limit for the disposal of PFOS wastes so as to prevent the creation of stockpiles that have no clear phase-out date.

64. For further information, see section IV.B of the general technical guidelines.

⁹ In these guidelines, national legislation and control measures include sub-national and other applicable forms of governance.

C. Waste prevention and minimization

65. Both the Basel and Stockholm conventions advocate waste prevention and minimization. PFOS, its salts and PFOSF are restricted under the Stockholm Convention to a limited number of acceptable purposes, as provided in part I of Annex B to the Convention.

66. Wastes containing PFOS and its related substances should be minimized through isolation and source separation to prevent mixing and contamination of other waste streams.

67. The mixing and blending of wastes with a content of PFOS, its salts and PFOSF above 50 mg/kg with other materials solely for the purpose of generating a mixture with a content of PFOS, its salts or PFOSF at or below 50 mg/kg is not environmentally sound. Nevertheless, the mixing or blending of materials as a pre-treatment method may be necessary in order to enable treatment or to optimize treatment efficiency.

68. For further information, see paragraph 5 and section IV.C of the general technical guidelines.

D. Identification of wastes

69. Article 6, paragraph 1 (a), of the Stockholm Convention requires each party to, inter alia, develop appropriate strategies for the identification of products and articles in use and wastes consisting of, containing or contaminated with POPs. The identification of PFOS wastes is the starting point for their effective ESM.

70. For general information on identification of wastes, see section IV.D of the general technical guidelines.

1. Identification

71. PFOS wastes can be found in the following stages of the PFOS life cycle:

- (a) PFOS manufacturing and processing:
 - (i) Waste generated from the production and processing of PFOS and PFOS-related substances;
 - (ii) In water, soil or sediment close to manufacturing or processing sites;
 - (iii) Industrial wastewater and sludge;
 - (iv) Landfill leachate from sites where chemical manufacturing or processing waste was disposed of;
 - (v) Stockpiles of unusable or unsellable material;
- (b) Industrial application of PFOS-related substances (pesticides production, metal plating, oil and gas production, the photographic industry, the semiconductor industry, leather treatment and carpet and textile finishing):
 - (i) Residues generated from the application of PFOS-related substances;
 - (ii) In water, soil or sediment close to manufacturing or processing sites;
 - (iii) Industrial wastewater and sludge;
 - (iv) Landfill leachate from sites where waste from industrial applications was disposed of;
 - (v) Stockpiles of unusable or unsellable products;
- (c) Use of products or articles containing PFOS-related substances:
 - (i) Waste generated during the use of such products or articles (e.g., spent fire-fighting foams, spent aviation hydraulic fluids, insect baits);
 - (ii) Stockpiles of expired products such as fire-fighting foams, aviation hydraulic fluids and insect baits;

- (iii) In water, soil or sediment close to sites where such products or articles were used;
- (d) Disposal of products or articles containing PFOS-related substances:
 - (i) In water, soil or sediment close to facilities for the recycling and recovery of textiles, paper and hydraulic fluids;
 - (ii) In municipal landfill leachate;
 - (iii) In municipal wastewater and sludge.

72. It should be noted that even experienced technical personnel may not be able to determine the nature of an effluent, substance, container or piece of equipment by its appearance or markings. Consequently, parties may find the information on production, use and types of waste provided in section I.B of the present guidelines useful in identifying PFOS and its related substances.

2. Inventories

73. Inventories are an important tool for identifying, quantifying and characterizing wastes. A step-by-step approach for the development of national inventories of PFOS generally includes the following steps:

- (a) Step 1: planning (i.e., identifying relevant sectors that use or produce PFOS and its related substances);
- (b) Step 2: choosing data collection methodologies using a tiered approach;
- (c) Step 3: collecting and compiling data from national statistics on the production, use, import and export of PFOS and its related substances;
- (d) Step 4: managing and evaluating the data obtained in step 3 using an estimation method;
- (e) Step 5: preparing an inventory report; and
- (f) Step 6: periodically updating the inventories.

74. For general information on sampling, analysis and monitoring, see section IV.E of the general technical guidelines. For further information, refer to the *Draft Guidance for the inventory of perfluorooctane sulfonic acid (PFOS) and related chemicals listed under the Stockholm Convention on Persistent Organic Pollutants (2015)*.

E. Sampling, analysis and monitoring

75. For general information on sampling, analysis and monitoring, see section IV.E of the general technical guidelines.

1. Sampling

76. Sampling serves as an important element for identifying and monitoring environmental concerns and human health risks.

77. Standard sampling procedures should be established and agreed upon before the start of the sampling campaign. Sampling should comply with specific national legislation, where it exists, or with international regulations and standards.

78. Types of matrices typically sampled for PFOS and PFOS-related substances include:

- (a) Liquids:
 - (i) Leachate from dumpsites and landfills;
 - (ii) Water (surface water, groundwater, drinking water and industrial and municipal effluents);
 - (iii) Biological fluids (blood, in the case of worker health monitoring; breast milk);

- (b) Solids:
 - (i) Soil, sediment and municipal and industrial sludge;
 - (ii) Indoor dust;
- (c) Gases:
 - (i) Air (indoor and outdoor);
 - (ii) Exhaust gases.

79. Samples of PFOS and PFOS-related substances in water (surface water, groundwater, drinking water) may be collected in 100-500 ml HDPE (high-density polyethylene) plastic bottles. The sample volume should be determined by an analytical laboratory and adapted to expected PFOS levels and the laboratory's analytical capacities. The instrumental limit of detection is the main factor limiting the sensitivity and the volume should be enough to reach quantification levels (UNEP, 2015b). Fluoropolymeric plastics, including Teflon, PTFE (polytetrafluoroethene) and rubber materials, should be avoided during sampling, sample storage and extraction (WRC Group, 2008).

80. Air measurement methods include high-volume air sampling, which measures a large volume of air and is better for detecting low PFOS concentrations often found in the environment, and passive air sampling, which gathers information on long-term exposure. The advantage of passive air samplers is their simplicity, ease of transport to remote sites and non-reliance on power sources (Environment Canada, 2013).

81. The PFOS anion is recommended for water monitoring using either passive or active (grab) sampling methods or passive sampling, including through the use of a modified POCIS (Polar Organic Chemical Integrative Sampler) and a weak anion exchange sorbent as a receiving phase to determine PFOS and other PFASs in water. In the Guidance on the global monitoring plan for POPs (UNEP, 2015b), the use of grab samples is recommended for PFOS; generally, samples are not filtered prior to extraction for PFOS analysis (see *ibid.*, chapter 4.3 and references therein).

82. Methods that may be used for the preparation of samples include solvent extraction, ion-pair extraction, solid-phase extraction and column-switching extraction (EPA, 2012).

2. Analysis

83. Analysis refers to the extraction, purification, separation, identification, quantification and reporting of POP concentrations in the matrix of interest. The development and dissemination of reliable analytical methods and the accumulation of high-quality analytical data are important to understand the environmental impact of hazardous chemicals, including POPs.

84. Selected analytical methods for PFOS and its related substances include:

- (a) ISO 25101 (2009): Water quality – Determination of perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) – Method for unfiltered samples using solid phase extraction and liquid chromatography/mass spectrometry;
- (b) EPA Method 537: Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS);
- (c) High-performance liquid chromatography (HPLC) coupled with tandem mass spectrometry (HPLC-MS/MS): This method allows for more sensitive determinations of individual PFOS and precursor compounds in air, water, soil and biota.

3. Monitoring

85. Monitoring and surveillance serve as elements for identifying and tracking environmental concerns and human health risks. Information collected from monitoring programmes feeds into science-based decision-making processes and is used for the evaluation of the effectiveness of risk management measures, including regulations. For example, under Canada's Chemicals Management Plan (CMP), scientists collect data on PFOS and its related substances in air, freshwater, sediments, aquatic biota

and wildlife across Canada. Recognizing that chemicals of concern are often found in wastes, Canada's CMP Environmental Monitoring and Surveillance Programme has monitored releases from landfills and wastewater treatment systems for a range of chemicals, including PFOS (Environment Canada, 2013).

86. Monitoring programmes should be implemented in facilities managing PFOS wastes. Particular attention should also be paid to facilities generating PFOS wastes.

F. Handling, collection, packaging, labelling, transportation and storage

87. For general information on handling, collection, packaging, labelling, transportation and storage, see section IV.F of the general technical guidelines.

88. The types, volumes and concentration levels of PFOS wastes will determine which stages of their waste management pose a risk to the environment or human health and therefore necessitate appropriate actions in order to eliminate, reduce and control the environmental load of PFOS and its related substances. Because of the lack of specific knowledge of the environmental and health impacts of the management of certain PFOS wastes, specific guidance on the handling, collection, packaging, labelling, transportation and storage of such wastes is not widely documented. PFOS wastes should be handled, collected, packaged, labelled, transported and stored in accordance with the environmentally sound management provisions of national legislation applicable to them.

89. In cases where PFOS waste was a household consumer product or article (e.g., textiles), specific handling, collection, packaging, labelling, transportation and storage considerations may not be required; such waste should be handled, collected, packaged, labelled, transported and stored in accordance with the environmentally sound management provisions of national legislation for that type of waste.

90. In cases where PFOS wastes are considered hazardous wastes, they should be handled, collected, packaged, labelled, transported and stored as such in accordance with applicable provisions of national legislation. Individuals involved in the handling, collection, packaging, labelling, transportation and storage of hazardous PFOS wastes should receive proper training. Where appropriate, procedures and processes for managing hazardous wastes should be considered for managing wastes with a content of PFOS above 50 mg/kg to prevent spills and leaks that could lead to worker or community exposure or releases to the environment.

91. Subsections (1) and (2) below outline considerations for the handling, collection, packaging, labelling, transportation and storage of waste streams that may be contaminated with PFOS and its related substances.

1. Liquids and semi-liquids (i.e., wastewater, landfill leachate, sewage sludge, hydraulic fluids and aqueous film-forming foams)

92. Wastewater, landfill leachate and sewage sludge contaminated with PFOS or its related substances are waste streams of importance because large volumes of these wastes exist.

93. Hydraulic fluids and aqueous film-forming foams containing PFOS or its related substances are waste streams of importance because of the concentration of PFOS found in these wastes.

94. Appropriate measures should be taken to prevent leakage of PFOS wastes during handling, collection, packaging, transportation and storage. Such wastes should also be handled and packaged separately to avoid their mixing with, and the contamination of, other materials.

95. Secondary containment of liquid PFOS wastes is a critical aspect of controlling accidental releases during storage and transportation. It is not necessary for secondary containments to meet long-term material compatibility as is the case with primary storage; however, their design and build should be able to contain releases of liquids at least until the leaked materials are recovered.

96. Containers should be appropriately labelled with details of their contents and stored in approved and designated enclosed areas that have secondary containment. The facilities should be subject to regular inspection and maintenance.

97. Liquid and semi-liquid PFOS wastes should not accumulate in large quantities for extended periods of time and should therefore be regularly collected and transported to an approved transfer station or to a central processing centre. If the wastes are initially sent to a transfer station, they should be further transported to the most appropriate central processing or disposal facility.

2. Solids (i.e., household and consumer textiles)

98. Textiles such as carpets, leather and upholstery containing PFOS or its related substances are waste streams of importance because they contain variable concentrations of PFOS.

99. Household and consumer textile wastes containing PFOS or its related substances are not documented to exhibit specific risks to the environment and human health during their handling, collection, transportation and storage. However, it is important to bear in mind that large quantities of such wastes, even if properly stored, are more likely to present risks than smaller quantities scattered over large areas. In addition, these wastes should be handled separately to avoid mixing with other materials and should accordingly be properly labelled with the details of the contents to facilitate their environmentally sound disposal.

100. Textile wastes containing PFOS or its related substances should not accumulate in large quantities for extended periods of time and should therefore be regularly collected and transported to an approved transfer station or to a central processing centre. If the wastes are initially sent to a transfer station, they should be further transported to the most appropriate central processing or disposal facility.

G. Environmentally sound disposal

1. Pre-treatment

101. Pre-treatment methods should be selected based on the nature and types of PFOS wastes to be pre-treated. Such methods may include:

- (a) Adsorption and absorption;
- (b) Membrane filtration, in particular reverse osmosis and nanofiltration;
- (c) Mixing;
- (d) Oil-water separation; and
- (e) Volume reduction.

102. For information, see subsection IV.G.1 of the general technical guidelines.

2. Destruction and irreversible transformation methods

103. Hazardous waste incineration is, according to the general technical guidelines, at least one of the destruction and irreversible transformation methods applicable for the environmentally sound disposal of wastes with a content of PFOS, its salts or PFOSF at or above 50 mg/kg.

104. For further information, see subsection IV.G.2 of the general technical guidelines.

3. Other disposal methods when neither destruction nor irreversible transformation is the environmentally preferable option

105. For information, see subsection IV.G.3 of the general technical guidelines.

4. Other disposal methods when the POP content is low

106. For information, see subsection IV.G.4 of the general technical guidelines.

H. Remediation of contaminated sites

107. For information, see section IV.H of the general technical guidelines.

I. Health and safety

108. For information, see section IV.I of the general technical guidelines.

1. Higher-risk situations

109. For general information, see subsection IV.I.1 of the general technical guidelines.

110. Higher-risk situations occur at sites where high concentrations of POPs or high volumes of POP wastes are found and a high potential for exposure of workers or the general population exists.

111. It is estimated that the concentration of PFOS and its related substances found in sewage sludge from wastewater treatment plants is generally in the order of 0.1 mg/kg to 1 mg/kg (ESWI Consortium, 2011). Although the POP content in sewage sludge is low, the high volumes of this waste stream could present a situation of higher risk to the environment and human health when applied to agricultural land.

112. Some countries have set specific contaminant thresholds for land application of sewage sludge. In Germany, for example, a limit of 0.1 mg/kg has been set for PFOS concentration in fertilizers.

2. Lower-risk situations

113. For information on lower risk situations, see subsection IV.I.2 of the general technical guidelines.

J. Emergency response

114. Emergency response plans should be in place for those PFOS and PFOS-related substances that are in service, in storage, in transport and at disposal sites. Further information on emergency response plans is provided in section IV.J of the general technical guidelines.

K. Public participation

115. Parties to the Basel or Stockholm Convention should have open public participation processes. For further information see section IV.K of the general technical guidelines.

Annex to the technical guidelines

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