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Open-ended Working Group of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal
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Item 3 (b) (i) a. of the provisional agenda*

Matters related to the work programme of the Open-ended Working Group for 2017–2018: scientific and technical matters: technical guidelines: technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants

Draft updated technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with hexabromodiphenyl ether and heptabromodiphenyl ether, or tetrabromodiphenyl ether and pentabromodiphenyl ether or decabromodiphenyl ether

Note by the Secretariat

1. As referred to in the note by the Secretariat on technical guidelines (UNEP/CHW/OEWG.11/4), the small intersessional working group on persistent organic pollutant wastes updated the technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with hexabromodiphenyl ether and heptabromodiphenyl ether, or tetrabromodiphenyl ether and pentabromodiphenyl ether, adopted by decision BC-12/3,[1] to include decabromodiphenyl ether, as set out in the annex to the present note.

2. The changes made by the small intersessional working group to the technical guidelines adopted by decision BC-12/3 have been tracked so that the revisions can be easily identified. The present note, including its annex, has not been formally edited.

* UNEP/CHW/OEWG.11/1/Rev.1.

[1] UNEP/ CHW.12/5/Add.6/Rev.1

Annex

Draft updated technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with hexabromodiphenyl ether and heptabromodiphenyl ether, or tetrabromodiphenyl ether and pentabromodiphenyl ether or decabromodiphenyl ether

(Draft of 17 May 2018)

Contents

Abbreviations and acronyms

ABS	acrylonitrile-butadiene-styrene
ATSDR	Agency for Toxic Substances and Disease Registry
BAT	best available technology
BDE	brominated diphenyl ether
BDE-209	decabromodiphenyl ether congener 209
BEP	best environmental practice
BFR	brominated flame retardant
CAS	Chemical Abstracts Service
CENELEC	National Committees of the European Committee f~~F~~or Electrotechnical Standardization
C-decaBDE	commercial decabromodiphenyl ether
C-octaBDE	commercial octabromodiphenyl ether
C-pentaBDE	commercial pentabromodiphenyl ether
decaBDE~~CAS~~	~~Chemical Abstracts Service~~decabromodiphenyl ether (BDE-209) present in c-decaBDE
EEE	electrical and electronic equipment
ELV	end-of-life vehicles
EPDM	ethylene propylene diene monomer
ESM	Environmentally sound management
EVA	ethylene, vinyl acetate
GC	gas chromatography
HeptaBDE	heptabromodiphenyl ether
HexaBDE	hexabromodiphenyl ether ~~and~~
~~HeptaBDE~~	~~heptabromodiphenyl ether~~
HIPS	high-impact polystyrene
ILO	International Labor Organization
ISO	International Organization for Standardization
MAC	mobile air-conditioning
MS	mass spectrometry
NIP	National Implementation Plan
NonaBDE	nonabrominated diphenyl ether
OECD	Organisation for Economic Co-operation and Development
PA	polyamide
PBDD	polybrominated dibenzo-p-dioxin
PBDEs	polybrominated diphenyl ethers
PBDF	polybrominated dibenzofuran
PBT	polybutyleneterephthalate
PBT	Persistent, Bioaccumulative and Toxic~~s~~
PC	polycarbonate
PCB	polychlorinated biphenyl
PE	polyethylen
PEE	poly(ether ester)
PentaBDE	pentabromodiphenyl ether
PET	~~P~~polyethylene terephthalate
POP	persistent organic pollutant
POP-BDEs	hexabromodiphenyl ether and heptabromodiphenyl ether, ~~and~~ tetrabromodiphenyl ether and pentabromodiphenyl ether and decabromodiphenyl ether
	polyamide polymers/propylene
PUR	Polyurethane
~~PBDF~~	~~polybrominated dibenzofuran~~
~~PBT~~	~~polybutyleneterephthalate~~
~~PCB~~	~~polychlorinated biphenyl~~
~~POP~~	~~persistent organic pollutant~~
PS	polystyrol
PVC	polyvinyl chloride
SPE	solid phase extraction
TetraBDE	tetrabromodiphenyl ether
UNEP	United Nations Environment
UPEW	unsaturated polyester
vPvB	very persistent and very bioaccumulative
~~UNEP~~	~~United Nations Environment Programme~~
WHO	World Health Organization

Units of measurement

mg/kg	milligram per kilogram. Corresponds to parts per million by mass.

I. Introduction

A. Scope

1. This document supersedes the Technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with hexabromodiphenyl ether and heptabromodiphenyl ether, or tetrabromodiphenyl ether and pentabromodiphenyl ether, of May 2015.

~~1.~~2. The present guidelines provide guidance on the environmentally sound management (ESM) of wastes consisting of, containing or contaminated with hexabromodiphenyl ether and heptabromodiphenyl ether, or tetrabromodiphenyl ether and pentabromodiphenyl ether, or decabromodiphenyl ether (i.e. "BDE-209"[2]) present in commercial decabromodiphenyl ether, pursuant to several decisions of ~~two~~ multilateral environmental agreements on chemicals and wastes~~.~~[~~1~~3].

~~2.~~3. Hexabromodiphenyl ether (hexaBDE) and heptabromodiphenyl ether (heptaBDE), as well as tetrabromodiphenyl ether (tetraBDE) and pentabromodiphenyl ether (pentaBDE), were listed in Annex A to the Stockholm Convention in 2009, through an amendment that entered into force in 2010. Decabromodiphenyl ether, defined as decabromodiphenyl ether (BDE-209) present in commercial decabromodiphenyl ether, was listed in Annex A to the Stockholm Convention in 2017 and the amendment will enter into force in 2018. In the present guidelines, hexaBDE, heptaBDE, tetraBDE ~~and,~~ pentaBDE and decaBDE as a group are referred to as "POP-BDEs~~".~~" (for further specification see section II.B.).

~~3.~~4. The present guidelines 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, […]) ~~(UNEP, XXXX)~~ (hereinafter referred to as "Ggeneral technical guidelines"). The Ggeneral 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 POP-BDEs for purposes of their identification and management.~~).

B. Description, production, use and wastes

1. Description

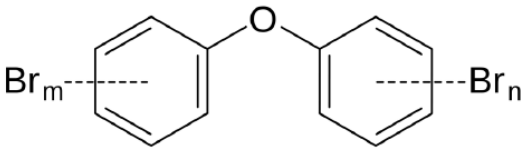
~~4.~~5. Brominated flame retardants (BFRs) are chemical substances used to reduce fire hazards by interfering with the combustion of the polymer. Some BFRs, such as polybrominated diphenyl ethers (PBDEs), are additives that do not chemically bind to plastics but are physically combined with them and therefore may be easily released into the environment.

~~5.~~6. PBDEs have different ~~atomic numbers and~~ degrees of bromination ranging from one to ten bromine atoms (figure 1). ~~Lower brominated BDEs, such as tetraBDEs and pentaBDEs, are seen as more dangerous than higher brominated BDEs (i.e., BDEs with more than 5 bromine atoms per molecule, e.g., octaBDEs and decaBDEs) because they bioaccumulate more efficiently, are slightly more soluble in water and have a greater propensity for volatilization and atmospheric transport than higher brominated BDEs.~~

Figure 1: Structure of PBDEs

[2] decabromodiphenylether congener 209

[3] Decisions BC-11/3, BC-12/3, BC-13/4 and BC-14/… 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, OEWG-9/3, and OEWG-11/… of the Open-ended Working Group of the Basel Convention; and decisions SC-4/14, SC-4/18, SC-5/9, SC- 6/11 and SC-8/10 of the Conference of the Parties to the Stockholm Convention on Persistent Organic Pollutants.



6.7. PBDEs are industrial aromatic organobromine chemicals that make up a group consisting of 209 congeners. The most common commercial formulations of PBDEs (represented in table 1 below) are commercial octabromodiphenyl ether (c-octaBDE), commercial pentabromodiphenyl ether (c-pentaBDE) and commercial decabromodiphenyl ether (c-decaBDE).

7.8. C-octaBDE designates a commercial mixture that typically contains mainly hexaBDEs, heptaBDEs, octaBDEs and nonabrominated diphenyl ethers (nonaBDEs). "Hexabromodiphenyl ether and heptabromodiphenyl ether" means, according to Annex A, part III, to the Stockholm Convention, BDE-153, BDE-154, BDE-175, BDE-183 and other hexa- and heptabromodiphenyl ethers present ~~inc~~in c-octaBDE.

8.9. C-pentaBDE designates a commercial mixture that typically contains tetraBDEs, pentaBDEs and hexaBDEs. "Tetrabromodiphenyl ether and pentabromodiphenyl ether" means, according to Annex A, part III, to the Stockholm Convention, BDE-47, BDE-99 and other tetra- and pentabromodiphenyl ethers present in c-pentaBDE.

10. ~~There is some evidence~~C-decaBDE designates a commercial mixture that ~~higher brominated BDEs~~typically contains mainly the congener BDE-209, with low levels of other PBDE congeners such as nonaBDE ether and octaBDE (UNEP/POPS/POPRC.11/10/Add.1).

9.11. Components of the commercial penta-, octa- and decaBDE mixtures are persistent organic pollutants according to Annex A to the Stockholm Convention. They have adverse effects to human health and/ or the environment, are persistent, they bioaccumulate and undergo long-range transport. Adverse effects are reported for numerous effects on human health and/ or the environment. C-decaBDE with its main constituent decaBDE is also degraded~~decaBDE can break down~~ to lower brominated ~~congeners. These higher~~PBDEs including hexaBDE, heptaBDE, tetraBDE and pentaBDE, with known PBT/vPvB and POP properties which contribute in the outcome of decaBDE toxicity. Due to debromination and historical reservoirs of c-penta- and c-octaBDE congeners ~~may therefore be precursors to the POP-BDEs that fall under the scope of the present technical guidelines.~~in the environment, organisms are exposed to a complex mixture of PBDEs that in combination pose a higher risk than BDE-209 alone (see UNEP/POPS/POPRC.10/10/Add.2).

Table 1: Typical composition of PBDE commercial mixtures (Environment Canada, 2013)

Commercial Mixtures	PBDE congener groups and concentrations of active ingredient						
	tetraBDE	**pentaBDE**	**hexaBDE**	**heptaBDE**	**octaBDE**	**nonaBDE**	**decaBDE**
	BDE-47, etc.	BDE-99, etc.	BDE-153, BDE-	BDE-175, BDE-	BDE-203,BDE-204, etc.	BDE-207,BDE-208	BDE-209
c-pentaBDE	24 – 38%	50 – 62%	4 – 12%	Trace	-	-	-
c-octaBDE	-	0.5%	12%	45%	33%	10%	0.7%
c-decaBDE	-	-	-	-	trace	0.3 – 3%	97 – 98%

~~1.~~2. Production

(a) C-octaBDE

12. Parties to the Stockholm Convention ~~must~~shall prohibit and/or eliminate the production of hexaBDE and heptaBDE and there are no exemptions under the Convention for the production of ~~those chemicals.~~the chemical. Information on the status of ratification by the P~~p~~arties of the amendment listing hexaBDE and heptaBDE in the Stockholm Convention can be found on the website of the Treaty Section of the United Nations (https://treaties.un.org/).

~~10.~~13. C-octaBDE has been produced in France, Norway, Switzerland, Canada, Japan, Israel, the Netherlands, the United ~~Kingdom of Great Britain and Northern Ireland, and~~Kingdom and the United States of America. Estimated annual worldwide production of c-octaBDE was 6,000 tonnes in 1994 and had decreased to 3,800 tonnes by 2001. Estimated total production of c-

octaBDE 1970 to 2005 was 102,700 to 118,500 tonnes (Schenker 2008). No information is available on whether c-octaBDE is being produced in developing countries (UNEP/POPS/POPRC, 2008). .4/15/Add1).

(b) C-pentaBDE

11.14. Parties of the Stockholm Convention mustshall prohibit and/or eliminate the production of tetraBDE and pentaBDE and there are no exemptions under the Convention for the production of the chemical. C-pentaBDE was produced in Australia, the European Union, Israel, Japan and the United States, but production ceased in 2004 (UNEP/POPS/POPRC.2/17/Add.1). According to (NO EA, 2015), it is possible that China produced for its own market as well. It is assumed that since the late 1990s, c-pentaBDE was mainly produced in the United States. The global estimated production of c-pentaBDE from 1970 to 2005 was between 91,000 to 105,000 tonnes (Schenker 2008). Information on the status of ratification by the Pparties of the amendment listing tetraBDE and pentaBDE in the Stockholm Convention can be found on the website of the Treaty Section of the United Nations (https://treaties.un.org/).

3. Use

(a) C-octaBDE

(c) C-decaBDE

15. Parties to the Stockholm Convention shall prohibit and/or eliminate the production of decaBDE with specific exemptions for the production of c-decaBDE as specified in part I of Annex A to the Stockholm Convention as allowed for the Parties listed in the register of specific exemptions of the Stockholm Convention on the Convention website (www.pops.int). Available production data indicate that about 75% per cent of all the world production of PBDEs was c-decaBDE. Currently c-decaBDE is manufactured only in a few countries globally. Many countries have already restricted or initiated voluntary programs to phase out the production of c-decaBDE. Total production of c-decaBDE in the period from 1970- to 2005 was between 1.1-1.25 million tonnes. According to document (UNEP/POPS/POPRC.10/3), the overall scale of c-decaBDE production today is currently unknown, and data on production, trade and stockpiles is only available for some countries. Production of c-decaBDE is still ongoing in a few countries (China, India, Japan). For example, the annual processing capacity of decaBDE in China in 2013 was 49,000 tons (Zhang et al., 2017). Production of c-decaBDE no longer takes place in the EU, the United States and Canada.

3. Use

(a) C-octaBDE

12.16. Parties to the Stockholm Convention shall prohibit and/or eliminate the use of hexaBDE and heptaBDE, unless they have notified the Secretariat of their intention to use either chemical for an acceptable purpose or in accordance with a specific exemption listed in part IV of Annex A to the Convention. HexaBDE and heptaBDE are still being used in accordance with the specific exemption listed in part IV of Annex A, which allows Pparties to use, recycle or dispose of articles that contain or may contain hexaBDE and heptaBDE. Information on specific exemptions can be found in the register of specific exemptions of the Stockholm Convention on the Convention website (www.pops.int). www.pops.int).

13.17. C-octaBDE is used mostly as an additive flame retardant in the manufacturing of plastic polymers, particularly in acrylonitrile-butadiene-styrene (ABS) polymers. ABS is used in housings of electrical and electronic equipment, such as office equipment, automotive parts and appliances, business machines, computers, business cabinets, pipes and fittings. A minor quantity is also being produced for use as an additive in high impact polystyrene (HIPS), polybutylene terephthalate (PBT) and polyamide polymers (PP) (POPRC, 2008). C-octaBDE was typically added at concentrations between 10 and 18 %per cent by weight (UNEP/POPS/POPRC.3/14). Around 95 %per cent of c-octaBDE supplied in the EU was used in ABS (globally approximately 70 %per cent). The total market demand for c-octaBDE was split with around 40 %per cent each being used in America and Asia, around 15 %per cent in

Europe and approximately 5 %per cent in the rest of the world (Watson et al., 2010).

~~(a)~~(b) C-pentaBDE

~~14.~~18. Parties to the Stockholm Convention ~~must~~shall prohibit and/or eliminate the use of tetraBDE and pentaBDE unless they have notified the Secretariat of their intention to use either chemical for an acceptable purpose or in accordance with a specific exemption listed in part V of Annex A to the Convention. TetraBDE and pentaBDE are still being used in accordance with the specific exemption listed in part V of Annex A, which allows parties to use, recycle or dispose of articles that contain or may contain tetraBDE and pentaBDE. Information on specific exemptions can be found in the register of specific exemptions of the Stockholm Convention on the Convention website (www.pops.int).

~~15.~~19. Before C-pentaBDE was phased out in the United States in 2004, 97 per cent of global production of c-pentaBDE was used in that country, as well as Canada. Alcock et al. have estimated that up to 2000, 85,000 tonnes of pentaBDE overall were used in the United States and 15,000 tonnes were used in Europe (Alcock et al., 2003). PentaBDEs may have been used in Asia but no reliable data are available to confirm this.

~~16.~~20. In some regions, c-pentaBDE was used almost exclusively as a flame retardant in the manufacture of flexible polyurethane (PUR) foams, with between 90 and 95 per cent of c-pentaBDE used for that purpose. This foam may contain between 10 and 18~~%~~ per cent of the c-PentaBDE formulation (UNEP/POPS/POPRC.2/17/Add.1). Flexible PUR foams were used mainly in automotive and upholstery applications, electrical and electronic ~~appliances~~equipment, building materials, furniture, textiles and packaging.

~~(b)~~(c) C-decaBDE

21. Parties of the Stockholm Convention shall prohibit and/or eliminate the use of decaBDE, unless they have notified the Secretariat of their intention to use it in accordance with a specific exemption as specified in parts I and IX of Annex A to the Stockholm Convention. Information on specific exemptions can be found in the register of specific exemptions of the Stockholm Convention on the Convention website (www.pops.int).The C-decaBDE consumption peaked in the early 2000's and c-decaBDE is still used worldwide (UNEP/CHW.13/INF/14). C-decaBDE has a variety of applications including in plastics, textiles, adhesives, sealants, coatings and inks. C-decaBDE containing plastics are used in electrical and electronic equipment, wires and cables, pipes and carpets. In textiles, c-decaBDE is mainly used in upholstery, window blinds, curtains and mattresses for public and domestic buildings, and in the transportation sector. The amount of c-decaBDE used in plastics and textiles globally varies but up to about 90~~%~~ per cent of c-decaBDE ends up in plastics including plastics used in electrical and electronic equipment while the remainder is used in coated textiles, upholstered furniture and mattresses (UNEP/POPS/POPRC.11/10/Add.1). C-decaBDE has also been used in modelling clay, washing and cleaning products and cosmetics and personal care products.

~~2.~~4. Wastes

~~17.~~22. Wastes consisting of, containing or contaminated with POP-BDEs (hereinafter referred to as “POP-BDE wastes”) may be found in:

(a) Solid obsolete stockpiles of POP-BDEs and their related substances in original packages that are no longer usable;

(b) Solid wastes from producers and users of POP-BDEs;

(c) Wastewater from industrial and municipal processes and residues from wastewater cleaning such as activated carbon treatment;

(d) Products (e.g., electrical and electronic equipment, building materials, plastics, textiles, adhesives, sealants, coatings, inks, wires and cables, pipes, carpets, upholstery, window blinds, curtains, matresses and vehicles,

aircrafts, trains and ships[4] including products from recyclates made of plastics which contained POP-BDEs[5]) that have become waste;

(e) Municipal and industrial sludges~~; and~~, contaminated soil[6] and sediments;

(f) Waste incineration residues, bottom ash in particular[7] in case of POP-BDE waste incineration; and

(g) Landfill leachate.

~~18.~~23. 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 POP-BDEs from waste management activities. In that context, the following should be recognized:

(a) It is likely that POP-BDEs are released into the environment throughout their life cycles (production, product assembly, consumer use, and disposal, including shredding[8] and recycling);

(b) Waste management activities have been identified as one route through which POP-BDEs can enter the environment, mainly through industrial and municipal wastewater discharges to surface water and through leachate from landfills;

(c) Wastes may contain variable concentrations of POP-BDEs, depending on the quantities in which POP-BDEs were originally present in specific products and the quantities released during product use and end-of-life management.

~~19.~~24. Waste streams of importance in terms of potential volume or concentration are:

(a) PUR foams used e.g. for ~~the production of automotive~~applications in the transport sector and upholstery ~~applications~~, in the case of c-pentaBDE;

(b) ABS polymers used for casings of electrical and electronic equipment, in the case of c-octaBDE;

(c) Solid wastes (in particular plastics) from ~~the dismantling of~~ electrical and electronic ~~waste~~equipment, vehicles, aircrafts, trains and ~~the recycling of waste plastics;~~ships, construction and demolition, textiles and furniture[9].

(d) Sludge and wastewater from municipal treatment plants, contaminated soil; and

(e) Landfill leachate.

~~20.~~25. POP-BDE wastes can be generated in a diverse range of applications, at different stages of the POP-BDEs life cycles and through different environmental release media. Knowledge of release media guides the analysis and choice of methods that may be required to manage these wastes. Table 2 below provides an overview of relevant information on the life cycle of POP-BDE wastes.

[4] C-decaBDE is used in all types of vehicles in the transportation sector (cars, airplanes, trains and ships; see UNEP/POPS/POPRC.11/10/Add.1)

[5] e.g., toys, hairdressing accessories and aids, kitchen utensils etc. from black plastic in particular, and carpet paddings (see DiGangi et al., 2011; DiGangi and Strakova, 2016; DiGangi et al., 2017; Kuang et al. 2018)

[6] Soil may be of concern due to application of contaminated sludge and around e-waste sites and recycling plants (see UNEP/POPS/POPRC.11/10/Add.1, paras 43, 109 and 110)

[7] See Borgnes and Rikheim 2005, Wang, Chen et al. 2010

[8] Mechanical treatment such as shredding seems to be a relevant source of PBDE releases to the environment; see (FI MoE, 2016) and (UBA, 2017)

[9] See UNEP/CHW.13/INF/14; chapter 3.3

Table 2: Overview of the production and application of POP-BDEs and their release media into the environment (sources: UNEP/POPS/POPRC.11/10/Add.1, UNEP/CHW.13/INF/14, decision SC-8-10)

Group	Source materials /Substances Used	Applications	End Product	Release Media
POP-BDEs CHEMICAL PRODUCTION				
Chemical Production	Diphenyl oxide, bromine	Chemical synt	POP-BDEs chemical	• Solid waste • Water • Sludge • Air
PRODUCTION OF ARTICLES CONTAINING POP-BDEs				
Plastic	Raw materials (ethylene, propylene, vinyl acetate, acrylonitrile, butadiene, styrene, isocyanate, polyhydric alcohols, polystyrene, prolene, butanediol, terephthalate, ethylene glycol, terephthalic acid, hexamethylenediamine, adipic acid, etc.) ~~adipic acid, etc.)~~ POP-BDEs and other additives	Expansion and molding	Flame-~~retardant plastic~~retard~~ed~~ant polymers: ~~• ABS~~ ~~• PUR~~ • Polyolefins (PE, PP, EVA) • Styrenics (PS, HIPS-, ABS) ~~• PP~~ ~~• PBT~~ • ~~PA~~Engineering Thermoplastics (PET, PBT, PA, PC, PC-ABS, PEE-HIPS) • Thermosets (UPE, epoxies, melamine-based resins) • Elastomers (EPDM rubber, thermoplastic PUR, EVA) • Waterborne emulsions and coatings (acrylic-, PVC-, ethylene vinyl chloride- and urethane-emulsion)	• Solid waste • Landfill leachate • Liquid industrial and household cleaning waste • Wastewater • Sludge • Air
Building materials	PUR foam POP-BDEs and other additives Plastics made from flame retard~~ed~~ant polymers	Expansion and molding	Board fireproofing: • Cold bridge insulation • Floors • Basement walls and foundations • Inverted roofs • Ceilings • Cavity insulation • Composite panels and laminates • Roofing materials such as membranes and films • Epoxy adhesive • Electrical insulation • Commercial grade carpeting	• Solid waste • Landfill leachate • Liquid industrial and household cleaning waste • Wastewater • Sludge • Air
Textile production	Flame-retard~~ed~~ant textile (back-coating or fabrics)		Residential and commercial upholstered furniture Transportation seating Wall coverings and draperies Protective clothing and other technical textiles Tents etc.	• Solid waste • Landfill leachate • Liquid industrial and household cleaning waste • Wastewater • Sludge • Air

Electric and electronic equipment	~~HIPS pellets~~ Plastics made from flame ~~retarded~~retardant polymers	Production of ~~casings~~components for electronic and electric equipment	Electric and electronic appliances	• Solid waste • Landfill leachate • Liquid industrial and household cleaning waste • Wastewater • Sludge • Air
Transport	Plastics Flame ~~retarded~~retardant fabric (made from flame ~~retarded~~retardant polymers)	Manufacturing of vehicles including cars, aircrafts, trains and ships	Products used in manufacturing cars, airplanes, trains and ships; examples in relation to cars include: • Powertrain and under-hood applications such as battery mass wires, battery interconnection wires, mobile air-conditioning (MAC) pipes, powertrains, exhaust manifold bushings, under-hood insulation, wiring and harness under hood (engine wiring, etc.), speed sensors, hoses, fan modules and knock sensors; • Fuel system applications such as fuel hoses, fuel tanks and fuel tanks under body; • Pyrotechnical devices and applications affected by pyrotechnical devices such as air bag ignition cables, seat covers/fabrics (only if airbag relevant) and airbags (front and side); • Suspension and interior applications such as trim components, acoustic material and seat belts; • Reinforced plastics (instrument panels and interior trim); • Under the hood or dash (terminal/fuse blocks, higher-amperage wires and cable jacketing (spark plug wires)); • Electric and electronic equipment (battery cases and battery trays, engine control electrical connectors, components of radio disks, navigation satellite systems, global positioning systems and computer systems); • Fabric such as rear decks, upholstery, headliners, automobile seats, head rests, sun visors, trim panels, carpets.	• Solid waste • Landfill leachate • Liquid industrial and household cleaning waste • Wastewater • Sludge • Air
WASTE RECYCLING AND DISPOSAL				
Electrical and ~~electronic waste~~electronic waste dismantling	Electrical and electronic waste (Electrical and electronic plastic shells, circuit boards, wire and polyurethane foams, etc.)	Dismantling Shredding Separation	Metals ~~Plastic~~Plastics Shredder residues	• Solid waste • Landfill leachate • Liquid industrial and household cleaning waste • Wastewater • Sludge • Air

ELVs (cars, aircrafts, trains and ships)	End of Life Vehicles~~LVs~~ (ELVs) (Electrical and electronic components, fuels system applications, pyrotechnical devices and applications, suspension and interior applications, reinforced plastics and fabrics e.g. as further specified in Annex A part IX. Paragraph 2 to the Stockholm Convention)	Dismantling Shredding Separation	Metals Plastics Textiles Shredder residues	• Solid waste • Landfill leachate • Liquid industrial and household cleaning waste • Wastewater • Sludge • Air
Construction and demolition waste	Construction and demolition waste (e.g. cold bridge insulation, floors, basement walls and foundations, inverted roofs, ceilings, cavity insulation, composite panels and laminates, roofing materials such as membranes and films, epoxy adhesives, electrical insulation, commercial grade carpeting)	Shredding Separation	Metals Plastics Textiles Shredder residues	• Solid waste • Landfill leachate • Liquid industrial and household cleaning waste • Wastewater • Sludge • Air
Textile and furniture waste	Textile and furniture waste (e.g. residential and commercial upholstered furniture, wall coverings and draperies, protective clothing and other technical textiles, tents etc.)	Dismantling Shredding Separation	Plastics Foams Textiles Shredder residues	• Solid waste • Landfill leachate • Liquid industrial and household cleaning waste • Wastewater • Sludge • Air
Waste plastic recycling	Waste plastic ~~(Waste ABS, HIPS, PP, polyesters,~~ Polyolefins (PE, PP, EVA), Styrenics (PS, HIPS, ABS), Engineering Thermoplastics (PET, PBT, PA, PC, PC-ABS, PEE-HIPS), Thermosets (UPE, epoxies, melamine-based resins), Elastomers (EPDM rubber, thermoplastic PUR, EVA), Waterborne emulsions and coatings (acrylic-, PVC-, ethylene vinyl chloride- and urethane-emulsion)~~polyamide, PBT, thermoplastic elastomer, polyolefins and other plastics)~~	Recycling	Plastic	• Solid waste • Landfill leachate • Liquid industrial and household cleaning waste • Wastewater • Sludge • Air

II. Relevant provisions of the Basel and Stockholm conventions

A. Basel Convention

~~21.~~26. 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").

~~22.~~27. Annexes I and II to the Basel Convention list some of the wastes that may consist of, contain or be contaminated with POP-BDEs. These include:

(a) Y9: Waste oils/water, hydrocarbons/water mixtures, emulsions;

(b) Y12: Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish;

(c) Y13 Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives;

~~(a)~~(d) Y18: Residues arising from industrial waste disposal operations;

~~(b)~~(e) Y40: Ethers;

~~(c)~~(f) Y45: Organohalogen compounds other than substances referred to in this Annex (e.g., Y39, Y41, Y42, Y43, Y44);

~~(d)~~(g) Y46: Wastes collected from households.

~~23.~~28. 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~~ documents for Annex III hazardous characteristics H11, H12 and H13 were adopted on an interim basis by the Conference of the Parties at its sixth and seventh meetings.

~~24.~~29. 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~~]~~hazardous 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 POP-BDEs, including:

(a) A1180: Waste electrical and electronic assemblies or scrap containing components such as accumulators and other batteries included on list A, mercury-switches, glass from cathode- ray tubes and other activated glass and PCB-capacitors, or contaminated with Annex I constituents (e.g., cadmium, mercury, lead, polychlorinated biphenyl) to an extent that they possess any of the characteristics contained in Annex III (note the related entry on list B B1110);

(b) A1190: Waste metal cables coated or insulated with plastics containing or contaminated with coal tar, PCB11, lead, cadmium, other organohalogen compounds or other Annex I constituents to an extent that they exhibit Annex III characteristics;

(c) A3050: Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives excluding such wastes specified on list B (note the related entry on list B B4020)

~~(a)~~(d) A3080: Waste ethers not including those specified on list B;

~~(b)~~(e) A4070: Wastes from the production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish excluding any such waste specified on list B (note the related entry on list B B4010)

~~(c)~~(f) A4130: Waste packages and containers containing Annex I substances in concentrations sufficient to exhibit Annex III hazard characteristics;

~~(d)~~(g) A4140: Waste consisting of or containing off specification or outdated chemicals corresponding to Annex I categories and exhibiting Annex III hazard characteristics;

~~(e)~~(h) A4160: Spent activated carbon not included on list B (note the related entry on

list B B2060).

~~25.~~30. List B of Annex IX includes wastes that "will not be wastes covered in 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 includes a number of wastes or waste categories which have the potential to contain or be contaminated with POP-BDEs, including:

(a) B1110: Electrical and electronic assemblies:

• Electronic assemblies consisting only of metals or alloys

• Waste electrical and electronic assemblies or scrap[10] (including printed circuit boards) not containing components such as accumulators and other batteries included on list A, mercury-switches, glass from cathode-ray tubes and other activated glass and PCB-capacitors, or not contaminated with Annex I constituents (e.g., cadmium, mercury, lead, polychlorinated biphenyl) or from which these have been removed, to an extent that they do not possess any of the characteristics contained in Annex III (note the related entry on list A A1180)

• Electrical and electronic assemblies (including printed circuit boards, electronic components and wires) destined for direct reuse and not for recycling or final disposal)

(b) B1115: Waste metal cables coated or insulated with plastics, not included in list A1190, excluding those destined for Annex IVA operations or any other disposal operations involving, at any stage, uncontrolled thermal processes, such as open burning;

~~(b)~~(c) B1250: Waste end-of-life motor vehicles, containing neither liquids nor other hazardous components;

~~(c)~~(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 processes of the food industry and vitamin production (note to the related entry on list A A4160);

~~(d)~~(e) B3010: Solid plastic waste;[11]

~~(e)~~(f) B3030: Textile wastes;[12]

~~(f)~~(g) B3035: Waste textile floor coverings, carpets;

~~(g)~~(h) B3040: Rubber wastes

The following materials, provided they are not mixed with other wastes:

• Waste and scrap of hard rubber (e.g., ebonite)
• Other rubber wastes (excluding such wastes specified elsewhere);

~~(h)~~(i) B3080: Waste parings and scrap of rubber~~.~~;

(j) B4010: Wastes consisting mainly of water-based/latex paints, inks and hardened varnishes not containing organic solvents, heavy metals or biocides to an extent to render them hazardous (note the related entry on list A A4070)

(k) B4020: Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives, not listed on list A, free of solvents and other contaminants to an extent that they do not exhibit Annex III characteristics, e.g., water-based, or glues based on casein starch, dextrin, cellulose ethers, polyvinyl alcohols (note the related entry on list A A3050).

~~26.~~31. For further information, see section II.A of the general technical guidelines.

[10] This entry does not include scrap from electrical power generation.

[11] Refer to Annex IX to the Basel Convention for a full description of this entry.

[12] Ibid 12.

B. Stockholm Convention

~~27.~~32. The present document covers intentionally produced POP-BDEs, whose production and use are to be eliminated in accordance with Article 3 and part I of Annex A to the Stockholm Convention.

~~28.~~33. Annex A, part III ("Definitions"), to the Stockholm Convention defines ~~POP-BDEs~~hexaBDE and heptaBDE as well as tetraBDE and pentaBDE as follows:

> (a)"Hexabromodiphenyl ether and heptabromodiphenyl ether" means2,2',4,4',5,5'-hexabromodiphenyl ether (BDE-153, CAS No: 68631-49-2), 2,2',4,4',5,6'-hexabromodiphenyl ether (BDE-154, CAS No: 207122-15-4), 2,2',3,3',4,5',6 heptabromodiphenyl ether (BDE-175, CAS No:446255-22-7), 2,2',3,4,4',5',6-heptabromodiphenyl ether (BDE-183, CAS No: 207122-16-5) and other hexa- and heptabromodiphenyl ethers present in commercial octabromodiphenyl ether.
>
> (b)"Tetrabromodiphenyl ether and pentabromodiphenyl ether" means 2,2',4,4'-tetrabromodiphenyl ether (BDE-47, CAS No: 5436-43-1) and 2,2',4,4',5-pentabromodiphenyl ether (BDE-99, CAS No: 60348-60-9) and other tetra- and pentabromodiphenyl ethers present in commercial pentabromodiphenyl ether."

~~29.~~34. Annex A, part IV ("Hexabromodiphenyl ether and heptabromodiphenyl ether"), to the Convention outlines specific requirements for hexaBDE and heptaBDE, as follows:

> "1. A Party may allow recycling of articles that contain or may contain hexabromodiphenyl ether and heptabromodiphenyl ether, and the use and final disposal of articles manufactured from recycled materials that contain or may contain hexabromodiphenyl ether and heptabromodiphenyl ether, provided that
>
> (a) The recycling and final disposal is carried out in an environmentally sound manner and does not lead to recovery of hexabromodiphenyl ether and heptabromodiphenyl ether for the purpose of their reuse;
>
> (b) The Party takes steps to prevent exports of such articles that contain levels/concentrations of hexabromodiphenyl ether and heptabromodiphenyl ether exceeding those permitted for the sale, use, import or manufacture of those articles within the territory of the Party; and
>
> (c) The Party has notified the Secretariat of its intention to make use of this exemption.
>
> 2. At its sixth ordinary meeting and at every second ordinary meeting thereafter the Conference of the Parties shall evaluate the progress that Parties have made towards achieving their ultimate objective of elimination of hexabromodiphenyl ether and heptabromodiphenyl ether contained in articles and review the continued need for this specific exemption. This specific exemption shall in any case expire at the latest in 2030."

~~30.~~35. Annex A, part V ("Tetrabromodiphenyl ether and pentabromodiphenyl ether"), to the Convention outlines specific requirements for tetraBDE and pentaBDE, as follows:

> "1. A Party may allow recycling of articles that contain or may contain tetrabromodiphenyl ether and pentabromodiphenyl ether, and the use and final disposal of articles manufactured from recycled materials that contain or may contain tetrabromodiphenyl ether and pentabromodiphenyl ether, provided that:
>
> (a) The recycling and final disposal is carried out in an environmentally sound manner and does not lead to recovery of tetrabromodiphenyl ether and pentabromodiphenyl ether for the purpose of their reuse;
>
> (b) The Party does not allow this exemption to lead to the export of articles containing levels/concentrations of tetrabromodiphenyl ether and pentabromodiphenyl ether that exceed those permitted to be sold within the territory of the Party; and
>
> (c) The Party has notified the Secretariat of its intention to make use of this exemption.

2. At its sixth ordinary meeting and at every second ordinary meeting thereafter the Conference of the Parties shall evaluate the progress that Parties have made towards achieving their ultimate objective of elimination of tetrabromodiphenyl ether and pentabromodiphenyl ether contained in articles and review the continued need for this specific exemption. This specific exemption shall in any case expire at the latest in 2030."

36. Annex A defines decaBDE as follows: "Decabromodiphenyl (BDE-209) present in commercial decabromodiphenyl ether".

37. Annex A, part I establishes the specific exemptions for the production and use of decaBDE as follows:

"Production: As allowed for the parties listed in the Register"

"Use: In accordance with Part IX of this Annex:

- Parts for use in vehicles specified in paragraph 2 of Part IX of this Annex
- Aircraft for which type approval has been applied for before December 2018 and has been received before December 2022 and spare parts for those aircraft
- Textile products that require anti-flammable characteristics, excluding clothing and toys
- Additives in plastic housings and parts used for heating home appliances, irons, fans, immersion heaters that contain or are in direct contact with electrical parts or are required to comply with fire retardancy standards, at concentrations lower than 10 per cent by weight of the part
- Polyurethane foam for building insulation"

38. Annex A, part IX outlines specific requirements for decaBDE as follows:

"1. The production and use of decabromodiphenyl ether shall be eliminated except for Parties that have notified the Secretariat of their intention to produce and/or use it in accordance with Article 4.

2. Specific exemptions for parts for use in vehicles may be available for the production and use of commercial decabromodiphenyl ether limited to the following:

(a) Parts for use in legacy vehicles, defined as vehicles that have ceased mass production, and with such parts falling into one or more of the following categories:

(i) Powertrain and under-hood applications such as battery mass wires, battery interconnection wires, mobile air-conditioning (MAC) pipes, powertrains, exhaust manifold bushings, under-hood insulation, wiring and harness under hood (engine wiring, etc.), speed sensors, hoses, fan modules and knock sensors;

(ii) Fuel system applications such as fuel hoses, fuel tanks and fuel tanks under body;

(iii) Pyrotechnical devices and applications affected by pyrotechnical devices such as air bag ignition cables, seat covers/fabrics (only if airbag relevant) and airbags (front and side);

(iv) Suspension and interior applications such as trim components, acoustic material and seat belts;

(b) Parts in vehicles specified in paragraphs 2 (a) (i)–(iv) above and those falling into one or more of the following categories:

(i) Reinforced plastics (instrument panels and interior trim);

(ii) Under the hood or dash (terminal/fuse blocks, higher-amperage wires and cable jacketing (spark plug wires));

(iii) Electric and electronic equipment (battery cases and battery trays, engine control electrical connectors, components of radio disks, navigation satellite systems, global positioning systems

and computer systems);

(iv) Fabric such as rear decks, upholstery, headliners, automobile seats, head rests, sun visors, trim panels, carpets.

3. The specific exemptions for parts specified in paragraph 2 (a) above shall expire at the end of the service life of legacy vehicles or in 2036, whichever comes earlier.

4. The specific exemptions for parts specified in paragraph 2 (b) above shall expire at the end of the service life of vehicles or in 2036, whichever comes earlier.

5. The specific exemptions for spare parts for aircraft for which type approval has been applied for before December 2018 and has been received before December 2022 shall expire at the end of the service life of those aircraft."

~~31.~~39. Information on the register of specific exemptions for POP-BDEs is available from: ~~.~~www.pops.int.

~~32.~~40. 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

41. The provisional definition of low POP content for hexaBDE, heptaBDE, pentaBDE ~~and,~~ tetraBDE is […] 50 mg/kg or 1000 mg/kg as a sum.[13] [The provisional definition of low POP content for decaBDE is […]] mg/kg.

~~33.~~42. The low POP content described in the Stockholm Convention is independent from the provisions on hazardous waste under the Basel Convention.

~~34.~~43. Wastes with a content of POP-BDEs above ~~50 mg/kg or 1000 mg/kg~~the values specified in paragraph ~~36~~41 must be disposed of in such a way that the POP content is destroyed or irreversibly transformed in accordance with the methods described in section IV.G.2 below. They should otherwise be 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 section IV.G.3.

~~35.~~44. Wastes with a content of POP-BDEs at or below ~~50 mg/kg or 1000 mg/kg~~the values specified in paragraph ~~36~~41 should be disposed of in accordance with the methods referred to in section IV.G.4 of the general technical guidelines (outlining disposal methods when POP content is low), taking into account section IV.I.1 below (pertinent to higher-risk situations).

~~36.~~45. For further information on low POP content, refer to section III.A of the general technical guidelines.

B. Levels of destruction and irreversible transformation

~~37.~~46. For the provisional definition of levels of destruction and irreversible transformation, see section III.B of the general technical guidelines.

C. Methods that constitute environmentally sound disposal

~~38.~~47. See section IV.G below and section IV.G of the general technical guidelines.

[13] Determined in accordance with national or international methods and standards. In addition, a limit value has been set for the sum of tetra-, penta-, hexa-, and hepta-BDE because the commercial mixtures of those substances have varying congener composition (see subsection I.B.1 above) and to achieve analytical efficiencies. Further work to agree on a single value will be undertaken in accordance with decision BC-12/3 by the Conference of the Parties to the Basel Convention.

IV. Guidance on environmentally sound management (ESM)

A. General considerations

~~39.~~48. For information, see section IV.A of the general technical guidelines.

B. Legislative and regulatory framework

~~40.~~49. Parties to the Basel and Stockholm conventions should examine their national strategies, policies, controls, standards and procedures to ensure that they are in agreement with of the two conventions and with their obligations under them, including those that pertain to ESM of POP-BDE wastes.

~~41.~~50. Elements of a regulatory framework applicable to POP-BDEs should, among others, 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 and/ or legal and administrative measures to eliminate ~~on~~ the production, sale, use, import and export of POP-BDEs in accordance with Articles 3 and Annex A of the Stockholm Convention, except in the case of parties that have notified the Secretariat of their intention to use or produce decaBDE in accordance with the time-limited specific exemptions listed in Annex A to the Stockholm Convention;

(c) ~~Recycling of articles containing POP-BDEs,~~ in accordance with Articles 3 and Annex A of the Stockholm Convention, except in the case of parties that have notified the Secretariat of their intention to use or produce decaBDE in accordance with the time-limited specific exemptions listed in Annex A to the Stockholm Convention;

(d) A requirement that best available technologies (BAT) and best environmental practices (BEP) be employed in the production and use of decaBDE, in cases where parties have notified the Secretariat of their intention to use or produce decaBDE in accordance with the time-limited exemptions listed in Annex A to the Stockholm Convention;

(e) Measures to ensure that POP-BDE waste cannot be disposed of in ways that may lead to recovery, recycling, reclamation, direct reuse or alternative uses of POP-BDEs ;.

~~(b)~~(f) Measures related to the recycling of articles that contain or may contain hexabromodiphenyl ether and heptabromodiphenyl ether, or tetrabromodiphenyl ether and pentabromodiphenyl ether (see Annex A, parts IV and V of the Stockholm Convention) in case Parties registered for a specific exemption ~~under the Stockholm Convention,~~ , set to expire at the latest in 2030;

~~(c)~~(g) Transportation requirements for hazardous materials and waste;

~~(d)~~(h) Specifications for containers, equipment, bulk containers and storage sites;

~~(e)~~(i) Specification of acceptable analytical and sampling methods for POP-BDEs;

~~(f)~~(j) Requirements for waste management and disposal facilities;

~~(g)~~(k) Definitions of hazardous waste and conditions and criteria for the identification and classification of POP-BDE wastes as hazardous wastes;

~~(h)~~(l) A general requirement for public notification and review of proposed waste-related government regulations, policies, certificates of approval, licences, inventory information and national releases and emissions data;

~~(i)~~(m) Requirements for identification, assessment and remediation of contaminated sites;

~~(j)~~(n) Requirements concerning the health and safety of workers; and

~~(k)~~(o) Legislative measures on, e.g., waste prevention and minimization, inventory development and emergency response.

~~42.~~51. Legislation should include a time limit for disposal of POP-~~BDEs including in products and articles, that have no clear phase-out dates~~BDE wastes so as to prevent the creation of

stockpiles ~~of such substances, products and articles~~that have no clear phase-out dates.

~~43.~~52. For further information, see section IV.B of the general technical guidelines.

C. Waste prevention and minimization

~~44.~~53. Both the Basel and Stockholm conventions advocate waste prevention and minimization. Under the Stockholm Convention, the production and use of ~~PDBEs~~POP-BDEs is to be eliminated, with limited exemptions for their use as provided in ~~part I of~~ Annex A to the Convention.

~~45.~~54. Quantities of waste containing POP-BDEs should be minimized through isolation and source separation to prevent mixing and contamination of other waste streams.

~~46.~~55. The mixing and blending of wastes with POP-BDEs content above ~~50 mg/kg or 1000 mg/kg~~the values specified in paragraph ~~36~~ 41- with other materials solely for the purpose of generating a mixture with a POP-BDEs content at or below ~~50 mg/kg or 1000 mg/kg~~the values specified in paragraph ~~36~~41 are 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.

~~47.~~56. For further information on waste prevention and minimization, see section IV.C of the general technical guidelines.

D. Identification of wastes

~~48.~~57. 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 POP-BDE wastes is the starting point for their effective ESM.

~~49.~~58. For general information on identification and inventories, see section IV.D of the general technical guidelines.

59. Detailed guidance and information on establishing inventories for PBDEs is provided in the "Guidance for the inventory of polybrominated diphenyl ethers (PBDEs) listed under the Stockholm Convention on Persistent Organic Pollutants" (UNEP 2017b). The objective of this document is to provide step-by-step guidance that enables Parties to establish inventories of hexabromodiphenyl ether and heptabromodiphenyl ether, tetrabromodiphenyl ether and pentabromodiphenyl ether listed under the Convention in 2009, and provides updated information on known uses, information that could be useful to identify POP-BDE containing waste.

1. Identification

~~50.~~60. POP-BDE wastes can be found in the following stages of the POP-BDEs lifecycles:

(a) ~~-~~BDE manufacturing and processing:

(i) Waste generated from the production and processing of BDEs;

(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 BDEs (PUR foams, plastics of electrical and electronic equipment, of building materials, vehicles, aircrafts, trains and ships, textiles, adhesives, sealants, coatings, inks, wires and cables, pipes, carpets, upholstery, window blinds, curtains, matresses):

(i) Residues generated from the application of BDEs;

(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 application was disposed of;

(v) Stockpiles of unusable or unsellable products;

(c) Use of products or articles containing BDEs:

(i) In water, soil or sediment close to sites where such products were used;

(d) Disposal of products or articles containing BDEs:

(i) In certain facilities for the collection, recycling and recovery of textiles, PUR foams and plastics of electronic and electrical equipment, building materials and vehicles;

(ii) In municipal landfill leachate;

(iii) In municipal wastewater and sludge.

~~51.~~61. 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 POP-BDEs.

2. Inventories

~~52.~~62. A national inventory should, as appropriate, include data on:

(a) Production of POP-BDEs within a country;

(b) Import and export of products and articles consisting of or containing POP-BDEs;

(c) Disposal of POP-BDE waste; and

(d) Import and export of POP-BDE waste.

~~53.~~63. Inventories are an important tool for identifying, quantifying and characterizing wastes. A step-by-step approach for the development of national inventories of POP-BDEs generally includes the following steps:

(a) Step 1: planning (i.e., identifying relevant sectors that use or produce POP-BDEs);

(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 POP-BDEs;

(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 inventory report.

~~54.~~64. For further information, please refer to the Revised guidance for the inventory of polybrominated diphenyl ethers (PBDEs) listed under the Stockholm Convention on Persistent Organic Pollutants (UNEP, ~~2015c~~2017b).

E. Sampling, analysis and monitoring

~~55.~~65. For general information on sampling, analysis and monitoring, see section IV.E of the general technical guidelines.

1. Sampling

~~56.~~66. Sampling serves as an important element for identifying and monitoring environmental concerns and human health risks.

~~57.~~67. 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.

68. For WEEE a sampling method is described in the Technical Specification TS 50625-3-1:

Collection, logistics & treatment requirements for WEEE - Part 3-1: Specification for de-pollution – General (UNEP 2017d).For EEE and WEEE plastic - the major POP-PBDEs contaminated products and material - a detailed sampling methodology and a sampling protocol has been developed and is described in Wäger et al, 2010. This sampling strategy and protocol can be applied (in a modified way) in other countries and regions having shredder plants with related WEEE plastic shredder fractions. An approach of sampling of single EEE for screening of POP-PBDEs in e.g. Cathode Ray Tube casings of TV and PC is shortly described in Annex 3-B of UNEP 2017d. Strategies of sampling along with the mechanical preparation of samples from electrotechnical products, electronic assemblies and electronic components is provided in IEC 62321-2:2013.

~~58.~~69. Types of matrices that are typically sampled for POP-BDEs include:

(a) Liquids:

(i) Leachate from dumpsites and landfills;

(ii) Water (surface water, drinking water and industrial effluents);

(iii) Waterborne emulsions~~(i) Stockpiles of products and formulations consisting of,~~ containing or contaminated with POP-BDEs;

(iv) ~~(ii)~~ Rinse solution;

(b) Solids:

(i) ABS, HIPS and other types of flame-~~retarded~~retardant polymers (wastes from production processes);

(ii) ABS, HIPS and other types of plastics of WEEE;

(iii) PUR foam, textile, rubber (from end-of-life vehicles);

(iv) Shredding materials and residues;

~~(i)~~(v) Solids from treatment or disposal processes (fly ash, bottom ash, sludge, still bottoms, other residues, clothing, etc.);

~~(iii) Equipment, containers and other packaging materials (rinse or wipe samples), and tissues or fabrics used in the collection of wipe samples;~~

~~(ii)~~(vi) ~~(iv)~~ Soil, sediment, rubble, sewage sludge and compost;

(c) Gases:

(i) Air (indoor and outdoor);

(ii) Exhaust gas.

2. Analysis

~~59.~~70. Analysis refers to the extraction, purification, separation, identification, quantification and reporting of POP-BDE concentrations in the matrix of interest. In order to obtain meaningful and acceptable results, analytical laboratories should have the necessary infrastructure (housing) and proven experience.

~~60.~~71. 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.

72. Chemical analysis of PBDEs is usually using gas chromatography coupled to mass spectrometry in different variations in order to optimise the analysis according to the specific matrix (UNEP/CHW.13/INF/14). In the toxicological profile for PBDEs, the Agency for Toxic Substances and Disease Registry (ATSDR) provides a summary of identified and well-established methods that are used as standard methods for analysing PBDEs. Additionally, analytical methods are included that modify previously used methods to obtain lower detection limits and/or to improve accuracy and precision (see ATSDR 2017). Further information on analytical methods for POP-BDEs is provided in the UNEP Draft Guidance on Sampling, Screening and Analysis of Persistent Organic Pollutants in Products and Articles (see UNEP 2017d).

61.73. Standardised mMethods of analysing the various matrices for POP-BDEs have been developed by the International Organization for Standardization (ISO) and by national authorities such as the Environmental Protection Agency. X-ray fluorescence (XRF) and sliding spark analysis can be used as inexpensive and rapid screening methods to determine whether a material contains bromine. However, these methods will not serve to distinguish the types of chemicals that contain bromine. Table 3 presents some methods that can be used for analysing POP-BDEs in products, wastes, sediments, flue gas and wastewater.

Table 3: Analytical methods of PBDEs

Standard No.	Analytical method
DIN EN 16694: 2015-12	Water quality – Determination of selected polybrominated diphenyl ether (PBDE) in whole water samples – Method using solid phase extraction (SPE) with SPE-disks combined with gas chromatography-mass spectrometry (GC-MS)
EPA Method 1614 A	Brominated Diphenyl Ethers in Water, Soil, Sediment, and Tissue by HRGC/HRMS
EPA Method 527	Determination of Selected Pesticides and Flame Retardants in Drinking Water by Solid Phase Extraction and Capillary Column Gas Chromatography/Mass Spectrometry (GC/MS)
EPA 8270D	Semi-volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)
IEC 62321-3-1:2013	Determination of certain substances in electrotechnical products - Part 3-1: Screening - Lead,
IEC 62321-3-2:2013	Determination of certain substances in electrotechnical products - 3-2: Screening - Total bromine in
IEC 62321-20086:2015	Electrotechnical products — Determination of levels of six regulatedcertain substances (lead, mercury, cadmium, hexavalent chromium, polybrominatedin electrotechnical products – Part 6: Polybrominated biphenyls, and polybrominated diphenyl ethers in polymers by gas chromatography – mass spectrometry (GC-MS)
ISO 22032: 20092013	Water quality – Determination of selected polybrominated diphenyl ethers in sediments and sewage sludge
China GB/Z 21277-2007	Rapid screening of lead, mercury, chromium, cadmium and bromine of regulated substances in electrical and electronic equipment - X-ray fluorescence spectrometry

3. Monitoring

62.74. 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.

63.75. Monitoring programmes should be implemented in facilities managing POP-BDE wastes.

76. Information on monitoring and analysis of POP-BDE in articles and products is described in the Stockholm Convention "Draft guidance on Sampling, Screening and Analysis of Persistent Organic Pollutants in Products and Articles". This document provides a step by step guidance on monitoring (sampling, screening and analysis) in articles, products and recycling streams (see UNEP 2017d).

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

64.77. POP-BDE wastes should be handled, collected, packaged, labelled, transported and stored so as to prevent spills and leaks leading to worker exposure, releases to the environment or exposure of the community. The guidance on waste handling and collection contained herein may not apply to POP-BDE wastes that are consumer or household wastes, such as WEEE, since it has not been documented that such wastes pose significant risks to the environment or human health during handling and collection.

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

1. Handling

65.79. POP-BDE wastes should be handled separately from other types of waste in order to

prevent contamination of other waste streams.

~~66.~~80. Organizations handling POP-BDE wastes should have in place procedures for handling such wastes and workers should be trained in such procedures.

2. Collection

~~67.~~81. Collection arrangements and collection depots for POP-BDE wastes should provide for the separation of POP-BDE wastes from other wastes. In Europe, Technical Specification (TS) 50625-3-1: Collection, logistics & treatment requirements for WEEE is ~~currently under development~~available at the National Committees of the European Committee f~~F~~or Electrotechnical Standardization (CENELEC)[14].

~~68.~~82. All POP-BDE wastes should be collected separately from those wastes that do not contain POP-BDEs. Legal or other mechanisms may be required to ensure the efficient collection of POP-BDE wastes, such as WEEE, from households. For example, governments, producers of articles containing POP-BDEs and others could provide arrangements for the collection of such wastes by local collectors.

~~69.~~83. Waste plastics containing POP-BDEs from electrical and electronic wastes recycling facilities should be collected separately during dismantling process.

3. Packaging

84. POP-~~BDEs~~BDE wastes should be properly packaged for ease of transport and before storage as a safety measure to reduce the risk of leaks and spills. For transporting POP-BDEs wastes from generators' premises or public collection points to waste treatment facilities, the wastes should be properly packaged.

(a) Packaging of solid POP-BDE wastes

~~70.~~85. The packaging of solid POP-BDE wastes can include corrugated cartons lined with protective anti-seepage plastic bags.

86. Special wooden pallets could be designed for use during storage to raise stored POP-BDE wastes above ground level and thereby protect them against moisture.

(b) Packaging of liquid POP-BDE wastes

~~71.~~87. PBDE-contaminated liquids can be packaged in special anti-seepage barrels.

(c) Packaging of POP-BDE contaminated soil

~~72.~~88. PBDE-contaminated soils can be packaged in triple layered, anti-leak, high-strength laminated bags.

4. Labelling

89. Every container carrying POP-BDE wastes should be clearly labelled with a hazard-warning label and a label giving details of the container and a unique serial number. Such details should include the contents of the container (e.g., exact counts of equipment, weight, type of waste carried), the name of the site from which the waste originated so as to allow its traceability and, if applicable, the date of repackaging and the name and telephone number of the person responsible for the repackaging operation. The label should be indelible, clear and plainly visible.

5. Transportation

~~73.~~90. Appropriate measures should be taken to prevent scattering or leakage of POP-BDE wastes. Such wastes should be handled separately during transport to avoid their mixing with other materials.

~~74.~~91. Transporters should employ trained and qualified drivers, loading and unloading management personnel and escort personnel, all of whom should carry their qualification

[14] The standard is available at https://www.cenelec.eu/dyn/www/f?p=WEB:5:1006113885681101. To purchase the standard please use the link to a website of a national CENELEC Member.

certificates.

~~75.~~92. Waste transporters should provide full and accurate information about their cargoes or shipments, safely transfer wastes to their destinations and hand them over to receivers in accordance with national regulations.

6. Storage

~~76.~~93. POP-BDE wastes should be stored in designated sites and appropriate measures should be taken at such sites to prevent scattering, leakage and underground seepage of POP-BDEs.

~~77.~~94. Appropriate measures, such as the installation of partitions, should be taken to avoid contamination of the POP-BDEs wastes.

~~78.~~95. POP-BDE waste storage areas should be controlled areas with defined boundaries. Warning signs should be posted around such areas and access should be restricted to authorized personnel.

~~79.~~96. POP-BDE waste storage areas should have adequate access roads for vehicles. Simple roads can be constructed when necessary.

~~80.~~97. Storage sites should have structures to prevent underground leakage of POP-BDEs. Containers should be sealable, easy to store and durable. Storage sites should be maintained and inspected to verify whether there have been any releases of POP-BDEs into the environment.

G. Environmentally sound disposal

1. Pre-treatment

~~81.~~98. Dismantling, disassembling and mechanical separation can be used to reduce the volume of POP-BDE wastes.

~~82.~~99. For information, see subsection IV.G.1 of the general technical guidelines.

2. Destruction and irreversible transformation methods

~~83.~~100.Destruction and irreversible transformation methods for the environmentally sound disposal of wastes with a ~~POPs~~POP-BDE content above ~~50 mg/kg or 1000 mg/kg~~the values specified in paragraph 36, according to the general technical guidelines, include ~~at least~~:

(a) Advanced solid waste incineration;

~~(a)~~(b) Cement kiln co-incineration;

~~(b)~~(c) Hazardous waste incineration; ~~and~~

~~(c)~~(d) Thermal and metallurgical production of metals~~.~~; and

(e) Gas-phase chemical reduction.

~~84.~~101.It should be noted that PBDDs/PBDFs can be generated from combustion and incineration of POP-BDE wastes.

~~85.~~102.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

~~86.~~103.For further information, see subsection IV.G.3 of the general technical guidelines.

4. Other disposal methods when the POP content is low

~~87.~~104.For information, see subsection IV.G.4 of the general technical guidelines.

H. Remediation of contaminated sites

105. Several remediation technologies are described in (Wu et al., 2012; Ye M. et al., 2015a; Ye M. et al., 2015b; Li J. et al., 2016).

~~88.~~106. For further information, see section IV.H of the general technical guidelines.

I. Health and safety

~~89.~~107. For information, see section IV.I of the general technical guidelines.

1. Higher-risk situations

~~90.~~108. For general information, see subsection IV.I.1 of the general technical guidelines.

~~91.~~109. Higher-risk situations occur at sites where high concentrations of POP-BDEs or high volumes of POP-BDE wastes are found and a high potential for exposure of workers or the general population exists. Potential higher-risk situations specific to POP-BDEs may occur at:

(a) Sites of former POP-BDEs production;

(b) Sites at which electrical and electronic wastes are dismantled;

(c) Sites at which waste plastic is shredded or recycled; and

(d) ~~Storage sites~~Sites for storage or disposal of POP-BDE wastes.

2. Lower-risk situations

~~92.~~110. For information on lower-risk situations, see subsection IV.I.2 of the general technical guidelines.

J. Emergency response

~~93.~~111. Emergency response plans should be in place for POP-BDEs in use, in storage, in transport or at disposal sites. Further information on emergency response plans is provided in section IV.J of the general technical guidelines.

K. Public participation

~~94.~~112. 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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