ENVIRONMENTAL ADMINISTRATION GUIDELINES 4en | 2016

ENVIRONMENTAL PROTECTION

Requirements for the management of waste containing persistent organic pollutants

Rules concerning waste in the POP Regulation and their application to waste electrical and electronic equipment and end-of-life vehicles

MINISTRY OF THE ENVIRONMENT

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FOREWORD

Persistent organic pollutants (POPs) are toxic chemical substances that degrade slowly, bioaccumulate in the food chain and travel far from the sources of the pollution. They can cause significant health and environmental hazards.

Persistent organic pollutants and the management of waste containing them is regulated by the EU Regulation (EC) No 850/2004. Since entering into force, the regulation has been amended several times; the latest amendment was made in 2016. As the legislation changes, products that previously had no obligations associated to the POP legislation must be removed from circulation and destroyed permanently in the waste management phase. For example, brominated flame retardants restricted by the POP Regulation can be found in vehicles, electrical and electronic equipment (EEE), textiles and construction products.

The EU directives on waste electrical and electronic equipment (WEEE) and end-of-life vehicles (ELV) impose an obligation to either prepare EEE and vehicles that have reached the end of their service life for reuse, or recycle them as far as possible. In order to ensure that the recycling does not cause health or environmental hazards, waste containing brominated flame retardants must be identified and separated from the rest of the waste stream before recycling. According to research, only a small part of the plastic parts of electrical and electronic equipment and end-of-life vehicles being recycled contain high levels of bromodiphenyl ethers (BDE) classified as POPs, but after shredding, the compounds can still be found at low levels in all of the plastic fractions separated from the examined EEE and the waste fractions of automotive shredder residue. Low concentrations of BDEs can also be found in products made out of recycled materials, such as insulation, wall-to-wall carpets, hard plastic and soft toys, and products that come into contact with food (Leslie, 2013, Bipro, 2015).

The purpose of this guide is to provide instructions on applying the POP Regulation to waste: when waste should be classified as POP waste, and what kinds of requirements the regulation sets on the treatment of POP waste. The guide also discusses potential treatment options for end-of-life vehicles and waste electrical and electronic equipment containing brominated flame retardants in more detail.

The guide is aimed at the environmental permit and supervisory authorities from municipalities and central government, businesses, whose activities may generate POP waste, waste management companies, and consultants planning the treatment of waste.

The guide has been prepared by the Finnish Environment Institute, commissioned by the Ministry of the Environment. Senior Adviser Eevaleena Häkkinen and Head of Unit Tuuli Myllymaa have been responsible for writing the guide under the guidance of the Ministry of the Environment. Reports on POPs and POP waste created previously by the Finnish Environment Institute have been used as background material for preparing the guide. A draft of the guide was sent out for public consultation in January 2016. The responses have been taken into account in preparing the final guide as far as possible.

23 September 2016
Ministry of the Environment

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DEFINITIONS AND ABBREVIATIONS

ABS	Acrylonitrile butadiene styrene
BAT	Best Available Technology
BDE	Bromodiphenyl ether
BFR	Brominated Flame Retardants
BREF	Best available techniques reference document
CENELEC	European Committee for Electrotechnical Standardization
CFC	Chlorofluorocarbons
DDT	Dichlorodiphenyltrichloroethane
Deca-BDE (commercial)	A commercial mixture containing decabromodiphenyl ether and small amounts of octa- and nonabromodiphenyl ether
EFTA	European Free Trade Association; its members include Norway, Iceland, Switzerland and Liechtenstein
EPS	Expanded polystyrene
HBB	Hexabromobiphenyl
PBDE	Polybrominated diphenyl ethers
PC	Polycarbonate
HBCDD	Hexabromocyclododecane
HCB	Hexachlorobenzene
HCBD	Hexachlorobutadiene
HCH	Hexachlorocyclohexane
HIPS	High-impact polystyrene
LCD	Liquid-crystal display
NIR	Near-infrared analysis
SSS	Sliding spark spectrometry
Octa-BDE (commercial)	A commercial mixture containing hexa-, hepta-, octa- and nonabromodiphenyl ethers
PBB	Polybrominated biphenyls
PBDD/F	Polybrominated dibenzodioxins and -furans
PBDE	Polybrominated diphenyl ethers
PCB	Polychlorinated biphenyls
PCDD/F	Polychlorinated dibenzodioxins and -furans
PCN	Polychlorinated naphthalenes
Penta-BDE (commercial)	A commercial mixture containing tetra-, penta- and hexabromodiphenyl ethers
PFOA	Perfluorooctanoic acid

PFOS	Perfluorooctanesulfonic acid
POP	Persistent Organic Pollutant
POP waste	Waste that contains, or a part of which contains, persistent organic pollutants at a content higher than the limit set in Annex IV of the POP Regulation
PS	Polystyrene
PTFE	Polytetrafluoroethylene
PUR	Polyurethane
SCCP	Short-chain chlorinated paraffins
EEE	Electrical and electronic equipment
WEEE	Waste electrical and electronic equipment
TBBPA	Tetrabromobisphenol A
WEEELABEX	Organisation of European producers of electrical and electronic equipment
XPS	Extruded polystyrene
XRF	X-ray fluorescence analysis
XRT	X-ray transmission
XRT	X-ray transmission

REFERENCES TO LEGISLATION

Basel Convention	Convention on the control of transboundary movements of hazardous wastes and their disposal
CLP Regulation	Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006 (Text with EEA relevance)
Directive 2002/45/EC	Directive 2002/45/EC of the European Parliament and of the Council of 25 June 2002 amending for the twentieth time Council Directive 76/769/EEC relating to restrictions on the marketing and use of certain dangerous substances and preparations (short-chain chlorinated paraffins)
Directive 2003/11/EC	Directive 2003/11/EC of the European Parliament and of the Council amending for the 24th time Council Directive 76/769/EEC relating to restrictions on the marketing and use of certain dangerous substances and preparations (pentabromodiphenyl ether, octabromodiphenyl ether)
The European List of Waste	Commission Decision amending Decision 2000/532/EC on the list of waste pursuant to Directive 2008/98/EC of the European Parliament and of the Council (2014/955/ EU)
Waste Act	646/2011
Waste Decree	Government Decree on Waste 179/2012
Waste Framework Directive	Directive 2008/98/EC of the European Parliament and of the Council on waste and repealing certain Directives
Annex III of the Waste Framework Directive	Commission Regulation (EU) No 1357/2014 replacing Annex III to Directive 2008/98/EC of the European Parliament and of the Council on waste and repealing certain Directives
Government Decree on Waste Incineration	Government Decree on Waste Incineration 151/2013
Waste Shipment Regulation	Regulation (EC) No 1013/2006 of the European Parliament and of the Council on shipments of waste
Government Decree on Landfills	Government Decree on Landfills 331/2013
Landfill Directive	Council Directive 1999/31/EC on the landfill of waste
PCB Directive	Council Directive 96/59/EC on the disposal of polychlorinated biphenyls and polychlorinated terphenyls (PCB/PCT)
POP Regulation	Regulation (EC) No 850/2004 of the European Parliament and of the Council of 29 April 2004 on persistent organic pollutants and amending Directive 79/117/EEC
REACH Regulation	Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC
RoHS Decree (old)	Government Decree on Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment 853/2004

RoHS Decree (new)	Decree of the Ministry of the Environment on Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment 419/2013
RoHS Directive	Directive 2011/65/EU of the European Parliament and of the Council on the restriction of the use of certain hazardous substances in electrical and electronic equipment
RoHS Act	Act on Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment 387/2013
Government Decree on End-of-Life Vehicles	Government Decree on End-of-Life Vehicles and Restriction of the Use of Certain Hazardous Substances in Vehicles 123/2015
ELV Directive	Directive 2000/53/EC of the European Parliament and of the Council on end-of life vehicles
Government Decree on Waste Electrical and Electronic Equipment	Government Decree on Waste Electrical and Electronic Equipment 519/2014
WEEE Directive	Directive 2012/19/EU of the European Parliament and of the Council on waste electrical and electronic equipment (WEEE)
Industrial Emissions Directive	Directive 2010/75/EU of the European Parliament and of the Council of on industrial emissions
Stockholm Convention	A convention on persistent organic pollutants
Government Decision 1071/1989	Government Decision on Restricting the Use of PCBs and PCTs 1071/1989
Government Decision on the Disposal of PCB	Government Decision on the Withdrawal from Use of PCBs and Equipment Containing PCBs and the Disposal of PCB Waste 711/1998
Environmental Protection Act	527/2014
Environmental Protection Decree	Government Decree on Environmental Protection 713/2014

1 Introduction

Persistent organic pollutants (POPs) are toxic chemical substances that degrade slowly, bioaccumulate in the food chain and travel far from the sources of the pollution via air, water or migrating animal species. Such chemicals may cause significant health and environmental hazards far away from the source of the pollution. For this reason, their use has been restricted by international conventions, such as the Stockholm Convention under the UN.

In the European Community, the restrictions of the Stockholm Convention have been implemented with Regulation (EC) No 850/2004 of the European Parliament and of the Council on persistent organic pollutants (the EU POP Regulation). The publication information of the POP Regulation and its amendments with their schedules can be found in Appendix 1. The POP Regulation is directly applicable legislation in all of the EU Member States.

At the moment, the EU POP Regulation includes 25 persistent organic compounds or groups of compounds (Table 1). The regulation stipulates obligations on the management of waste containing these compounds, depending on the concentration of POPs in the waste. The latest additions to the regulation are important to waste management, because these compounds can also be found in ordinary consumer goods that end up being processed in the management of municipal waste. Previously, the regulation applied mainly to the waste management of various kinds of industrial chemicals and pesticides.

Table 1. Persistent organic pollutants within the scope of application of the EU POP Regulation, and the date of application of the regulation's stipulations on waste for each compound

Compound	The time from which the application of the POP Regulation's stipulations on waste has started for the compound	The time starting from which the compound's concentration limits in waste entered into force (Annexes IV and V of the regulation)
Aldrin	20 May 2004 (Regulation (EC) No 850/2004 of the European Parliament and of the Council)	26 August 2010 (Commission Regulation 756/2010)
DDT		
Dieldrin		
Endrin		
Hexabromobiphenyl (HBB)		
Hexachlorobenzene (HCB)		
Hexachlorocyclohexanes (incl. lindane) (HCH)		
Heptachlor		
Chlordane		
Chlordecone		
Mirex		
Pentachlorobenzene		
Polychlorinated biphenyls (PCB)		
Polychlorinated dibenzodioxins and -furans (PCDD/F)		
Toxaphene		
Perfluorooctanesulfonic acid and its derivatives (PFOS)	26 August 2010 (Commission Regulation 756/2010)	18 June 2015 (Commission Regulation 1342/2014)
Tetra-, penta-, hexa- and heptabromodiphenyl ethers (BDE)		
Endosulfan	18 June 2015 (Commission Regulation 1342/2014)	
Hexachlorobutadiene (HCBD)		
Short-chain chlorinated paraffins (SCCP)		
Polychlorinated naphthalenes (PCN)		
Hexabromocyclododecane (HBCDD)	30 September 2016 (Commission Regulation 2016/460)	30 September 2016 (Commission Regulation 2016/460)

2 When does waste become POP waste?

If waste contains persistent organic pollutants, their concentration determines how the waste must or can be processed in waste management. The EU POP Regulation provides for the treatment methods permitted for waste, depending on whether the concentration limits determined in the regulation are exceeded or not.

Two concentration limits have been set for waste. In this guide, POP waste refers to waste, whose concentration of persistent organic pollutants exceeds the lower concentration limit (see Table 2 or Annex IV of the regulation). POP waste must be treated using the methods stipulated by the regulation. If the upper concentration limit is exceeded, additional restrictions apply (Figure 1). The obligations and restrictions related to treatment are described in more detail in Chapter 4.

At the moment, the POP Regulation includes a total of 25 persistent organic compounds or groups of compounds. The Commission Regulation 1342/2014 added four more compounds and their concentration limits to the POP Regulation in December 2014, as well as concentration limits in waste for two compounds that had earlier been included in the regulation. In March 2016, Commission Regulation 2016/460 added the flame retardant hexabromocyclododecane to the POP Regulation; the regulation's obligations on waste management have applied to it since 30 September 2016 (Table 2).

2.1 Substances likely to be classified as POPs in the future

New chemicals are constantly being added to the Stockholm Convention on Persistent Organic Pollutants under the UN based on proposals from the parties. The Stockholm Convention's review committee assesses whether the proposed compounds fulfil the criteria of persistent organic pollutants, i.e. that they are toxic chemical substances that degrade slowly, bioaccumulate in the food chain and travel far from the sources of the pollution via air, water or migrating animal species. If the review committee considers the POP criteria to be fulfilled and that transboundary pollution could cause significant health and environmental hazards, agreements on restrictions on the use of the compound and possible exceptions are made in negotiations between the parties to the Convention (Conference of the Parties).

After a new POP substance has been added to the Stockholm Convention, the countries that are party to the convention must include it in their national legislation within one year of the secretariat of the Stockholm Convention recording the decision of the Conference of the Parties in the United Nations Treaty Collection. In the EU Member States, the changes to the Stockholm Convention are implemented by adding the new compounds to the EU POP Regulation. The compounds that will most likely be added to the regulation next can be found in Table 3 (p. 16).

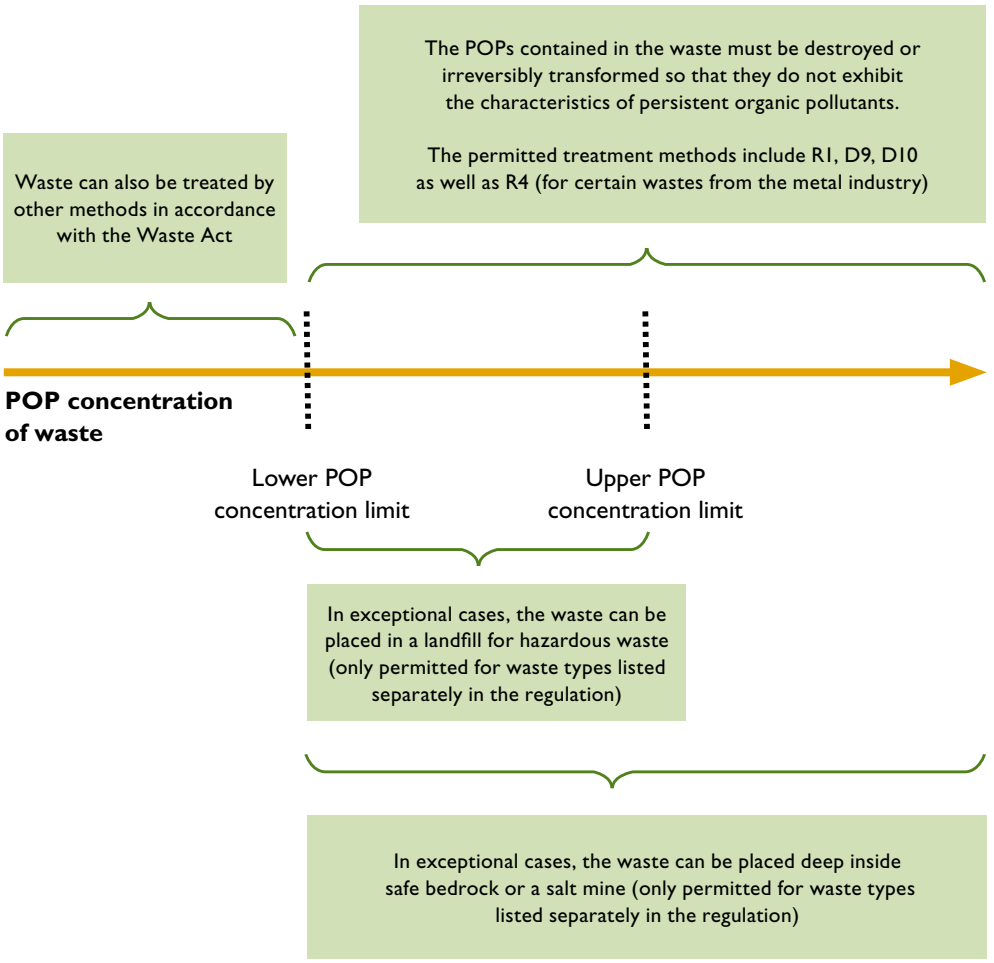

Figure 1: Significance of the upper and lower concentration limit according to the POP Regulation on the treatment of waste. Treatment methods (Government Decree on Waste 179/2012, Annexes 1 and 2):
R1 = Use principally as a fuel or other means to generate energy
R4 = Recycling/reclamation of metals and metal compounds
D9 = Physico-chemical treatment which results in final compounds or mixtures which are discarded by means of any of the operations numbered
D 1 to D 12 (e.g. evaporation, drying, calcination, etc.)
D10 = Incineration on land

Table 2. Concentration limits for all waste containing compounds included in the EU POP Regulation The completely new POPs and ones with lower and upper concentration limits added in Annex IV in Commission Regulations 1342/2014 and 2016/460 are marked in green.

Persistent organic pollutant	Lower concentration limit (POP Regulation, Annex IV)	Upper concentration limit (POP Regulation, Annex V)
Aldrin	50 mg/kg	5 000 mg/kg
DDT	50 mg/kg	5 000 mg/kg
Dieldrin	50 mg/kg	5 000 mg/kg
Endrin	50 mg/kg	5 000 mg/kg
Hexabromobiphenyl (HBB)	50 mg/kg	5 000 mg/kg
Hexachlorobenzene (HCB)	50 mg/kg	5 000 mg/kg
Hexachlorocyclohexanes (incl. lindane) (HCH)	50 mg/kg	5 000 mg/kg
Heptachlor	50 mg/kg	5 000 mg/kg
Chlordane	50 mg/kg	5 000 mg/kg
Chlordecone	50 mg/kg	5 000 mg/kg
Mirex	50 mg/kg	5 000 mg/kg
Polychlorinated biphenyls (PCB)	50 mg/kg	50 mg/kg
Pentachlorobenzene	50 mg/kg	5 000 mg/kg
Polychlorinated dibenzodioxins and -furans (PCDD/F)	15 µg TEQ/kg	5 000 µg TEQ/kg
Toxaphene	50 mg/kg	5 000 mg/kg
Compounds with concentration limits added in Commission Regulation 1342/2014		
Perfluorooctanesulfonic acid and its derivatives (PFOS)	50 mg/kg	50 mg/kg
Sum of the concentrations of tetra-, penta-, hexa- and heptabromodiphenyl ethers (BDE)	1 000 mg/kg	10 000 mg/kg
New compounds added in Commission Regulation 1342/2014		
Endosulfan	50 mg/kg	5 000 mg/kg
Hexachlorobutadiene (HCBD)	100 mg/kg	1 000 mg/kg
Short-chain chlorinated paraffins (SCCP) (alkanes C10-C13)	10 000 mg/kg	10 000 mg/kg
Polychlorinated naphthalenes (PCN)	10 mg/kg	1 000 mg/kg
New compound added in Commission Regulation 2016/460		
Hexabromocyclododecane (HBCDD)	1 000 mg/kg *)	1 000 mg/kg

*) The lower concentration limit of hexabromocyclododecane will be reviewed again in the EU on 20 April 2019 at the latest.

Table 3. POPs most likely to be added to the EU POP Regulation next, their usages, and a situation assessment.

Decabromodiphenyl ether (deca-BDE)	
Usage	Flame retardant. Used in e.g. plastic parts of electrical and electronic equipment and vehicles (especially hard plastic parts manufactured out of ABS and HIPS plastic), vehicle upholstery, construction materials, sealants and glues, as well as furniture, leather products and textiles (Bipro, 2015). In the EU, its use was permitted in electrical and electronic equipment until 2006, and from 2006 to 2008 it was permitted for use in polymeric applications in EEE. Since 2008, the concentration of deca-BDE in the constituents of the flame-retarded parts of EEE must be either equal to or below 0.001 % by weight.
Situation assessment	Approved for the REACH Regulation's list of Substance of Very High Concern (SVHC) in 2012. A general restriction on the use of deca-BDE as a chemical or in articles is being prepared in the EU (ECHA, 2015). In October 2014, the Stockholm Convention's review committee decided to propose adding the substance to the Convention's Annex A listing prohibited substances. It will most likely be included in this list at the Conference of the Parties to the Stockholm Convention in 2017. In that case, the substance could be added to the EU POP Regulation in 2018 at the earliest.
Dicofol	
Usage	Pesticide
Situation assessment	The EU has proposed adding dicofol to the Stockholm Convention. The Stockholm Convention's review committee has found that it fulfils the POP criteria. A risk assessment on the substance is being prepared.
Perfluorooctanoic acid (PFOA), its salts and derivatives	
Usage	Perfluorooctanoic acid (PFOA), its salts and derivatives are widely used both as such in products as well as in manufacturing fluoroelastomers and fluoropolymers. The most important fluoropolymer is PTFE. PFOA derivatives are used in products such as fire-fighting foams, wetting agents and cleaning agents. Side-chain fluoropolymers are used in e.g. textiles, leather products, paper and cardboard packaging, paints, lacquers, glues, sealants and floor polishes. Fluorotelomers are mainly used in textiles and carpets as well as carpet care products and textile and paper product coatings (Stockholm Convention, 2015).
Situation assessment	PFOA was approved for inclusion on the REACH Regulation's list of Substance of Very High Concern (SVHC) in 2013. The EU has proposed adding PFOA, its salts and derivatives to the Stockholm Convention. The proposal is being processed by the Stockholm Convention's review committee.

3 What kind of waste may contain POPs?

The new compounds that were added last to the POP Regulation have been used in a variety of products, such as vehicles, electrical and electronic equipment, textiles, construction products, hydraulic fluids, paints and industrial chemicals, and as pesticides. Table 4 presents products and materials that may contain the latest compounds to be included in the POP restrictions in more detail, and lists the usages that are still permitted for the compounds. Appendix 2 contains a summary of all POPs and their usages.

Table 4: Usages of new compounds added to the POP Regulation, as well as products and materials that may contain these compounds (ESWI, 2011, Häkkinen, 2012, Myllymaa et al., 2015).

Endosulfan	
Products and materials that may contain endosulfan	Pesticide
Usages of endosulfan that are still allowed	According to Annex I of the POP Regulation, the placing on the market and use of articles already in use before 11 July 2012 containing endosulfan as a constituent of such articles is allowed. However, as far as is known, no articles containing endosulfan as a constituent are used in Finland. Its use as a pesticide has been prohibited in Finland since 2001; however, it was still used at certain farms with an exceptional permit from 2003 to 2005.

Hexachlorobutadiene (HCBD)	
Products and materials that may contain HCBD	Heat carrier fluids Transformer fluids Hydraulic fluids Solvent (rubber and other polymers) By-product of manufacturing chlorinated hydrocarbons Pesticide
Usages of HCBD that are still allowed	According to Annex I of the POP Regulation, the placing on the market and use of articles already in use before 11 July 2012 containing HCBD as a constituent of such articles is allowed.

Hexabromocyclododecane (HBCDD)	
Products and materials that may contain HBCDD	Flame retardant: • Polystyrene foam in building insulation (EPS and XPS) • Plastic electrical and electronic equipment casings • Video cassette casings • Stereo and video player casings • Junction and extension boxes • Furnishing fabrics • Vehicle seats, interiors and bodies
Usages of HBCDD that are still allowed	According to Annex I of the POP Regulation, the placing on the market and use of articles containing HBCDD and that were already in use before 23 March 2016 is allowed. The HBCDD content of new substances, preparations, articles or parts of articles may not exceed 100 mg/kg. The concentration limit is not applied to expanded polystyrene used in buildings, if a fixed-term exceptional permit in accordance with the REACH Regulation has been granted for manufacturing it and placing it on the market. No separate exceptions to the concentration limit exist for preparations and articles manufactured out of recycled material. The concentration limit for placing HBCDD on the market will be reviewed on 22 March 2019 at the latest.

Short-chain chlorinated paraffins (SCCP)	
Products and materials that may contain SCCPs	Flame retardant in rubber (e.g. conveyor belts) Rubber, plastic Textiles, shoes Sealants and joint sealing compounds Paints, glues Metal processing fluids Lubricating oils Lava lamps
Usages of SCCPs that are still allowed	According to Annex I of the POP Regulation, the production, placing on the market and use of substances and preparations containing below 1 % of SCCP by weight is allowed. The production, placing on the market and use of articles containing below 0.15 % of SCCP by weight is allowed. However, the use of conveyor belts in the mining industry and dam sealants may continue, if they were already in use before 5 December 2015. The use of other articles containing more than 0.15 % of SCCP by weight may continue, if they were already in use before 11 July 2012.

Polychlorinated naphthalenes (PCN)	
Products and materials that may contain PCNs	Wood preservative Additive in paints and motor oils Cable insulation Capacitors Generated unintentionally in incineration processes
Usages of PCNs that are still allowed	According to Annex I of the POP Regulation, the placing on the market and use of articles already in use before 11 July 2012 containing polychlorinated naphthalenes as a constituent of such articles is allowed.

Perfluorooctanesulfonic acid and its derivatives (PFOS)	
Products and materials that may contain PFOS compounds	Fire-fighting foams Surface-treated textiles and leather (e.g. clothes, furniture, carpets, vehicle interior upholstery) Paper and packaging (surface treatment) X-ray films Photography products (films, papers, photographic coatings applied to printing plates) Chrome plating and surface treatment baths Aviation hydraulic fluids Floor polishes and cleaning agents Paints and lacquers
Usages of PFOS compounds that are still allowed	According to Annex I of the POP Regulation, use of articles already in use before 25 August 2010 containing PFOS as a constituent of such articles is allowed. The exception is fire-fighting foams; their use was to be completely ended in 2011. Substances or preparations placed on the market may contain 0.001 % of PFOS by weight at the maximum. The concentration of these compounds in semi-finished products and articles, or parts thereof, may not exceed 0.1 % by weight. The percentage is calculated with reference to the mass of structurally or micro-structurally distinct parts that contain PFOS. For textiles or other coated materials, the amount of PFOS must be lower than 1 µg/m^2. In addition, PFOS may still be used in photoresists or anti-reflective coatings for photolithography processes, photographic coatings applied to films, papers, or printing plates, mist suppressants for non-decorative hard chromium (VI) plating in closed loop systems, and hydraulic fluids for aviation. Their use as wetting agents in controlled electroplating systems was to end on 26 August 2015 at the latest.

Tetra-, penta-, hexa- and heptabromodiphenyl ether (BDE)	
Products and materials that may contain tetra-, penta-, hexa- and hepta-BDE	Flame retardant, e.g.: • Plastic electrical and electronic equipment casings • Circuit boards • Insulation in refrigerating equipment • Hard plastic vehicle parts, such as bumpers and dashboards • Vehicle seat and furniture padding manufactured out of polyurethane foam, mattresses • Building sound insulation boards • Imitation wood materials in buildings • Products manufactured out of recycled plastics (unintentional contamination)
Usages of tetra-, penta-, hexa- and hepta-BDE that are still allowed	According to Annex I of the POP Regulation, use of articles already in use before 25 August 2010 containing tetra-, penta-, hexa- or hepta-BDE as a constituent of such articles is allowed. Substances, preparations, articles or flame-retarded parts of articles placed on the market may contain 0.001 % of tetra-, penta-, hexa- or hepta-BDE by weight at the maximum. An exception is the production, placing on the market and use of articles or preparations manufactured out of recycled materials or materials from waste prepared for reuse, which is permitted if the article or preparation contains less than 0.1 % of the aforementioned BDEs by weight.

4 How should POP waste be treated?

Provisions on the treatment of waste are given in Article 7 and Annex V of the EU POP Regulation. Waste[1], whose concentration of POPs exceeds the lower concentration limit stipulated, must be disposed of or recovered so that the compounds in the waste are destroyed or irreversibly transformed into a form that does not exhibit the characteristics of persistent organic pollutants. The concentration limits on POP waste can be found in Chapter 2, Table 2.

The regulation prohibits disposal or recovery operations that may lead to recovery, recycling, reclamation or reuse of POPs.

Annex V of the regulation defines the permitted recovery and disposal methods for waste that exceeds the lower concentration limit as follows:

- **physico-chemical treatment (disposal method D9)[2]** (see Section 4.2)
- **incineration without energy recovery (disposal method D10)** (see Section 4.1)
- **incineration, using the waste to generate energy (recovery method R1)** (see Section 4.1)
- **recycling and reclamation of metals (recovery method R4); only permitted for certain types of waste containing metal and with certain methods** (see Section 4.3)

The regulation does not define the concepts related to destruction or irreversible transformation. In the guidelines on the management of POP waste of the Basel Convention (2015a), the proposed reference value for the destruction efficiency of a treatment method that is considered environmentally sound is 99.999 %. Destruction efficiency refers to the percentage of POPs that are destroyed or irreversibly transformed using the treatment method in question. The POP emissions into the air, water and both liquid and solid wastes are taken into account in calculating it.

[1] Even though the definition of waste of the POP Regulation refers directly to the definition of waste in the EU Waste Framework Directive (2008/98/EC), the scope of application of the POP Regulation is wider than the Waste Framework Directive and the Waste Act (646/2011). In the Waste Framework Directive, some of the waste is left outside the scope of application of the directive, but the POP Regulation has no such limitation. For this reason, the POP Regulation also applies to e.g. out-of-date or banned fireworks that contain POPs such as hexachlorobenzene, even though explosives are left outside the scope of application of the EU Waste Framework Directive and the Waste Act.

[2] Disposal methods are listed in Annex 1 of the Waste Decree (179/2012), while the recovery methods are listed in Annex 2.

It should be noted that also PCB waste can only be treated with the above-mentioned options. This is despite the fact that biological treatment (D8) is specified as one of the permitted disposal methods for PCB waste in Government Decision 711/1998. However, because this method is not allowed for treating POP waste in the EU POP Regulation, using it to treat PCB waste is no longer allowed.[3]

According to the regulation, waste that consists of, contains, or is contaminated by persistent organic pollutants must be disposed of or recovered without delay by using one of the aforementioned methods. **As far as possible, the producer and holder of waste must prevent the contamination of waste with POPs. Therefore, the whole POP waste treatment chain must be organised first and foremost so that the other waste created during treatment cannot be contaminated by persistent organic pollutants at any point.**

If only a part of the waste contains or is contaminated by persistent organic pollutants, the part in question must be separated from the other waste in accordance with Annex V of the POP Regulation and treated afterwards using the aforementioned methods.

If none of the treatment methods listed above is not the best option with regard to the environment for treating POP waste, the authorities can, in certain exceptional cases, grant a permit to place the waste in a landfill for hazardous waste, deep inside safe bedrock or a salt mine. If the concentration of the POP also exceeds the upper concentration limit specified in the regulation, the waste can only be placed deep inside safe bedrock or a salt mine according to an exceptional procedure. The application of an exceptional procedure is discussed in more detail in Section 4.5.

The possible POP waste treatment options are presented in a diagram on the next page in Figure 2.

[3] A reform of the Government Decision 711/1998 is being prepared by the Ministry of the Environment; its aim is to harmonise the regulations on the treatment of PCB waste with the regulations of the POP Regulation.

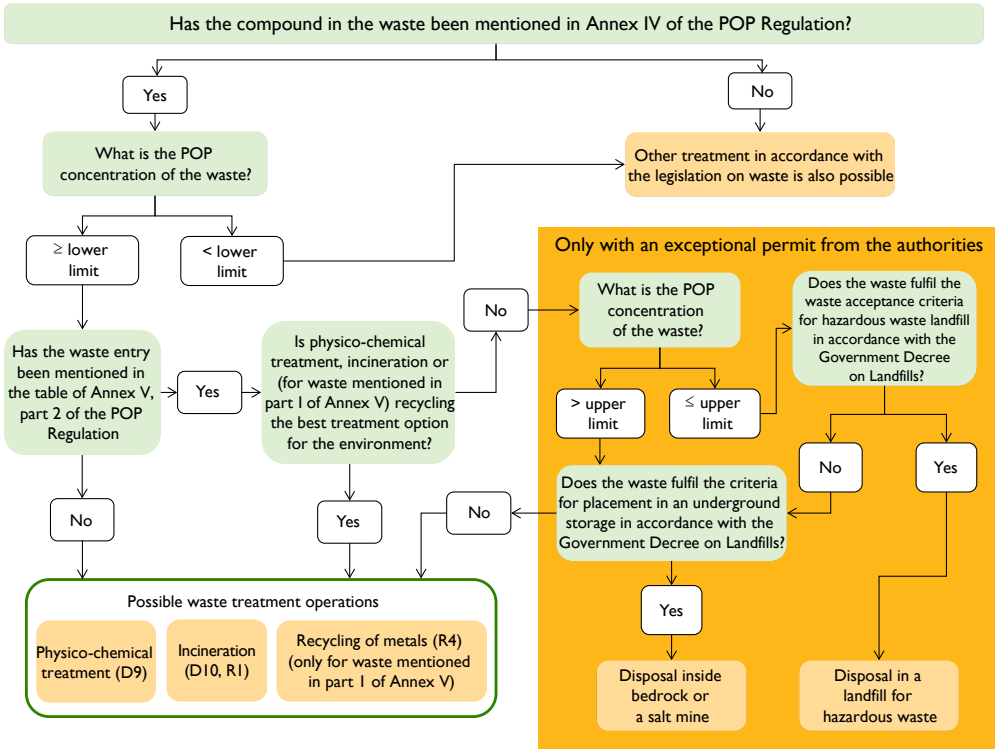

Figure 2: Treatment options specified in the EU POP Regulation for waste containing POPs

4.1

Incineration

An incineration plant incinerating POP waste must fulfil the requirements on incinerating waste set by the EU Industrial Emissions Directive 2010/75/EU. In Finland, these requirements have been implemented by the Government Decree on Waste Incineration (151/2013).

POPs are halogenated organic compounds, i.e., they contain fluorine, chlorine or bromine. If waste containing halogenated organic compounds has been classified as hazardous waste and the concentration of the compound in the waste exceeds 1 % (expressed as chlorine), the kiln used in incinerating waste must reach the temperature of 1 100 °C for at least two seconds in accordance with the Government Decree on Waste Incineration. If the concentration of halogenated organic compounds in hazardous waste is less than 1 %, or the waste containing these compounds has been classified as non-hazardous waste, the temperature requirement for incineration is 850 °C. The classification of POP waste as hazardous waste has been discussed in Chapter 5.

In the POP Regulation and the EU PCB Directive, the incineration of PCB waste is only allowed using treatment method D10. Therefore, incineration of PCB waste is always considered as disposal, not recovery (R1).

The instructions of the Basel Convention on POP waste (2015a) examine what kind of incineration processes are known to be suitable for destroying POPs with the required destruction efficiency:

- Hazardous waste incineration plants (over 1 100 °C) are suitable for incinerating all POPs.
- Co-incineration in cement kilns, in which the temperature rises to 1 400–1 500 °C, is suitable for destroying almost all POPs. So far, there is not enough research data concerning the destruction of PFOS or HBB in cement kilns.
- As of yet, there is only enough research data about treating POP waste in municipal waste incineration plants of high quality (over 850 °C) for destroying hexabromocyclododecane found in polystyrene, but not about other substances. HBCDD was found to be destroyed at a temperature of 900–1 000 °C with a destruction efficiency of over 99.999 %, when EPS and XPS plastics containing 6 000–21 000 mg/kg of HBCDD constituted 1–2 % of the total amount of waste processed at a municipal waste incineration plant (Mark et al., 2015).[4]
- Certain thermal processes in metal production have been found suitable for destroying waste containing dioxins and furans as well as bromodiphenyl ethers (BDE). There is not enough research data on other POPs.
- Plasma arcs have been found suitable for treating liquid PCB waste and pesticides.

More information about research on the suitability of incineration processes can be found in the general technical guidelines on POP waste in the Basel Convention (2015a).

The Reference Document (BREF) on the Best Available Techniques (BAT) for Waste Incineration provides more detailed information on the suitability of different methods for e.g. the incineration of PCB waste (European Commission, 2006). The BREF document on waste incineration is currently being updated in the EU.

4.2

Physico-chemical treatment

Several different methods have been developed for the physico-chemical treatment of POP waste. Each method is usually suitable for only some of the POPs. The suitability of methods can also be limited by the POP concentration of waste and other aspects of its composition, such as the state and particle size of the waste, the non-homogeneous nature of the material, or other similar characteristics. The use of the methods often also requires pre-treatment of waste (Basel Convention, 2015a).

[4] BDEs classified as POPs are also likely to be destroyed in municipal waste incineration plants. In a Norwegian study, brominated flame retardants were found to be destroyed at a destruction efficiency of 99.999 % (when the feed contained 0.1 % of bromine at the maximum), but the study did not examine which brominated flame retardants the plastic feed material contained. Hence there is no accurate information how much the waste treated in the incineration plant contained flame retardants classified as POPs (Borgnes and Rikheim, 2005).

Examples of physico-chemical treatment methods suitable for POP waste include:

- *Alkali Metal Reduction,* suitable for treating PCB oils and, out of pesticides, chlordane and hexachlorobenzene. In the method, the chlorine contained by waste reacts with the alkali metal, forming salts and non-halogenated waste. The most common reducing agent used is metallic sodium. The method can reach a destruction efficiency of over 99.999 %.
- *Base Catalysed Decomposition* is suitable for treating at least PCB, dioxins, furans, DDT, HCB, heptachlor, chlordane and HCH, according to studies. In the method, the waste reacts with extremely reactive atomic hydrogen. The reported destruction efficiency of the method is over 99.99 %.
- In *Catalytic Dehydrogenation*, hydrogen reacts with the chlorine in chlorinated halogens at a temperature of 180–260 °C and normal pressure, forming hydrochloric acid and non-halogenated waste. Suitable for treating PCB waste as well as dioxins and furans. The reported destruction efficiency is over 99.98 %.
- In *Supercritical/Subcritical Water Oxidation*, the waste is treated using an oxidiser in water, in conditions either above or below the critical temperature and pressure of water. Chlorinated hydrocarbons oxidise into carbon monoxide, water and inorganic acids or salts. The method has been assessed as suitable for all POPs. It can be used to treat liquid POP waste, oils and solvents, as well as solid waste particles with a diameter of less than 200 µm. The share of organic material contained by the waste must be less than 20 %. The reported destruction efficiency is over 99.99 %.
- In the *Gas Phase Chemical Reduction*, hydrogen reacts with chlorinated organic compounds at a temperature of over 850 °C and in low pressure, producing methane, hydrogen chloride and small amounts of small hydrocarbon molecules, such as benzene and ethylene. The method is suitable for treating DDT, hexachlorobenzene and PCB as well as dioxins and furans. Their reported destruction efficiency is over 99.9999 %. It is also assumed to be suitable for treating all other POPs, such as liquid and oily waste, soil, sediments, sludges and transformers. However, as of yet there is no certain research data available for all POPs.

More information about the methods described above can be found in the general technical guidelines on POP waste in the Basel Convention (2015a).

4.3

Material recycling – only for certain types of waste in the metal industry

The material recycling of POP waste is only allowed for certain types of metal containing wastes from metal industry. The recycling of other POP wastes is prohibited (Annex V of the regulation). The recovery and recycling of metal compounds is only allowed for:

- residues from iron- and steel-making processes (such as dusts or sludges from gas treatment or mill scale or zinc-containing filter dusts from steelworks),
- dusts from gas cleaning systems of copper smelters and similar wastes, and
- lead-containing leaching residues of non-ferrous metal production.

The aforementioned types of waste may only be recycled in processes for the recovery of iron and iron alloys (blast furnace, shaft furnace and hearth furnace) and non-ferrous metals (Waelz rotary kiln process, and bath melting processes using vertical or horizontal furnaces). As minimum requirements, the facilities must meet the emission limit values for dioxin and furan compounds laid down in the Industrial Emissions Directive (2010/75/EU); in Finland, these requirements have been implemented by the Government Decree on Waste Incineration.

4.4

Pre-treatment and storage

The POP Regulation allows the pre-treatment of POP waste before its destruction or irreversible transformation. Pre-treatment may be necessary in order to ensure that the waste treatment method operates optimally. The POPs separated during pre-treatment must be treated using the methods described in Sections 4.1–4.3.

Pre-treatment may involve e.g. mechanical separation or shredding to a particle size suitable for the treatment process, mixing, pH adjustment, vaporisation, removing water from the waste, or disassembling the equipment containing POPs. Harmful substances can also be separated from the waste using e.g. adsorption or absorption, desorption, membrane filtration or a solvent wash. **However, waste containing POPs cannot be diluted or mixed with other waste solely for the purpose of lowering the concentration under the POP concentration limit** (Basel Convention, 2015a, JRC, 2015).

If only a part of the waste contains persistent organic pollutants or is contaminated by them, according to Annex V of the POP Regulation, the said part must be separated from the other waste and treated afterwards using the methods described in Sections 4.1–4.3. A waste fraction, from which the part containing POPs has been isolated, can also be treated by using other methods in accordance with the legislation on waste.

According to the POP Regulation, the POP waste can be repackaged and stored temporarily before pre-treatment or disposal.

More information about pre-treatment methods can be found in the general technical guidelines on POP waste in the Basel Convention (2015a).

The pre-treatment of POP waste on a professional basis or at installation requires an environmental permit. Storing the waste usually also requires an environmental permit, excluding temporary storage at the place, in which it was generated. Depending on the nature of the activities, the permit authority is either the Regional State Administrative Agency or the municipal environmental protection authority (see Section 5.1).

4.5

Exceptions to general requirements on disposal and treatment concerning certain wastes

In principle, the waste management obligations in Article 7 of the POP Regulation apply to all waste containing POPs, regardless of their concentration. However, Article 7(4) stipulates certain exceptions to the treatment obligations.

If the POP concentration of waste is below the lower concentration limit, the waste can also be treated using methods in which the POPs contained by the waste are not irreversibly transformed or completely destroyed. Such waste does not constitute POP waste discussed in this guide. However, waste must not be diluted in order to ensure that it is below the concentration limit. The lower and upper concentration limits of all POPs are presented in Table 2 (Chapter 2).

In exceptional cases, the competent authority may also permit the permanent storage of waste containing POPs above the lower concentration limit deep inside safe bedrock, in salt mines, or in a landfill for hazardous waste. The procedure is only allowed for certain types of waste listed in part 2 of Annex V of the regulation (see Section 4.5.1)**.**

If the concentration of persistent organic pollutant in the waste also exceeds the higher concentration limit specified in the regulation, permission to place the waste in a landfill for hazardous waste cannot be granted. Instead, placing it deep inside bedrock or in a salt mine may be allowed if the upper POP concentration limit is exceeded. Concerning the placement of POP waste in a landfill or an underground storage, the competent permit authority is the Regional State Administrative Agency (Environmental Protection Act 527/2014, section 220).

The exception for placement in a landfill for hazardous waste or deep inside bedrock can be applied if the waste in question has been mentioned in part 2 of Annex V, and if the holder of the waste can prove that:

- removing the POPs from the waste is not possible, and
- the destruction or irreversible transformation of POPs is not the environmentally preferable option.

Financial considerations cannot be used as a basis for making a decision on an exception; instead, the decision must be based only on considerations of environmental protection (Article 7(4)(b) of the regulation). For example, the physical or chemical composition of the waste may make it unsuitable for incineration or physico-chemical treatment despite possible pre-treatment, or the pre-treatment required by the waste would cause a health or environmental hazard.

Before placement in a landfill for hazardous waste, the POP waste must be solidified or partly stabilised where technically feasible in accordance with Annex V of the regulation. It should be noted that even stabilised POP waste cannot be placed in a landfill for non-hazardous waste, unless it can be reliably proven that all POPs have been transformed during the process into compounds that do not have the characteristics of persistent organic pollutants.

When placing waste in a landfill for hazardous waste or inside an underground storage, the requirements of the EU Landfill Directive (1999/31/EC) must be followed in addition to the POP Regulation; in Finland, they have been implemented by the Government Decree on Landfills (331/2013).

The Government Decree on Landfills prohibits placing liquid, explosive, corrosive, oxidizing, flammable or infectious waste in a landfill. Placing waste with a total concentration of organic carbon higher than 6 % (or a higher than 10 % loss on ignition) in a landfill for hazardous waste is also prohibited. In addition, the Government Decree on Landfills sets limits on the solubility of the metals as well as chloride, fluoride and sulphate contained by the waste. The landfill permit authority (Regional State Administrative Agency) can, with certain conditions, moderate these limits.

As for placing POP waste deep inside bedrock or in a salt mine according to an exceptional procedure, this always requires a safety assessment to be carried out at the placement site. The waste must fulfil the criteria set down in Annex II of the Landfill Directive (Council Decision 2003/33/EC) regarding underground storages (Government Decree on Landfills, section 33). Annex II of the Landfill Directive prohibits placing waste, in which unwanted physical, chemical or biological transformations may occur, inside bedrock or a salt mine. According to the directive, such waste includes biodegradable, infectious or liquid wastes, wastes with a pungent smell, explosive, corrosive, oxidising, flammable or volatile wastes, or wastes that may react with water or the bedrock in the storage conditions in a way that risks the safety of the barrier.

The Commission and other EU Member States must be informed of the decisions of the Regional State Administrative Agency on exceptions concerning the placement of POP waste in a landfill or deep inside bedrock and their justifications. The Regional State Administrative Agency must submit the decisions it has made with justifications to the Finnish Environment Institute SYKE (Government Decree on Landfills, section 50). SYKE delivers the decisions and their justifications further on to the Commission and the other Member States.

4.5.1

Which POP wastes can be placed in a landfill for hazardous waste or an underground storage in exceptional cases?

The possibility of placing POP waste in a landfill for hazardous waste, deep inside bedrock or in a salt mine according to an exceptional procedure only applies to the waste listed in Annex V of the regulation. The exceptional procedure can be applied to the disposal of e.g. certain construction wastes, ashes and slags from waste incineration and co-incineration, certain slags and wastes from gas cleaning in the metal industry, as well as linings and refractories from metallurgical processes. A complete list of the waste entries can be found in Appendix 3 of this guide.

The exceptional procedure only applies to hazardous waste entries. However, waste containing POPs does not always constitute hazardous waste, even if the concentration of the compound was above the lower concentration limit laid down in the regulation. If the POP waste is not classified as hazardous waste, in accordance with the POP Regulation and the Government Decree on Landfills, it cannot be placed in a landfill for hazardous waste or an underground storage according to an exceptional procedure. The classification of POP waste as hazardous waste has been discussed in Chapter 5.

It should be noted that the exceptional procedure cannot be applied to waste that contains more than 50 ppm of PCB, even though construction and demolition waste containing PCB (waste entry 17 09 02*) has been listed in the waste categories of Annex V of the regulation. The Government Decision (711/1998) on the treatment of PCB waste prohibits placing PCB waste in a landfill or an underground storage[5].

In practice, it is not possible to grant an exceptional permit to place waste containing PFOS, SCCP or HBCDD in a landfill for hazardous waste, either. The POP Regulation has specified the same values for the upper and lower concentration limits of these compounds, which means that when the lower concentration limit is exceeded, so is the upper concentration limit. However, PFOS, SCCP and HBCDD waste could be placed deep inside bedrock or in a salt mine according to an exceptional procedure.

[5] A reform of the Government Decision 711/1998 is being prepared by the Ministry of the Environment; its aim is to harmonise the regulations on the treatment of PCB waste with the regulations of the POP Regulation. After amendments made to the decree, it would be possible to grant a permit for placing PCB waste in an underground storage according to an exceptional procedure. In contrast, it would still not be possible to grant an exceptional permit for placing PCB waste in a landfill for hazardous waste, because the POP Regulation has specified the same value (50 ppm) for both the lower and upper concentration limit of the compound, which means that when the lower concentration limit is exceeded, so is the upper concentration limit.

5 When does POP waste also constitute hazardous waste?

Finland's waste and environmental protection legislation provides special provisions regarding hazardous waste. Based on these provisions, the classification of waste as hazardous or non-hazardous may affect the choice of disposal method, the environmental permit of the facility handling the waste, the packing or marking of the waste, and related record-keeping, among other things. Waste may be classified as hazardous due to its flammable, explosive, infectious, otherwise harmful or ecotoxic characteristics.

The classification of waste as hazardous or non-hazardous is based on the Waste Framework Directive (2008/98/EC) and the European List of Waste (Commission Decision 2014/955/EU). According to the Waste Framework Directive, waste is considered as hazardous waste if it has one or more of the hazardous properties listed in Annex III of the directive. Annex III also includes more specific criteria, such as the concentration limits for hazardous substances applied to the classification of waste. The text of Annex III has been replaced by the Commission Regulation (EU) No 1357/2014, and it also constitutes directly applicable legislation in Finland. The definition has been supplemented by the European List of Waste, which lists the wastes considered as hazardous waste in the EU. The list of the most common types of waste as well as hazardous waste, based on the European List of Waste, can be found in Annex 4 of the Waste Decree (179/2012, amended by 86/2015).

Annex 4 of the Waste Decree also stipulates when waste containing POPs is considered hazardous waste. According to the decree, the concentration limit given in Annex IV of the POP Regulation (lower POP concentration limit) is applied to most of the POPs as the concentration limit for hazardous waste. Exceptions to this rule are:

- tetra-, penta-, hexa- and heptabromodiphenyl ethers
- PFOS and its derivatives
- endosulfan
- hexachlorobutadiene
- polychlorinated naphthalenes
- SCCP
- hexabromocyclododecane

In their classification as hazardous waste, the general waste classification concentration limits laid down in Annex III of the Waste Framework Directive are applied.

The concentration limits of hazardous waste to be applied to all of the compounds in the EU POP Regulation are listed in Appendix 4 of this guide. It should be noted that POP waste can also be hazardous waste due to other hazardous substances it contains, even if the POP concentration of the waste was lower than the concentration limit for hazardous waste.

In addition to the concentrations of hazardous substances in the waste, a key issue in classifying the waste is whether the waste in question has been classified as hazardous or non-hazardous in the European List of Waste. The List of Waste has three kinds of entries:

- waste always listed as hazardous (entries marked with an asterisk in the list)
- waste always listed as non-hazardous
- waste listed under both non-hazardous and hazardous entries (mirror entries)

If the waste comes under a waste entry always classified as hazardous waste or non-hazardous waste, there is no need to make a separate assessment on classifying the waste. In contrast, if the waste has been classified under a mirror entry, meaning that both a hazardous waste and a non-hazardous waste entry exist for the waste, its classification must be carried out on a case-by-case basis according to the criteria (such as concentration limits for hazardous substances) laid down in Annex III of the Waste Framework Directive (Häkkinen, 2016).

The valid List of Waste has several non-hazardous waste entries that also apply to POP waste. These types of waste are considered non-hazardous waste, even if the POP concentration limit for hazardous waste was exceeded, unless the Regional State Administrative Agency or the regional Centre for Economic Development, Transport and the Environment (ELY Centre) has made a decision on an exemption from the waste classification in accordance with section 7 of the Waste Act. Such wastes classified as non-hazardous include, for example, many waste fractions that may contain PFOS or brominated flame retardants, like plastic and textile fractions created in the mechanical processing of waste (such as sorting, shredding, baling and pelletisation), textiles, clothes, leather waste, furniture, mattresses and plastics from municipalities, sludge from municipal wastewater treatment plants, as well as photographic film and paper waste.

5.1

What kind of effects does classifying POP waste as hazardous or non-hazardous waste have?

Classifying the waste as hazardous or non-hazardous waste does not affect the waste treatment obligations laid down in the EU POP Regulation. Waste with a POP concentration above the lower concentration limit must be treated in a manner required by Article 7 of the regulation regardless of its classification.

In contrast, the classification of waste may affect the placement of POP waste in a landfill or an underground storage in exceptional cases (see Section 4.5). In the POP Regulation, all waste entries for which the exceptional procedure is allowed are hazardous waste entries. If POP waste has not been classified as hazardous waste that comes under one of the waste entries listed in Annex V of the regulation, the exceptional procedure cannot be applied.

Classifying a consignment of waste as non-hazardous or hazardous waste may also affect whether the treatment plant can accept the POP waste in question or not. The classification of waste may affect issues such as the incineration plant's process requirements. If the waste contains halogenated organic compounds, such as POPs, at a concentration exceeding 1 % (expressed as chlorine), the kiln used in incinerating waste must reach the temperature of 1 100 ºC for at least two seconds. If the concentration of halogenated organic compounds in hazardous waste is less than 1 %, the temperature of the kiln must be at least 850 °C. As for the incineration of non-hazardous halogenated waste, the minimum temperature required is always 850 °C regardless of the concentration of halogenated compounds (Government Decree on Waste Incineration, section 9).

Diluting or otherwise mixing hazardous waste in other types of waste or other materials is prohibited by the Waste Act (section 17). An exception to the prohibition on mixing can be made, if mixing is necessary for treating the waste and an environmental permit has been granted for the purpose. In addition, in accordance with the Waste Act, a shipment of waste classified as hazardous must be accompanied with a shipping document, and an operator carrying out operations that produce hazardous waste must keep records on the amount, type, delivery location and treatment of the produced waste, among other things.

In individual cases, the classification of waste may also have an effect on which authority is competent with regard to the treatment of POP waste. Table 5 presents whether the environmental permit authority for a facility treating POP waste in accordance with the Environmental Protection Decree (713/2014) is the Regional State Administrative Agency or the municipal environmental protection authority. The regional ELY Centre acts as the supervisory authority for environmental permits granted by the Regional State Administrative Agency. The municipal environmental protection authority is responsible for monitoring the permits granted by the municipality.

5.2

Classification of plastics containing brominated flame retardants

Waste electrical and electronic equipment and end-of-life vehicles may contain many different brominated flame retardants, only some of which are POPs. Substances used as flame retardants in plastics include polybrominated diphenyl ethers (PBDE), bis(tribromophenoxy)ethane (BTBPE), polybrominated biphenyls (PBB or HBB), 1,1'-(ethane-1,2-diyl)bis[pentabromobenzene] (EBP), tetrabromobisphenol A (TBBPA) and hexabromocyclododecane (HBCDD) (Weil and Levchik, 2009, Ministry of Ecology, Sustainable Development and Energy, French Republic, 2012). Additives improving the effect of flame retardants are often also used with brominated flame retardants. A synergist commonly used together with halogenated flame retardants is antimony (such as antimony trioxide, Sb2O3). For example, commercial octa-BDE has always been used together with antimony trioxide (Stockholm Convention, 2007, Retkin, 2012). Completely halogen-free phosphate- or nitrogen-based flame retardants may also have been used as flame retardants.

The hazardous characteristics of flame retardants vary on a compound-specific basis. Table 6 examines the classification of certain brominated flame retardants used in vehicles and electrical and electronic equipment as hazardous substances, and the corresponding concentration limits for hazardous waste.

In practice, defining plastic parts as hazardous waste based on their concentrations of flame retardants would require analysing individual parts in a laboratory, unless product-specific information from the manufacturer is available. There is no general concentration limit based on the bromine content of plastic in legislation that would cause flame-retarded plastic with a higher concentration to be considered as hazardous waste.

Table 5: Determining the environmental permit authority of a plant that treats or stores POP waste on a professional basis or at an installation (Environmental Protection Decree, sections 1 and 2)

POP waste treatment operation	Authority granting the environmental permit	
	Regional State Administrative Agency	Municipal environmental protection authority
Incineration plant for POP waste classified as hazardous or non-hazardous	all	-
Physico-chemical treatment of POP waste classified as hazardous	all	-
Physico-chemical treatment of POP waste classified as non-hazardous	amount of waste treated ≥ 20 000 t/year	amount of waste treated < 20 000 t/year
Pre-treatment of POP waste classified as hazardous (excluding car dismantling companies)	all	-
Pre-treatment of POP waste classified as non-hazardous	amount of waste treated ≥ 20 000 t/year	amount of waste treated < 20 000 t/year
Car dismantling company	-	all
Storage site for POP waste classified as hazardous, excluding the storage of waste electrical and electronic equipment, end-of-life vehicles and hazardous waste generated at households or in comparable activities	all	-
Storage site for hazardous waste generated at households or in comparable activities	storage capacity > 50 t	storage capacity ≤ 50 t
Storage site for end-of-life vehicles classified as hazardous	storage capacity > 50 t	storage capacity ≤ 50 t
Storage site for waste electrical and electronic equipment classified as hazardous	storage capacity > 50 t	storage capacity ≤ 50 t
Storage site for POP waste classified as non-hazardous	amount of waste treated ≥ 20 000 t/year	amount of waste treated < 20 000 t/year

Table 6: Classifications of certain brominated flame retardants and active substances used with them in accordance with the legislation on chemicals, and the concentration limits for hazardous waste applied to them.

One compound may have several hazard classifications in accordance with the CLP Regulation (1272/2008). All hazard classifications of an individual compound in accordance with the CLP Regulation and the concentration limit for hazardous waste corresponding to each classification have been listed in the table (Commission Regulation 1357/2014). The applicable concentration limit for hazardous waste in the waste classification is the lowest out of the concentration limits in accordance with the compound's hazard classification (bolded in the table).

Brominated flame retardant or active substance	Classification in accordance with the CLP Regulation	Applicable hazardous waste classification concentration limit (Commission Regulation 1357/2014)	Is the substance a POP?
Commercial pentabromodiphenyl ether	Lact. (H362) STOT RE 2 (H373) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	(-) (10 %) (25 %) **0,25 % (2 500 mg/kg)**[*)]	yes
Commercial octabromodiphenyl ether	Repr. 1B (H360)	**0,3 % (3 000 mg/kg)**	yes
Commercial decabromodiphenyl ether	No harmonised classification Classifications created by the industry in REACH registration[**)] such as: Acute Tox. 4 (H302) Acute Tox. 4 (H312) Skin Irrit. 2 (H315) Eye Irrit. 2 (H319) Muta 2 (H341) STOT RE 2 (H373) STOT SE 3 (H319) Aquatic Chronic 4 (H413)	- (25 %) (55 %) (20 %) (20 %) **1 % (10 000 mg/ kg)** (10 %) (20 %) (25 %) [*)]	proposed for inclusion in the Stockholm Convention, decision likely to be made in 2017
Hexabromocyclododecane (HBCDD)	Repr. 2 (H361) Lact. (H362)	**3 % (30 000 mg/kg)** (-)	yes
Tetrabromobisphenol A (TBBPA)	Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	(25 %)[*)] **0,25 % (2 500 mg/kg)** [*)]	no
Bis(tribromophenoxy)ethane (TBPE)	Not classified	-	no
1,1'-(ethane-1,2-diyl) bis[pentabromobenzene] (EBP)	Not classified as a solid	-	no
Antimony trioxide (synergist in flame retardants)	Carc. 2	**1 % (10 000 mg/kg)**	no
Other antimony compounds (except for tetroxide, pentoxide, trisulphide, pentasulphide)	Acute Tox. 4 (H302) Acute Tox. 4 (H322) Aquatic Chronic 2 (H411)	(25 %) (22,5 %) **2,5 % (25 000 mg/kg)** [*)]	no

[*)] National concentration limit for ecotoxic waste (Häkkinen, 2016)

[**)] European Chemicals Agency (ECHA), C&L Inventory Database. Accessed 6 October 2015

6 Import and export of waste containing POPs

6.1

Permit requirement on the shipments of POP waste

Waste shipments between EU Member States and outside the EU are regulated by the Regulation (EC) No 1013/2006 of the European Parliament and of the Council (Waste Shipment Regulation). In Finland, the competent authority in accordance with the Waste Shipment Regulation is the Finnish Environment Institute, which monitors the shipments of waste crossing the state borders together with the Finnish Customs.

Exporting POP waste from Finland to another country, importing them from another country to Finland, or transit through Finland always requires a written permit from the Finnish Environment Institute, regardless of the handling method or whether the waste is classified as hazardous or not:

- **Waste intended for disposal:** In accordance with the Waste Shipment Regulation, a written permit is always required for the transfrontier shipment of all waste intended for disposal, i.e. including POP waste, regardless of the waste's hazardousness. The possibility of granting a permit is assessed on a case-by-case basis; the assessment criteria can be found in Section 6.2.
- **Waste intended for recovery:** A permit in accordance with the Waste Shipment Regulation is always required for the shipment of POP waste intended for recovery as material or energy. In the Waste Shipment Regulation, the so-called green list wastes that can be transported to another country to be recovered, as material or energy without a permit process have usually been excluded from the permit procedure. However, this procedure cannot be applied to POP waste. Even though some types of POP waste can be found among the green list waste entries (such as plastic and textile waste), according to the Waste Shipment Regulation, the waste cannot be classified as green list waste if it is contaminated by other materials to the extent that it substantially increases the risks related to the waste or prevents the recovery of waste in an environmentally sound manner. Waste containing POPs above the lower concentration limit is always a risk to health or the environment; therefore, it cannot be transported as green list waste.

6.2

Shipment of waste containing POPs for disposal

The EU Waste Framework Directive and the Waste Shipment Regulation require that the community as a whole must be self-sufficient with regard to the disposal of waste. In fact, the EU Waste Shipment Regulation prohibits the export of all waste for disposal outside the EU and EEA countries, excluding Switzerland and Liechtenstein. Every Member State of the community should also be as self-sufficient as possible with regard to the disposal of waste. The principle of self-sufficiency is also applied to the export and import of POP waste for disposal.

In Finland, the more detailed implementation of the self-sufficiency principle is provided for in the Waste Act. According to section 109 of the act, **export** for disposal in another EU or EEA country as well as Switzerland and Liechtenstein is permitted, if:

- no suitable waste treatment capacity can be found in Finland,
- the waste can be treated substantially better in a country other than Finland with regard to environmental protection,
- the treatment in another country is at least at the same level as in Finland but essentially less expensive,
- the operation involves testing a new treatment method, or
- the export of waste classified as non-hazardous to Sweden or Norway takes place as a part of regional waste management cooperation between municipalities.

If one of the aforementioned conditions is fulfilled, permission to export POP waste could be granted for the disposal methods allowed by the POP Regulation. These include incineration (D10) as well as physico-chemical treatment (D9), in which the POPs are irreversibly transformed into a less harmful form (c.f. Chapter 4).

The **import** of POP waste from another country to Finland for disposal may only be permitted for treatment methods that would also be allowed for the treatment of POP waste generated in Finland in accordance with the POP Regulation. In addition, the restrictions on importing waste laid down in section 110 of the Waste Act and the EU Waste Shipment Regulation must be followed:

- Importing waste from another country to Finland for disposal is not allowed, if the treatment of waste generated in Finland is prevented or delayed due to the shipment.
- If there is sufficient treatment capacity, the import of POP waste could be allowed for physico-chemical treatment (D9) in accordance with the Waste Act. In addition, the Waste Act permits the import of POP waste classified as hazardous into Finland for disposal by incineration (D10). In contrast, importing POP waste classified as non-hazardous for disposal by incineration is only permitted by the Waste Act if this involves regional waste management cooperation with municipalities in Sweden or Norway.

The EU PCB Directive requires that PCB waste must always be disposed of. For this reason, the regulations and permit procedure of the Waste Shipment Regulation concerning disposal are always applied to the transfrontier shipments of PCB waste.

6.3

Import and export of waste containing POPs for recovery

The export or import of POP waste for recycling or energy recovery can only be allowed in the cases, in which similar treatment of POP waste would be allowed in Finland:

- The import or export of POP waste (excluding PCB waste) to be used as energy can be allowed, if the receiving facility fulfils the requirements set on incinerating waste in the Industrial Emissions Directive.
- An import or export permit for material recycling can only be granted for residues from iron- and steel-making processes, dust from gas cleaning systems of copper smelters and similar wastes, and lead-containing leaching residues from non-ferrous metal production. The recycling of these types of waste must be carried out in the thermal processes mentioned in Annex V of the regulation[6], which fulfil the emission requirements on dioxins and furans laid down in the EU Industrial Emissions Directive.

If POP waste is exported for recovery from Finland to outside the EU or the EEA, the receiving facility located outside the EU must also fulfil the minimum requirements of the EU legislation mentioned above. According to Article 49 of the Waste Shipment Regulation, the competent authority must prohibit the export of waste to a country outside the EU, if it has reason to suspect that the treatment of waste in the said country is not carried out in an acceptable manner with regard to the environment. According to the Waste Shipment Regulation, operations that mainly follow the norms confirmed by EU legislation can be considered acceptable with regard to the environment.

The export of waste classified as hazardous, i.e. also hazardous POP waste, for recycling or recovery to countries outside the OECD (such as China or India) is completely prohibited by the Waste Shipment Regulation.

6.4

Shipment of waste for pre-treatment

The POP Regulation allows pre-treatment of POP waste in the manner required by the regulation, if it is necessary before the actual treatment of waste (see Section 4.4). Shipping POP waste for pre-treatment always requires a waste shipment permit (even if the waste was mentioned in the green list of waste, see Section 6.1). The permit procedure would review, among other things, if the pre-treatment of waste and the following actual treatment fulfil the requirements of the POP Regulation and the Waste Shipment Regulation.

When shipping POP waste for pre-treatment, the shipment follows the additional regulations on interim recovery and disposal operations laid down in Article 15 of the Waste Shipment Regulation. Among other things, they require that the contract made and financial guarantee given for the shipment of waste must (with certain exceptions) be valid until the waste fractions containing POPs have been disposed of in the way required by the POP Regulation.

[6] According to Annex V of the POP Regulation, recycling is only allowed in processes for the recovery of iron and iron alloys (blast furnace, shaft furnace and hearth furnace) and non-ferrous metals (Waelz rotary kiln process, and bath melting processes using vertical or horizontal furnaces).

7 Instructions for applying POP legislation concerning waste electrical and electronic equipment and end-of-life vehicles

7.1 General information about brominated flame retardants

The use of brominated flame retardants (BFR) has increased until the early 2000s. In 2007, the use of brominated flame retardants constituted approximately one-third of the total global use of flame retardants (EFRA, 2010, Retkin, 2012). There are approximately 75 different brominated flame retardants available, of which 30–40 compounds are in wider use. Over 50 % of the global consumption of brominated flame retardants is related to the use in plastic parts of electrical and electronic equipment (ACAP, 2007, Wäger et al., 2010, Retkin, 2012).

At the moment, six brominated flame retardants have been classified as POPs in the EU: tetra-, penta-, hexa- and heptabromodiphenyl ethers (BDE), hexabromobiphenyl (HBB) and hexabromocyclododecane (HBCDD). The next new brominated flame retardant, deca-BDE, will probably be included in the Stockholm Convention in 2017, and in the EU POP Regulation in 2018 at the earliest.

The commercially available bromodiphenyl ethers are mixtures of several BDEs. Of the POPs, commercial penta-BDE contains tetra- and penta-BDE as well as a smaller amount of hexa-BDE. As for commercial octabromodiphenyl ether, it contains hexa-, hepta-, octa- and nona-BDE, while commercial decabromodiphenyl ether contains deca-BDE as well as small amounts of octa- and nona-BDE (Retkin, 2012, Bipro 2015).

Commercial penta-, octa- and decabromodiphenyl ethers have previously been commonly used as flame retardants in the plastic parts of vehicles and electrical and electronic equipment. The use of deca-BDE has been the most widespread; the cumulative amount of it manufactured by 2005 was roughly ten times higher than commercial penta- and octa-BDE. In 2001, the use of penta- and octa-BDE comprised a bit less than 4 % of the total use of brominated flame retardants globally. As for the use of all polybrominated diphenyl ethers and HBCDD, all in all they covered approximately 27 % of the total use of brominated flame retardants in the same year (Retkin, 2012, Bipro, 2015).

Bromodiphenyl ethers and HBCDD are additive flame retardants that do not bond chemically with the plastic material to be flame-retarded. They can be released into the environment more easily than chemically bonded reactive flame retardants. Release from the flame-retarded object may occur during use through evaporation or wear, or during waste treatment while the material is shredded, for example (Stockholm Convention, 2014, Basel Convention, 2015b, Basel Convention, 2015c).

7.2

Prohibitions and restrictions on the use of POP flame retardants

Of the flame retardants considered POPs, the use of **hexabromobiphenyl (HBB)** as a flame retardant has been replaced by bromodiphenyl ethers since the 1980s (Seppälä et al., 2012), and it is not likely to be found any longer in end-of-life vehicles or waste electrical and electronic equipment. Placing products containing HBB on the market in the EU has been prohibited in the POP Regulation since 2004.

The restrictions on the use of **bromodiphenyl ethers (BDE)** have become gradually stricter this century:

- Since 2004, the concentration of penta- and octabromodiphenyl ether cannot exceed 0.1 % by weight in flame-retarded parts of products placed on the EU market (Directive 2003/11/EC).
- Placing electrical and electronic equipment containing polybrominated diphenyl ethers on the market has been prohibited[7] with certain exceptions since 1 July 2006 by the RoHS Decree (Government Decree 853/2004)[8]. The concentration of bromodiphenyl ethers in flame-retarded parts was not allowed to exceed 0.1 % by weight. However, spare parts recovered from old EEE can still be used with certain restrictions (see Section 8.5).
- Placing articles or flame-retarded parts of articles with a concentration of tetra-, penta-, hexa- and heptabromodiphenyl ethers higher than 0.001 % by weight on the market has been prohibited since 2010 by the amendment 757/2009 of the POP Regulation. As an exception, the placing on the market of articles and preparations manufactured out of recycled materials was allowed, if the concentration of tetra-, penta-, hexa- and heptabromodiphenyl ethers does not exceed 0.1 % by weight.

All use of **hexabromocyclododecane (HBCDD)** was stipulated by the EU REACH Regulation to require a permit since 21 August 2015. The maximum concentrations of HBCDD in products are provided for in the POP Regulation. Substances, preparations, articles or parts of articles placed on the market since 22 March 2016 may contain a maximum of 100 mg/kg of HBCDD (0.01 % by weight). The concentration limit does not apply to expanded polystyrene (EPS), if a fixed-term exceptional permit in accordance with the REACH Regulation has been granted for its manufacture and placing on the market[9]. There is no exception to the concentration limit for articles or preparations manufactured out of recycled material.

[7] In addition to the bromodiphenyl ethers already classified as POPs, the prohibition also applies to all other BDEs, such as deca-BDE. However, the use of deca-BDE in EEE for polymer purposes was permitted until 1 July 2008.
[8] Government Decree 853/2004 has been replaced by the RoHS Act 387/2013 and the new RoHS Decree 419/2013.
[9] The exceptional permits granted can be found at the address http://ec.europa.eu/growth/sectors/chemicals/reach/about/index_en.htm, in the section 'Authorization Decisions.'

7.3

Plastics containing brominated flame retardants in end-of-life vehicles

The use of flame retardants classified as POPs in vehicles varies based on the manufacturer, model and year of manufacture. Detailed information on the substances used in different vehicle models is not available.

Commercial **pentabromodiphenyl ether** has been used as a flame retardant, especially in vehicle seats manufactured out of polyurethane (PUR). Typically, approximately 4 % of flame retardant has been added to the polyurethane. Penta-BDE has also been used to a certain degree in epoxy resin used in circuit boards (ESWI, 2011, Häkkinen, 2012). However, the most common flame retardant used in circuit boards is tetrabromobisphenol A (TBBPA), which is not a POP.

Commercial **octabromodiphenyl ether** has been used as a flame retardant in hard plastic vehicle parts, such as casings, especially in acrylonitrile butadiene styrene (ABS) and to a lesser extent in high-impact polystyrene (HIPS). Typically, 10–18 % of octa-BDE by weight has been added to ABS plastic and 12–15 % of the total weight to HIPS plastic (Stockholm Convention, 2007, ESWI, 2011, Häkkinen, 2012).

Hexabromocyclododecane (HBCDD) has been used in vehicle upholstery materials in e.g. seats, casings and interior materials and especially body parts manufactured out of HIPS plastic (Stockholm Convention, 2010a, ESWI, 2011, Retkin, 2012, Stockholm Convention, 2014, Myllymaa et al., 2015). Approximately 1–7 % of HBCDD by weight has been added to HIPS and approximately 2–4 % by weight to textiles (Stockholm Convention, 2010a, Retkin, 2012).

Decabromodiphenyl ether, which is likely to be added to the POP Regulation next, has been commonly used in vehicle parts manufactured out of hard ABS and HIPS plastics, electronic parts and their casings, as well as vehicle textiles, especially seats. Typically, 10–15 % of deca-BDE by weight has been added to plastics. Textiles contain a maximum of 12 % of it (Bipro, 2015). The use of decabromodiphenyl ether in vehicles is still allowed, but the automotive industry is abandoning its use.

From 2010 to 2015, the average age of scrapped vehicles in Finland has been approximately 20 years. It has been estimated that penta- and octa-BDE will probably be found in vehicles to be scrapped until ca. 2024, if the age of vehicles to be scrapped does not change within the next 10 years (Retkin, 2012). As for HBCDD and deca-BDE, they will probably be found in vehicles until the late 2030s.

7.4

Plastics containing brominated flame retardants in electrical and electronic equipment

Commercial **octabromodiphenyl ether** has been used widely in acrylonitrile butadiene styrene (ABS) plastic, especially in electrical equipment intended for office use, as well as in high-impact polystyrene (HIPS), which has been used in plastic computer and television casings. Typically, 10–18 % of octa-BDE by weight has been added to ABS plastic and 12–15 % of the total weight to HIPS plastic (Stockholm Convention, 2007, ESWI, 2011, Häkkinen, 2012). Hexa- and hepta-BDE have been found especially in televisions, IT equipment and circuit boards at concentrations above the lower concentration limit (1 000 mg/kg) of the POP Regulation. Smaller amounts have been found in e.g. digital television adapters and large household appliances (over 500 mg/kg). Concentrations remaining under the POP concentration limit are most likely due to the use of recycled plastic in manufacturing the devices (Peacock et al., 2012, Bipro, 2015).

The use of commercial **pentabromodiphenyl ether** in EEE has not been significant. It has been used to a certain extent in polyurethane in refrigerating equipment as well as in circuit boards in small amounts (ESWI, 2011, Häkkinen, 2012). However, the most common flame retardant used in circuit boards is tetrabromobisphenol A (TBBPA), which is not a POP.

Hexabromocyclododecane (HBCDD) has been used in HIPS and polypropylene plastic in electrical and electronic equipment, such as wires, audio equipment cabinets and interior materials of refrigerating equipment, but its use is not likely to have been widespread (Stockholm Convention, 2010a, ESWI, 2011, Myllymaa et al., 2015). Approximately 1–7 % of HBCDD has been added to HIPS plastic (Stockholm Convention, 2010a, Retkin, 2012).

Decabromodiphenyl ether, which will probably be added next to the POP Regulation, was used in HIPS plastic, especially in TV and computer displays, as well as in ABS plastic and polypropylene (large household appliances, small appliances that get hot) until 2008 (Wäger et al., 2010, Peeters et al., 2014).

The average service life of electrical and electronic equipment is approximately 10 years (ESWI, 2011). The average age of IT and telecommunications equipment is only 3–5 years, while that of refrigerating equipment is 12–15 years (Ignatius et al., 2009). In Finland, penta- and octa-BDE are likely to be found in electrical and electronic equipment until ca. 2016, and longer in devices manufactured out of recycled plastic (ESWI, 2011, Retkin, 2012). However, in devices manufactured out of recycled plastic, the concentration of the compounds is usually under the lower concentration limit set down in the POP Regulation, which means that they do not constitute POP waste referred to in this guide. As for deca-BDE, it will probably be found in EEE at concentrations above the POP concentration limit until ca. 2018. HBCDD can be expected to still be found in the plastic parts of EEE in the late 2020s.

8 Requirements on removing harmful substances

8.1

Pre-treatment requirements and recycling goals of end-of-life vehicles

The Government Decree on End-of-Life Vehicles (123/2015) provides for the pre-treatment obligations of end-of-life vehicles in detail. The environmental permit for pre-treatment carried out on a professional basis or at an installation must issue the necessary regulations to implement these obligations.

According to section 7 of the decree, end-of-life vehicles must be pre-treated in a way that ensures that any harm or hazard to health or the environment from the operations is prevented. In pre-treatment, the parts suitable for reuse must be removed and stored appropriately. The parts and materials not suitable for reuse must be sent out for recycling or other recovery as far as possible. During pre-treatment, the hazardous parts and materials must be removed and sorted so that they do not contaminate the waste created when the end-of-life vehicles are shredded. According to Annex 2 of the decree, the parts to be removed include the battery, liquefied petroleum gas containers, hazardous fluids such as oils and coolants, as well as the parts that contain mercury. The decree also lays down a new national obligation, according to which **the parts known to contain POPs must be removed from end-of-life vehicles during pre-treatment, as far as possible**. The obligation entered into force in February 2015.

Annex 2 of the Government Decree on End-of-Life Vehicles also requires removing large plastic parts, such as bumpers, dashboards and fluid tanks during the pre-treatment to promote recycling, unless the materials are separated in the shredding process.

The recycling goals set in the ELV Directive (2000/53/EC) have become stricter since early 2015. At least 85 % of end-of-life vehicles must be prepared for reuse or recycled as material, while previously the minimum goal for reuse and recycling was 80 % of the average weight of the vehicle. Reaching the goal will be difficult, unless at least some of the plastic vehicle parts are separated for recycling. So that plastics could be recycled in a way that is safe for the environment, it must be possible to separate plastics that contain POPs from the other plastic vehicle parts.

8.2

Requirements on removing harmful substances and recycling goals for waste electrical and electronic equipment

Appendix 3 of the Government Decree on Waste Electrical and Electronic Equipment (519/2014) lays down the minimum requirements for the treatment of WEEE. According to it, the equipment and parts suited for reuse must be directed to reuse as far as possible. Hazardous parts and materials, such as PCB capacitors, components containing mercury, colour cartridges, circuit boards, CFCs and asbestos, must be removed from the devices that are collected separately. **The parts to be removed include all plastics containing brominated flame retardants.** The separation obligation is based on the EU Directive on waste electrical and electronic equipment (2012/19/EU), and it also applies to plastics that contain brominated flame retardants other than those classified as POPs.

According to the Government Decree on Waste Electrical and Electronic Equipment, the removal of hazardous materials and parts can involve manual, mechanical, chemical or metallurgic handling with the result that hazardous substances, mixtures and components are contained in an identifiable stream or are an identifiable part of a stream within the treatment process. A hazardous substance, mixture or component is identifiable if it can be monitored to verify environmentally safe treatment. The substances and components removed from the waste must be treated in accordance with the Waste Act.

The recycling targets set for electrical and electronic equipment became stricter in August 2015. At the moment the recycling goal is 55–80 %, depending on the equipment category:

- Large household appliances as well as gas discharge lamps, 80 %
- IT and telecommunications equipment, consumer equipment and solar panels, 70 %
- Small household appliances, lighting equipment, electrical and electronic tools, toys, leisure and sports equipment, medical equipment and monitoring and control instruments, 55 %

The hazardous substances or parts removed based on legal requirements, such as plastics containing brominated flame retardants, are not taken into account when calculating the percentage of recycled electrical and electronic equipment.

8.3

Treatment standards for waste electrical and electronic equipment

WEEELABEX, an organisation of European producers of electrical and electronic equipment, has published normative standards in order to standardise the collection, logistics and treatment of waste electrical and electronic equipment. They discuss e.g. removing the hazardous substances found in equipment in the way required by the WEEE Directive.

The aim is to make the requirements of WEEELABEX's standard into EN standards, drawn up by the European Committee for Electrotechnical Standardization CENELEC. The EN standard SFS-EN 50625 (SFS, 2014) on the general requirements on recycling WEEE was approved in 2014, and it has been supplemented by the technical specification CLC/TS 50625-3-1 (SFS, 2015) on removing hazardous substances and parts from equipment.

According to the WEEELABEX (WEEE Forum, 2013) and CENELEC (SFS, 2014, SFS, 2015) standards on the treatment of WEEE, the following procedures should be followed in removing plastics that contain brominated flame retardants:

- The operator carrying out the treatment must specify the procedures for identifying the substances and parts ordered to be removed in the WEEE Directive, such as plastics containing brominated flame retardants. The operator must make training material and instructions available to employees, such as technical instructions and images of the parts that must be removed from the equipment in accordance with the legislation.
- Separating the hazardous substances and parts can be carried out by disassembling the equipment and removing them manually, or by using mechanical, chemical or metallurgical methods so that the substances or parts can be separated into identifiable fractions at the end of the process.
- The removal of parts must be implemented in a way that prevents the release of hazardous substances into the environment. The spreading of harmful substances into the fractions separated during the process must also be prevented, unless it has been ensured that they will be treated appropriately in the later stages of the treatment chain. The separated hazardous substances and parts or waste fractions containing them must be marked clearly. All fractions containing hazardous substances must be stored in a way that prevents fugitive emissions from spreading into the environment.
- Fractions containing harmful substances cannot be diluted or mixed with other fractions to lower the concentration.
- The separated hazardous substances and parts, or fractions containing these substances, must be kept apart in order to ensure that the material stream remains clean. If it is not certain whether a device or a part contains hazardous substances such as brominated flame retardants or not, it must be handled as if it did contain these substances.
- If plastics containing brominated flame retardants have not been separated from the plastic fraction or if the bromine content of the plastic fraction has not been assessed using a method required by the standard, the fraction is considered to contain brominated flame retardants and the related rules must be applied to its treatment. Similarly, a fraction containing brominated flame retardants must be handled as POP waste, unless it can be proven that it does not contain POPs.
- The success of separation must be monitored e.g. by analysing the quality of clean material fractions, from which the hazardous substances or parts have already been removed.
- In the standard, the requirements on brominated flame retardants in the legislation on products are considered as a sufficient level of purity of the plastic fraction. Mixing

several WEEE plastic fractions with each other in order to reach the level of purity in accordance with the legislation on products is prohibited, unless the portion that contains brominated flame retardants is separated from the plastic fractions at a later stage of treatment. The standard has not specified to which laws on products it refers.[10]

- If the separation of plastics containing brominated flame retardants has not been carried out in the manner required by the standard, the party carrying out the further treatment must be informed.
- Operators cannot participate in or allow shipments of waste that may lead to treating electrical and electronic equipment in a way that does not fulfil the requirements of the WEEE directive or the procedures set in the recycling standards of the industry. The hazardous parts separated from the devices (such as BFR plastics) or devices that still contain them cannot be exported outside the EU or EFTA countries, unless the operator can prove that the requirements of the directive and the standard are fulfilled by the receiving facility.
- The operator must keep records of the treatment of each consignment and fulfilling the obligations set down in the legislation. Records must also be kept on the parties carrying out further treatment of waste fractions that contain brominated flame retardants at the later stages of the treatment chain, until the consignment has been recovered or disposed of in the manner required by the directive, or until the material is no longer considered waste.

Both the WEEELABEX and the CENELEC standards were prepared before the amendments of the POP Regulation concerning brominated flame retardants entered into force; therefore, **the practices regarding the removal of plastics that contain brominated flame retardants do not completely fulfil the requirements of POP legislation. However, the standards emphasise that the operator must follow the binding EU legislation.**

The standards differ from the regulations on POPs, especially regarding the concentration limits on brominated flame retardants:

- **The concentration limits on waste laid down in the POP Regulation are 50 mg/kg for HBB, which is a polybrominated biphenyl (PBB), 1 000 mg/kg calculated in total for tetra-, penta-, hexa- and hepta-BDE, and 1 000 mg/kg for HBCDD. The concentration limits apply to each individual part in electrical and electronic equipment.**
- In the WEEELABEX standard, the concentration limit given for polybrominated biphenyls (PBB) in plastic waste fractions is 50 mg/kg, and the concentration limit of commercial penta- and octabromodiphenyl ether in BDE mixtures[11] is 1 000 mg/kg for each commercial preparation separately. No concentration limit has been set for HBCDD.
- In the technical specification CLC/TS 50625-3-1 of CENELEC, plastic that may contain brominated flame retardants would be considered free from these substances if the bromine content of the plastic fraction is below 2 000 mg/kg. Plastic fractions that contain over 2 000 mg/kg of the substances must be sent out for further treatment, where the

[10] Maximum concentration limits in product legislation concerning brominated flame retardants include, for example, the concentration limits on PBDEs and PBB in EEE set by the RoHS Directive, as well as the concentration limits set in Annex I of the POP Regulation on tetra-, penta-, hexa- and hepta-BDEs and HBCDD in articles.
[11] Commercial octa-BDE contains hexa-, hepta-, octa- and nonabromodiphenyl ethers, while commercial penta-BDE contains tetra-, penta- and hexabromodiphenyl ethers.

plastics containing brominated flame retardants are isolated. If the procedure outlined in the standard is followed in the treatment of plastic parts, a part of POP waste will end up in waste fractions considered free from bromine and will be left out of further treatment.

8.4

Other international instructions

According to the technical instructions of the Basel Convention on the environmentally sound management of POPs (Basel Convention, 2015a, 2015b and 2015c):

- Waste containing POPs should be treated separately from other waste in order to avoid the contamination of other waste streams.
- In order to prevent emissions of flame retardants into the environment, breaking the polymer structure of the plastic should be avoided in their treatment.
- Treating wastes intentionally in a way that leads to the concentration of POPs being diluted below the concentration limit is not acceptable. However, mixing may be allowed if it is necessary for the appropriate treatment of waste.
- If only a part of the waste, such as electronic equipment, contains POPs, that part should be separated from the rest of the equipment and treated separately.
- Cutting up and shredding waste includes a risk of contaminating the processing equipment.

The Conference of the Parties to the Stockholm Convention issued a recommendation in 2011 to remove brominated flame retardants from the waste stream. A key instruction in the recommendation is to identify and separate materials containing POPs from the rest of the waste stream before recycling. (Stockholm Convention, 2010b). In addition, according to the preamble of the EU POP Regulation (recital 16), it is important that waste consisting of, containing or contaminated by any persistent organic compounds is identified and sorted at source in order to ensure that as little of the said chemicals as possible end up in other waste.

8.5

Use of parts removed from vehicles and EEE as spare parts

One of the central goals of both the Government Decree on End-of-Life Vehicles (123/2015) as well as the Government Decree on Waste Electrical and Electronic Equipment (519/2014) is to promote the reuse of vehicle or EEE parts as spare parts.

The EU POP Regulation (Annex I) allows the placing on the market and continued use of articles containing HBCDD, if the article in question was already in use before 23 March 2016. This also applies to parts taken from vehicles and EEE, which can be used as spare parts as is. Similarly, Annex I of the regulation allows the continued use of articles that contain bromodiphenyl ethers as a constituent, if they were already in use before 25 August 2010.

As for the production, placing on the market and use of articles or preparations manufactured out of recycled materials or materials from waste prepared for reuse, it is permitted if they contain less than 0.1 % of bromodiphenyl ethers by weight.

The RoHS Decree (419/2013) issues certain additional restrictions on the use of spare parts containing BDEs in EEE. The restrictions are based on the EU RoHS Directive (2011/65/EU). Spare parts containing more than 0.1 % of polybromodiphenyl ethers by weight may only be used as spare parts for electrical and electronic equipment placed on the market before July 2006. An exception consists of monitoring and control instruments and medical devices (for which the time limit for placing on the market is July 2014), in vitro diagnostic medical devices (time limit: July 2016) and industrial monitoring and control instruments (time limit: July 2017). In addition to BDEs already classified as POPs, these additional restrictions on the use of spare parts also apply to other BDEs, such as deca-BDE.

9 Options for treating plastic waste that contains POPs

When the legal requirements and the technology in use are taken into account (see Appendix 5), there are three options for separating and treating plastics that contain persistent organic pollutants on an industrial scale:

1. **Manually disassembling and removing plastics that contain brominated flame retardants from EEE or vehicles and treating the separate fraction as POP waste**
2. **Separating plastics that contain brominated flame retardants from shredded material and treating the separate fraction as POP waste**
3. **Further treatment of the whole fraction created during shredding as POP waste without separating the plastic that contains brominated flame retardants**

Out of these treatment options, the most appropriate one should be selected, taking account of the functionality of the whole producer responsibility chain.

Plastics containing POPs must be treated by incinerating them in an incineration plant that fulfils the requirements of the Government Decree on Waste Incineration (151/2013). So far, no other environmentally sound treatment methods exist for plastics containing brominated flame retardants that are tested on a large scale. Even though the POP Regulation also allows physico-chemical treatment, as of yet there is not enough research data about its suitability for the treatment of plastic waste that contains brominated flame retardants.

In practice, the only usable method for separating plastics that contain POPs is to identify and isolate all plastics containing brominated flame retardants and treat them as POP waste, regardless of which bromine compounds have been used as flame retardants in the plastic. This procedure is supported by the literature, which does not consider plastics containing brominated flame retardants as suitable for material recycling (Baxter et al., 2014). In practice, flame-retarded plastic is only suitable for recycling if the flame retardants used in the plastic and their characteristics are known and if they are suitable for the intended purpose. 0.1 % of brominated flame retardant by weight (1 000 mg/kg) can be considered as the concentration limit; it is the lower POP concentration limit for tetra-, penta-, hexa- and heptabromodiphenyl ether as well as hexabromocyclododecane.

It should be noted that in the POP Regulation, the concentration limit applies to compounds containing bromine. However, in practice the identification of plastics containing brominated flame retardants is usually based on measuring bromine as an element. Table 7 presents compound-specific concentration limits for bromine in flame retardants that correspond to the concentration limits in the POP Regulation. **In plastics separation, the concentration limit of 750 mg/kg of elemental bromine can be used to assess the amount of POP flame retardants based on bromine content**. The concentration limit in the POP Regulation has been set for the combined concentration of different tetra-, penta-, hexa- and hepta-BDEs, thus it would be reasonable to apply as the concentration limit of elemental bromine the average of concentration limits for commercial penta- and octabromodiphenyl ethers of 750 mg/kg. It is also the concentration limit of hexabromocyclododecane converted into bromine.

Appendix 6 discusses issues related to the three options presented above in more detail.

Issues related to environmental protection in shredding and the treatment of the resulting waste fractions have been discussed in more detail in **Appendix 7**.

Table 7: Estimating the concentration limit set for brominated flame retardants in the POP Regulation by calculation based on bromine.

Compound or commercial mixture	Lower concentration limit for the compound in waste based on the POP Regulation	Percentage of bromine in the compound or commercial mixture	Calculated concentration limit based on the POP Regulation for elemental bromine in the flame retardant
Commercial pentabromodiphenyl ether (contains tetra-, penta- and hexabromodiphenyl ethers)	1 000 mg/kg (0,1 %)	70 % *)	700 mg/kg (0,07 %)
Commercial octabromodiphenyl ether (contains hexa-, hepta-, octa- and nonabromodiphenyl ethers)	1 000 mg/kg (0,1 %)	79 % *)	790 mg/kg (0,079 %)
Hexabromocyclododecane	1 000 mg/kg (0,1 %)	75 % **)	750 mg/kg (0,075 %)

*) Alaee et al., 2003

**) calculated based on the compound's molecular mass

10 A summary of the application of the POP Regulation's requirements regarding the treatment of end-of-life vehicles and waste electrical and electronic equipment containing POPs

The obligations of the POP Regulation on waste must be applied to plastic waste from electrical and electronic equipment and end-of-life vehicles, if the concentration of brominated flame retardants is above the lower concentration limit according to the POP Regulation (see Chapter 2, Table 2). If the concentration of brominated flame retardants is determined by measuring the amount of bromine in the plastic, the applicable concentration limit is 750 mg/kg calculated as bromine. The concentration should be estimated in relation to an individual flame-retarded part, not the whole device, for example.

According to the regulation, POP waste may only be treated by incineration or physico-chemical treatment. During the treatment, the compounds must be destroyed or permanently transformed so that they no longer exhibit characteristics of persistent organic pollutants. As far as possible, the producer and holder of waste must prevent the contamination of waste with POPs. Therefore, the whole POP waste treatment chain must be arranged first and foremost so that any other waste created during the treatment cannot be contaminated by persistent organic pollutants at any point.

If only a part of the waste contains or is contaminated by persistent organic pollutants, the said part must be separated from the rest of the waste in accordance with Annex V of the POP Regulation and treated afterwards using the methods provided for in the regulation. The waste fraction generated during separation that does not contain POPs at a concentration above the lower concentration limit of the POP Regulation can also be treated using other acceptable methods according to the legislation on waste.

At the moment, incineration is the only applicable option for the treatment of plastic containing brominated flame retardants. Even though some of the physico-chemical treatments have also been considered suitable for the treatment of bromodiphenyl ethers and HBCDD, their functionality has not yet been sufficiently proven (Basel Convention, 2015a). An incineration plant incinerating plastics that contain brominated flame retardants classified as POPs must fulfil the technical and emission requirements laid down in the Government Decree on Waste Incineration (151/2013). Classifying the waste as hazardous or non-hazardous waste affects

the technical requirements set for incineration. If waste containing brominated flame retardants is classified as hazardous waste, and its concentration of halogenated organic compounds is above 1 % (expressed as chlorine), the waste must be incinerated in a kiln that reaches a temperature of 1,100 °C for at least two seconds. Waste classified as non-hazardous can be incinerated at the lower temperature of 850 °C, regardless of its concentration of halogenated organic compounds.

Material recycling of plastics that contain brominated flame retardants classified as POPs is not allowed if the lower concentration limits in accordance with the regulation are exceeded. Annex V of the regulation lists the types of POP waste that can be recycled as material. The recycling option only applies to certain metal containing wastes from the metal industry, but not waste fractions from end-of-life vehicles or EEE, such as plastics.

The regulation provides the option of placing POP waste in a landfill for hazardous waste, or deep inside bedrock in exceptional cases. However, the exception only applies to certain types of waste listed separately in the regulation. The exception on placement in a landfill or inside bedrock cannot be applied to waste from end-of-life vehicles or electrical and electronic equipment, because they are not among the waste entries in the European List of Waste, for which the exceptional procedure is allowed (see Appendix 3).

When the legal requirements and the technology used are taken into account, three options for separating and treating plastics that contain persistent organic pollutants on an industrial scale can be specified:

- Manually disassembling and removing plastics that contain brominated flame retardants from EEE or vehicles, and treating the separate fraction as POP waste
- Separating plastics that contain brominated flame retardants from shredded material and treating the separate fraction as POP waste
- Further treatment of the whole fraction created during shredding as POP waste without separating the plastic that contains brominated flame retardants

The most appropriate treatment option should be selected, taking account of the functionality of the whole producer responsibility chain.

Manually disassembling and removing plastics that contain brominated flame retardants is especially suitable for a producer responsibility system in which only the products manufactured by a specific producer or producers are pre-treated. In that case, there is usually more detailed information on the composition of the original products available in the scrap processing chain which has been provided by the manufacturer. Separation based only on the workers' experience on the flame retardants contained by individual parts is vulnerable to errors, in which case plastic containing POPs ends up in material streams considered suitable for recycling. Therefore, separation must be complemented by measuring the bromine content of the plastics. In manual separation, the polymer structure of plastics remains intact better than in shredding, which means that POPs will not contaminate clean waste fractions or the environment as easily. However, manual separation carries the risk of the workers being exposed to brominated flame retardants. Therefore, special attention must be paid to the occupational safety and health of the workers (see Appendix 6).

Plastics containing brominated flame retardants can also be separated from shredded waste and treated by incineration. Clean, bromine-free plastic fractions can be recycled in the manner allowed by the Waste Act (646/2011). Technical methods needed to separate plastic containing bromine from shredded material exist and are commercially available, but separation usually requires a combination of several separation methods (see Appendix 6).

If plastics from electrical and electronic equipment or end-of-life vehicles containing brominated flame retardants are not isolated from the shredded material, all fractions created during shredding that contain plastic must be treated as POP waste.

Even if the average concentration of bromine in the fraction created by cutting up or shredding was under the concentration limit of 750 mg/kg for bromine, in practice the low concentration may be due to the dilution of the concentration of compounds that has occurred during the process. Treatment of wastes that contain flame retardants classified as POPs intentionally in a way that leads to the concentration of the compounds in the waste being diluted under the concentration limit is not considered environmentally sound (Basel Convention, 2015b, JRC, 2015). Dilution or mixing may only be allowed if it is necessary for the appropriate treatment of POP waste. For example, dilution may be necessary if the required POP destruction efficiency for the chosen treatment method can be reached only, if the POP concentration of the waste being treated remains lower than a certain maximum concentration (see Appendix 7).

The industry´s own standards on the appropriate treatment of waste electrical and electronic equipment (WEEE Forum, 2013, SFS, 2014, SFS, 2015) also prohibit the dilution of fractions containing harmful substances or mixing them with other fractions to lower the concentration. The WEEE plastic fractions, from which brominated flame retardants have not been separated, are considered to contain brominated flame retardants, and regulations applying to them must be applied to their treatment. Similarly, according to the standard, WEEE plastic fractions containing brominated flame retardants must be treated as POP waste, unless it can be proven that they do not contain POPs.

In organising the operation of shredding and cutting up facilities, special attention must be paid to managing POP emissions, especially emissions into the air and dust control. Bromodiphenyl ethers and HBCDD bind with particles in significant amounts, which means that they can be found especially in the dust created during shredding. Dust control should be taken into account for both the shredding process itself as well as in the transport and storage of shredder residue. The shredding process and the shredder residue conveyor belts should be equipped with sufficient protective covers and dust collectors to prevent the dust from spreading (see Appendix 7).

A waste shipment permit granted by the Finnish Environment Institute is required for exporting plastic fractions containing brominated flame retardants classified as POPs (Waste Shipment Regulation (EC) No 1013/2006). Export can only be permitted for treatment considered acceptable in accordance with the POP Regulation. If the waste is classified as hazardous waste, exporting it to countries outside the OECD, such as China or India, is prohibited according to the Waste Shipment Regulation.

The industry´s own standards on the appropriate treatment of electrical and electronic equipment have also issued stipulations on the export of hazardous parts and materials from

EEE. According to the standards, operators cannot allow or participate in waste shipments, if they may lead to treating electrical and electronic equipment in a way that does not fulfil the requirements of the WEEE Directive (2012/19/EU) or the procedures of the recycling standard of the industry. The directive sets an obligation to separate all plastics containing brominated flame retardants from devices and treat them appropriately. The separation obligation also applies to plastics containing brominated flame retardants other than those included in the POP Regulation. According to the standard, parts and materials containing brominated flame retardants cannot be exported outside the EU or EFTA countries at all, unless the operator can prove that the requirements of the WEEE Directive and the standard are followed by the receiving facility.

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Appendix 1: Publication information on the EU POP Regulation and its amendments

Publication information on the EU POP Regulation and its amendments		
Regulation	Official Journal of the EU No	Date of publication
Regulation (EC) No 850/2004 of the European Parliament and of the Council on persistent organic pollutants and amending Directive 79/117/EEC	L 158	30 April 2004
Corrigendum	L 229	29 June 2004
Council Regulation (EC) No 1195/2006	L 217	8 August 2006
Council Regulation (EC) No 172/2007	L 55	23 February 2007
Council Regulation (EC) No 323/2007	L 85	27 March 2007
Regulation (EC) No 219/2009 of the European Parliament and of the Council	L 87	31 March 2009
Council Regulation (EC) No 304/2009	L 96	15 April 2009
Council Regulation (EC) No 756/2010	L 223	25 August 2010
Council Regulation (EC) No 757/2010	L 223	25 August 2010
Council Regulation (EC) No 519/2012	L 159	20 June 2012
Council Regulation (EC) No 1342/2014	L 363	17 December 2014
Commission Regulation (EU) 2015/2030	L 298	14 November 2015
Commission Regulation (EU) 2016/293	L 55	2 March 2016
Commission Regulation (EU) 2016/460	L 80	30 March 2016

Appendix 2: Information about the permitted usages of POPs, ending the use, and products and materials that may contain POPs

(ESWI, 2011, Häkkinen, 2012, Myllymaa et al., 2015)

Aldrin	
Products and materials that may contain aldrin	Pesticide
Still permitted usages / information on end of use	No more permitted usages. Agricultural use ended in Finland in the 1970s..
Dieldrin	
Products and materials that may contain dieldrin	Pesticide Wood preservative (plywood)
Still permitted usages / information on end of use	No more permitted usages. Agricultural use ended in Finland in the 1970s. Plywood treated with wood preservatives in Finland was inteded for export
Dichlorodiphenyltrichloroethane (DDT)	
Products and materials that may contain DDT	Pesticide
Still permitted usages / information on end of use	No more permitted usages. Agricultural use ended in Finland in the 1970s..
Dioxins and furans (PCDD/F)	
Products and materials that may contain dioxins and furans	Generated unintentionally in incineration and industrial processes as well as fires, such as landfill and forest fires • Ashes and slags from waste incineration • Dusts and residue from gas cleaning in the metal industry
Still permitted usages / information on end of use	Has not been manufactured intentionally
Endosulfan	
Products and materials that may contain endosulfan	Pesticide
Still permitted usages / information on end of use	According to Annex I of the POP Regulation, the placing on the market and use of articles already in use before 11 July 2012 containing endosulfan as a constituent of such articles is allowed. However, as far as known, no articles containing endosulfan as a constituent are used in Finland. Its use as a pesticide has been prohibited in Finland since 2001; however, it was still used at certain farms with an exceptional permit from 2003 to 2005

Endrin	
Products and materials that may contain endrin	Pesticide
Still permitted usages / information on end of use	No more permitted usages. Agricultural use ended in Finland in the 1970s.
Hexabromobiphenyl (HBB)	
Products and materials that may contain hexabromobiphenyl	Flame retardant: • Heat resistant materials • Electronic products • Coatings in the automotive industry • Polyurethane foam Lacquers
Still permitted usages / information on end of use	No more permitted usages. The substance has been replaced by bromodiphenyl ethers since the 1980s.
Hexabromocyclododecane (HBCDD)	
Products and materials that may contain HBCDD	Flame retardant: • Polystyrene foam in building insulation (EPS and XPS) • Plastic electrical and electronic equipment casings • Video cassette casings • Stereo and video player casings • Junction and extension boxes • Furnishing fabrics • Vehicle seats, interiors and bodies
Still permitted usages / information on end of use	According to Annex I of the POP Regulation, the placing on the market and use of articles containing HBCDD and already in use before 23 March 2016 is allowed. According to Annex I of the POP Regulation, substances, preparations, articles or parts of articles to be placed on the market may contain a maximum of 100 mg/kg of HBCDD. The concentration limit is not applied to expanded polystyrene used in buildings, if a fixed-term exceptional permit in accordance with the REACH Regulation has been granted for manufacturing it and placing it on the market. The exceptional permits granted can be found at http://ec.europa.eu/growth/sectors/chemicals/reach/about/index_en.htm, in the section 'Authorization Decisions'. No separate exceptions to the concentration limit exist for preparations and articles manufactured out of recycled material. The concentration limit for placing HBCDD on the market will be reviewed on 22 March 2019 at the latest.

Heksaklooribentseeni (HCB)	
Products and materials that may contain hexachlorobenzene	Wood preservative Pesticide Solvent in the plastic, chemical, textile and metal industries By-product of manufacturing chlorine, hydrochloric acid and other industrial chemicals containing chlorine Fireworks Generated unintentionally in incineration processes
Still permitted usages / information on end of use	No more permitted usages. Agricultural use ended in Finland in the 1970s. The use of HCB and the manufacturing and use of preparations containing it were prohibited in 2002.
Hexachlorobutadiene (HCBD)	
Products and materials that may contain HCBD	Heat carrier fluids Transformer fluids Hydraulic fluids Solvent (rubber and other polymers) By-product of manufacturing chlorinated hydrocarbons Pesticide
Still permitted usages / information on end of use	According to Annex I of the POP Regulation, the placing on the market and use of articles already in use before 11 July 2012 containing HCBD as a constituent of such articles is allowed.
Hexachlorocyclohexanes: Lindane (gamma-HCH)	
Products and materials that may contain lindane	Pesticide Pesticides for ectoparasites of humans and animals, such as lice shampoos Wood preservative
Still permitted usages / information on end of use	No more permitted usages. Agricultural use ended in the late 1980s. Use as a wood preservative most likely ended in the 1980s. Used to combat ectoparasites of humans and animals until the late 1990s.
Hexachlorocyclohexanes: isomers other than lindane (alpha- and beta-HCH)	
Products and materials that may contain alpha and beta isomers of HCH	Pesticide Solvent in the plastic, chemical, textile and metal industries as well as manufacturing paints
Still permitted usages / information on end of use	No more permitted usages. Technical HCH was used as a solvent until the early 1990s.
Heptachlor	
Products and materials that may contain heptachlor	Pesticide Wood preservative
Still permitted usages / information on end of use	No more permitted usages. Use as a pesticide has been prohibited since the mid-1990s. Use as wood preservative ended in the mid-1990s.

Chlordane	
Products and materials that may contain chlordane	Pesticide Wood preservative
Still permitted usages / information on end of use	No more permitted usages. Agricultural use ended in Finland in the 1970s. Use as wood preservative ended in the mid-1990s.
Chlordecone	
Products and materials that may contain chlordecone	Pesticide
Still permitted usages / information on end of use	No more permitted usages. Has not been used in Finland.
Short-chain chlorinated paraffins (SCCP)	
Products and materials that may contain SCCPs	Flame retardant in rubber (e.g. conveyor belts) Rubber, plastic Textiles, shoes Sealants and joint sealing compounds Paints, glues Metal processing fluids Lubricating oils Lava lamps
Still permitted usages / information on end of use	The use of SCCP has been restricted in the EU at concentrations higher than one per cent (10 000 mg/kg) in certain uses (in metal-working, for fat liquoring of leather) since 2002 through Directive 2002/45/EC. The use of SCCP has been restricted more extensively with the POP Regulation since 2012. According to Annex I of the regulation, the production, placing on the market and use of substances and preparations containing below 1 % of SCCP by weight is allowed. The production, placing on the market and use of articles containing below 0.15 % of SCCP by weight is allowed. However, the use of conveyor belts in the mining industry and dam sealants may continue, if they were already in use before 5 December 2015. The use of other articles containing more than 0.15 % of SCCP by weight may continue, if they were already in use before 11 July 2012.
Mirex	
Products and materials that may contain mirex	Pesticide
Still permitted usages / information on end of use	Agricultural use ended in Finland in the 1970s.
Polychlorinated biphenyls (PCB)	
Products and materials that may contain PCBs	Transformers and capacitors Joint sealing compounds in prefabricated houses Sealing compounds in multiple glass units Hydraulic, lubricating and machining oils Paints and lacquers

Still permitted usages / information on end of use	The manufacturing and sale of PCBs and the import, sale and transfer of articles containing PCBs has been prohibited since 1990 (Government Decision 1071/1989). Transformers containing PCB and capacitors of at least one KVAR were to be removed from service by the end of 1994. Equipment of over 5 dm^2 were to be removed from service in 1999 (Government Decision 711/1998).
Perfluorooctanesulfonic acid and its derivatives (PFOS)	
Products and materials that may contain PFOS compounds	Fire-fighting foams Surface-treated textiles and leather (e.g. clothes, furniture, carpets, vehicle interior upholstery) Paper and packaging (surface treatment) X-ray films Photography products (films, papers, photographic coatings applied to printing plates) Chrome plating and surface treatment baths Aviation hydraulic fluids Floor polishes and cleaning agents Paints and lacquers
Still permitted usages / information on end of use	According to Annex I of the POP Regulation, the use of articles already in use before 25 August 2010 containing PFOS as a constituent of such articles is allowed. The exception is fire-fighting foams; their use was to be completely ended in 2011. Substances or preparations placed on the market may contain 0.001 % of PFOS by weight at the maximum. The concentration of PFOS in semi-finished products and articles, or parts thereof, may not exceed 0.1 % by weight. The percentage is calculated with reference to the mass of structurally or micro-structurally distinct parts that contain PFOS. For textiles or other coated materials, the amount of PFOS must be lower than 1 µg/m2. In addition, PFOS may still be used in photoresists or anti-reflective coatings for photolithography processes, photographic coatings applied to films, papers, or printing plates, mist suppressants for non-decorative hard chromium (VI) plating in closed loop systems, and hydraulic fluids for aviation. Their use as wetting agents in controlled electroplating systems was to end on 26 August 2015 at the latest.
Pentachlorobenzene	
Products and materials that may contain pentachlorobenzene	PCB oil additive Flame retardant Colour binding agent in polyester fibres Impurity in certain pesticides and solvents Generated unintentionally in incineration and industrial processes, among other things
Still permitted usages /information on end of use	No more permitted usages.

Polychlorinated naphthalenes (PCN)	
Products and materials that may contain PCNs	Wood preservative Additive in paints and motor oils Cable insulation Capacitors Generated unintentionally in incineration processes
Still permitted usages / information on end of use	According to Annex I of the POP Regulation, the placing on the market and use of articles already in use before 11 July 2012 containing polychlorinated naphthalenes as a constituent of such articles is allowed.
Tetra-, penta-, hexa- and heptabromodiphenyl ether (BDE)	
Products and materials that may contain tetra-, penta-, hexa- and hepta-BDE	Flame retardant, e.g.: • Plastic electrical and electronic equipment casings • Circuit boards • Insulation in refrigerating equipment • Hard plastic vehicle parts, such as bumpers and dashboards • Vehicle seat and furniture padding manufactured out of polyurethane foam, mattresses • Building sound insulation boards • Imitation wood materials in buildings • Products manufactured out of recycled plastics (unintentional contamination)
Still permitted usages / information on end of use	Since 2004, the concentration of penta- and octabromodiphenyl ethers has not been permitted to exceed 0.1 % by weight in the flame-retarded parts of articles placed on the EU market (Directive 2003/11/EC of the European Parliament and of the Council). According to Annex I of the POP Regulation, substances, preparations, articles or flame-retarded parts of articles placed on the market since 26 August 2010 may contain 0.001 % of tetra-, penta-, hexa- or hepta-BDE by weight at the maximum. An exception is the production, placing on the market and use of articles or preparations manufactured out of recycled materials or materials from waste prepared for reuse, which is permitted if the article or preparation contains less than 0.1 % of the aforementioned BDEs by weight. Use of articles already in use before 25 August 2010 containing tetra-, penta-, hexa- or hepta-BDE as a constituent of such articles is still allowed.
Toxaphene	
Products and materials that may contain toxaphene	Pesticide
Still permitted usages / information on end of use	Agricultural use ended in Finland in the 1970s.

Appendix 3: Waste entries, for which a permit can be granted in exceptional cases for permanent storage in landfill for hazardous waste or in an underground storage

The permission to place POP waste in exceptional cases in a landfill for hazardous waste, deep inside safe bedrock or in a salt mine in accordance with the Article 7(4)(b) and Annex V, part 2, of the EU POP Regulation can be granted to waste listed in one of the following six-digit codes in the European List of Waste (Commission Decision 2014/955/EU):

The operation generating the waste	The wastes, to which the exception may apply	Entries in the European List of Waste[1)]
Waste generated in power plants and other combustion plants as well as waste incineration and pyrolysis plants	Fly ash, bottom ash, slag and boiler dust containing hazardous substances, from co-incineration in power plants and other (waste) incineration plants	10 01 14* 10 01 16*
	Fly ash, bottom ash, slag and boiler dust as well as solid wastes from gas treatment containing hazardous substances, created in waste incineration and pyrolysis	19 01 07* 19 01 11* 19 01 13* 19 01 15*
Wastes from the iron and steel industry	Solid wastes from gas treatment containing hazardous substances	10 02 07*
Wastes from aluminium thermal metallurgy	Primary production slags as well as salt slags and black drosses from secondary production	10 03 04* 10 03 08* 10 03 09*
	Wastes from treatment of salt slags and black drosses containing hazardous substances	10 03 29*
	Flue-gas dust as well as other particulates and dust (including ball-mill dust) containing hazardous substances	10 03 19* 10 03 21*
Wastes from lead thermal metallurgy	Dross and skimmings from primary and secondary production	10 04 01* 10 04 02*
	Flue-gas dust, other particulates and dust as well as solid wastes from gas treatment containing hazardous substances	10 04 04* 10 04 05* 10 04 06*
Wastes from zinc thermal metallurgy	Flue-gas dust and solid wastes from gas treatment containing hazardous substances	10 05 03* 10 05 05*
Wastes from copper thermal metallurgy	Flue-gas dust and solid wastes from gas treatment containing hazardous substances	10 06 03* 10 06 06*
Wastes from other non-ferrous thermal metallurgy	Salt slags from primary and secondary production	10 08 08*
	Flue-gas dust containing hazardous substances	10 08 15*
Wastes from casting of ferrous pieces	Flue-gas dust containing hazardous substances	10 09 09*
Waste linings and refractories	Linings and refractories from metallurgical processes containing hazardous substances	16 11 01* 16 11 03*

The operation generating the waste	The wastes, to which the exception may apply	Entries in the European List of Waste[1)]
Construction and demolition wastes (including excavated soil from contaminated sites)	Mixtures or separate fractions of concrete, bricks, tiles and ceramics containing hazardous substances	17 01 06*
	Soil and stones containing hazardous substances	17 05 03*
	Construction and demolition wastes containing PCB, excluding PCB containing equipment	17 09 02*
	Other construction and demolition wastes containing hazardous substances	17 09 03*
Wastes from vitrification	Fly ash and other flue-gas treatment wastes	19 04 02*
	Non-vitrified solid phase	19 04 03*

[1)] In Finland, the European List of Waste has been implemented in Annex 4 of the Waste Decree (179/2012, amended by 86/2015). The waste entries classified as hazardous have been marked in the list with an asterisk (*) after the waste identification number.

Appendix 4: Concentration limits for hazardous waste applied to the compounds in the EU POP Regulation

A separate substance-specific concentration limit for hazardous waste has been set on some of the POPs in Annex 4 of the Waste Decree (86/2015). If a separate substance-specific concentration limit for hazardous waste has not been set, the general hazardous waste classification concentration limits laid down in Commission Regulation 1357/2014 are applied. One POP may have several hazard classifications in accordance with the CLP Regulation (1272/2008) on the classification of chemicals. All hazard classifications of individual POPs in accordance with the CLP Regulation and the concentration limit for hazardous waste corresponding to each classification (Commission Regulation 1357/2014) have been listed in the table. The applicable concentration limit for hazardous waste in the waste classification is the lowest out of the concentration limits in accordance with the compound's hazard classification (shown in bold in the table).

POP	Classification of the substance in the list of hazardous substances in the CLP Regulation or another database	Hazardous waste classification concentration limit (the applicable concentration limit is shown in bold)	Basis for determining the hazardous waste concentration limit
Aldrin	Acute Tox. 3 (H301) Acute Tox. 3 (H311) Carc. 2 (H351) STOT RE 1 (H372) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	**50 mg/kg**	Substance-specific concentration limit (Waste Decree, Annex 4; 86/2015)
DDT	Acute Tox. 3 (H301) Carc. 2 (H351) STOT RE 1 (H372) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	**50 mg/kg**	Substance-specific concentration limit (Waste Decree, Annex 4; 86/2015)
Dieldrin	Acute Tox. 3 (H301) Acute Tox. 1(H310) Carc. 2 (H351) STOT RE 1 (H372) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	**50 mg/kg**	Substance-specific concentration limit (Waste Decree, Annex 4; 86/2015)
Endrin	Acute Tox. 2 (H300) Acute Tox. 3 (H311) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	**50 mg/kg**	Substance-specific concentration limit (Waste Decree, Annex 4; 86/2015)
Endosulfan	Acute Tox. 2 (H300) Acute Tox. 2 (H330) Acute Tox. 4 (H312) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	**0,25 % (2 500 mg/kg)** (0,5 %) (55 %) (25 %) (0,25 %)	General concentration limit of hazardous substances in waste (Commission Regulation 1357/2014)

POP	Classification of the substance in the list of hazardous substances in the CLP Regulation or another database	Hazardous waste classification concentration limit (the applicable concentration limit is shown in bold)	Basis for determining the hazardous waste concentration limit
Hexabromobiphenyl[1)]	(IARC group 2B)	**50 mg/kg**	Substance-specific concentration limit
Hexabromocyclododecane (HBCDD)	Repr. 2 (H361) Lact. (H362)	**3 % (30 000 mg/kg)** (-)	General concentration limit of hazardous substances in waste (Commission Regulation 1357/2014)
Hexachlorobenzene	Carc. 1B (H350) STOT RE 1 (H372) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	**50 mg/kg**	Substance-specific concentration limit (Waste Decree, Annex 4; 86/2015)
Hexachlorobutadiene[2)]	Carc. 1B (H350) Acute Tox. 3 (H301) Acute Tox. 2 (H310) Acute Tox. 2 (H330) Skin Irrit. 2 (H315) Eye Irrit. 2 (H319) STOT SE 2 (H371) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	**0,1 % (1 000 mg/kg)** (5 %) (2,5 %) (0,5 %) (20 %) (20%) (10 %) (25 %) (0,25 %)	General concentration limit of hazardous substances in waste (Commission Regulation 1357/2014)
Hexachlorocyclohexanes: Lindane (gamma-HCH)	Acute Tox. 3 (H301) Acute Tox. 4 (H312) Acute Tox. 4 (H332) Lact. (H362) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	**50 mg/kg**	Substance-specific concentration limit (Waste Decree, Annex 4; 86/2015)
Hexachlorocyclohexanes: Alpha and beta isomers of HCH[3)]	Acute Tox. 3 (H301) Acute Tox. 4 (H312) Carc. 2 (H351) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	**50 mg/kg**	Substance-specific concentration limit (Waste Decree, Annex 4; 86/2015)
Heptachlor	Acute Tox. 3 (H301) Acute Tox. 3 (H311) Carc. 2 (H351) STOT RE 2 (H373) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	**50 mg/kg**	Substance-specific concentration limit (Waste Decree, Annex 4; 86/2015)
Commercial pentabromodiphenyl ether (contains tetra-, and pentabromodiphenyl ethers)	Lact. (H362) STOT RE 2 (H373) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	(-) (10 %) (25 %) **0,25 % (2 500 mg/kg)**	Nationally applicable concentration limit for ecotoxicity (Häkkinen, 2016)

POP	Classification of the substance in the list of hazardous substances in the CLP Regulation or another database	Hazardous waste classification concentration limit (the applicable concentration limit is shown in bold)	Basis for determining the hazardous waste concentration limit
Commercial octabromodiphenyl ether (contains hexa- and heptabromodiphenyl ethers)	Repr. 1B (H360)	**0,3 % (3 000 mg/kg)**	General concentration limit of hazardous substances in waste (Commission Regulation 1357/2014)
Chlordane	Acute Tox. 4 (H302) Acute Tox. 3 (H312) Carc. 2 (H351) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	**50 mg/kg**	Substance-specific concentration limit (Waste Decree, Annex 4; 86/2015)
Chlordecone	Acute Tox. 3 (H301) Acute Tox. 3 (H311) Carc. 2 (H351) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	**50 mg/kg**	Substance-specific concentration limit (Waste Decree, Annex 4; 86/2015)
Short-chain chlorinated paraffins (SCCP) (alkanes C10-C13)	Carc. 2 (H351) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	(1 %) (25 %) **0,25 % (2 500 mg/kg)**	Nationally applicable concentration limit for ecotoxicity (Häkkinen, 2016)
Mirex	Acute Tox. 4 (H302) Acute Tox. 4 (H312) Carc. 2 (H351) Repr. 2 (H361) Lact. (H362) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	**50 mg/kg**	Substance-specific concentration limit (Waste Decree, Annex 4; 86/2015)
PCB	STOT RE 2 (H373) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	**50 mg/kg**	Substance-specific concentration limit (Waste Decree, Annex 4;
PCDD/PCDF	- [4)]	**15 µg WHO-TEQ/kg**	Substance-specific concentration limit (Waste Decree, Annex 4; 86/2015)
Pentachlorobenzene	Flam. Sol. 1 (H228) Acute Tox. 4 (H302) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	**50 mg/kg**	Substance-specific concentration limit (Waste Decree, Annex 4; 86/2015)
Perfluorooctanesulfonic acid and its salts	Acute Tox. 4 (H302) Acute Tox. 4 (H332) Carc. 2 (H351) Repr. 1B (H360) Lact. (H362) STOT RE 1 (H372) Aquatic Chronic 2 (H411)	(25 %) (22,5 %) (1 %) **0,3 % (3 000 mg/kg)** - (1 %) (2,5 %)	General concentration limit of hazardous substances in waste (Commission Regulation 1357/2014)

POP	Classification of the substance in the list of hazardous substances in the CLP Regulation or another database	Hazardous waste classification concentration limit (the applicable concentration limit is shown in bold)	Basis for determining the hazardous waste concentration limit
Polychlorinated naphthalenes[5)]	Acute Tox. 4 (H302) Acute Tox. 4 (H312) Skin Irrit. 2 (H315) Eye Irrit. 2 (H319) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	(25 %) (55 %) (20 %) (20 %) (25 %) **0,25 % (2 500 mg/kg)**	Nationally applicable concentration limit for ecotoxicity (Häkkinen, 2016)
Toxaphene	Acute Tox. 3 (H301) Acute Tox. 4 (H312) Skin Irrit. 2 (H315) STOT SE 3 (H335) Carc. 2 (H351) Aquatic Acute 1 (H400) Aquatic Chronic 1 (H410)	**50 mg/kg**	Substance-specific concentration limit (Waste Decree, Annex 4; 86/2015)

[1)] Classification information on hexabromobiphenyl in accordance with the EU legislation on chemicals is not available; IARC (The International Agency for Research on Cancer) has classified hexabromobiphenyl as possibly carcinogenic (IARC group 2B)

[2)] No harmonised EU classification is included for hexachlorobutadiene in Annex VI, table 3 of the CLP Regulation (1272/2008). Out of the classifications created by the industry in REACH registration, the one with the most complete information has been selected as the classification information. Because the classification information in question did not have a cancer hazard classification due to a lack of research data, the classification information has been supplemented by a cancer hazard classification from another REACH registration (group 1B carcinogen, H350). Other classifications created by the industry in REACH registration for hexachlorobutadiene include:

- Acute Tox. 4 (H302), Acute Tox. 4 (H312), Acute Tox. 4 (H332), Skin Irrit. 2 (H315), Skin Sens. 1 (H317), Aquatic Acute 1 (H400)
- Acute Tox. 3 (H301), Acute Tox. 2 (H310), Skin Irrit. 2 (H315), Eye Dam. 1 (H318), Carc. 2 (H351)
- Acute Tox. 3 (H301), Acute Tox. 3 (H311), Acute Tox. 2 (H330), Skin Corr. 1 (H314), Carc. 1B (H350)

(European Chemicals Agency (ECHA), C&L Inventory Database; accessed 29 May 2015)

[3)] There is no harmonised EU classification for alpha- and beta-HCH in Table 3, Annex VI of the CLP Regulation (1272/2008), the classification information is from classifications created by the industry in REACH registration (European Chemicals Agency (ECHA), C&L Inventory Database, accessed 29 January 2015)

[4)] Dioxins and furans are not classified in the legislation on chemicals, because they are not manufactured as products

[5)] Harmonised classification for pentachloronaphthalene. Classifications created by the industry in REACH registration for other PCNs, such as:

- monochloronaphthalene: Acute Tox. 4 (H302), Skin Irrit.2 (H315), Eye Irrit. 2 (H319), STOT SE 3 (H335), Aquatic Acute 1 (H400)
- dichloronaphthalene: Acute Tox. 4 (H302), Skin Irrit. 2 (H315), Eye Dam. 1 (H318), STOT SE 3 (H335), Aquatic Chronic 2 (H411)
- octachloronaphthalene: Acute Tox. 4 (H302)

(European Chemicals Agency (ECHA), C&L Inventory Database; accessed 29 May 2015)

Appendix 5: Methods suitable for separating plastic that contains bromine

In treatment of plastics that contain POPs, the key issue is how to identify and separate them from other plastics. At the moment, there is no suitable method for industrial activity for identifying plastics containing brominated flame retardants classified as POPs at the compound level (i.e. identifying the specific bromine compound). At the compound level, identifying brominated flame retardants is only possible by laboratory analysis. The brominated flame retardants are extracted from the sample, and the extract is analysed using a gas chromatograph mass spectrometer (GC-MS), for example. The standard SFS-EN 16377:en 'Characterization of waste. Determination of brominated flame retardants (BFR) in solid waste' (SFS, 2013) can be used in the determination process. However, laboratory analyses are slow, expensive and labour-intensive, and therefore they are only suitable for spot checks and separate investigations.

Technology for separating plastics containing brominated flame retardants without identification at the compound level exists and is commercially available. The effective separation of plastics is not always possible by using one single method; instead, it requires a combination of several methods.

In practice, there are two main alternative approaches for separating plastics that contain bromine from electrical and electronic equipment and end-of-life vehicles: The plastic parts can be manually disassembled and removed from equipment or vehicles and the plastics containing bromine identified using e.g. an XRF analyser, or the plastic pieces containing bromine can be separated from shredded material by optical separation, which may be followed by separation based on density (Peeters et al., 2014, Baxter et al., 2015, Myllymaa et al., 2015).

The choice of method also has a significant impact on the separation efficiency (Peeters et al., 2014). The separation of plastics from electrical and electronic equipment by disassembling them manually leads to a more effective separation of the plastic fraction containing brominated flame retardants (Baxter et al., 2015). The lower purchase price of separation equipment is another benefit of the method, but the long-term operating costs are higher than separation from shredded material, because manual separation requires a lot of manpower. In addition, the method is vulnerable to human error.

Technical methods presented in the literature for separating plastics containing brominated flame retardants:

The *XRF analyser* (X-ray fluorescence, XRF) is a handheld device, and each plastic part has to be measured separately. In the method, the sample is exposed to X-rays, which excite the atoms in the sample's elements, making them send X-rays characteristic to them. The method can be used for taking measurements when manually disassembling vehicles or EEE. XRF analysers have a sufficiently low limit of identification (10-100 mg/kg) that they can be used to detect bromine concentrations above the concentration limit set for POPs. Based on studies, taking measurements from a single plastic part takes 3–60 seconds, depending on the type of device being studied. In a Norwegian study, it took 8 minutes to examine an entire vehicle. Handheld XRF analysers are commonly used to identify brominated flame retardants in new devices in the monitoring related to the RoHS Directive (2011/65/EU) that regulates the use of hazardous

substances in electrical and electronic equipment (Bratland, 2012, Stockholm Convention et al., 2015, Myllymaa et al., 2015).

XRF measurements can also be automated. In a study by Peeters et al. (2014), a sorter was set to separate pieces of plastic with a bromine concentration above 1 000 mg/kg from the shredded material. The speed of the conveyor belt can be used to influence the purity of the fraction. Fractions containing brominated flame retardants (BRF) can be separated from the shredded material effectively using this method, but plastic that does not contain brominated flame retardants can also end up in the plastic fraction containing BRFs. When separating shredded plastic originating from LCD TVs, an estimated 30 % of the plastic stream ended up in the plastic fraction containing brominated flame retardants, while based on analyses, slightly less than 20 % of the TV casings actually contained brominated flame retardants. The degree of purity of the plastic fraction free from BFRs as a result of the separation was over 95 % (Peeters et al., 2014, Baxter et al., 2015).

Sliding spark spectrometry, SSS, is another manual measurement method. The sample is vaporised and its atoms are excited in an arc, which makes them emit radiation characteristic of the element. The radiation can be measured using a spectrometer. Measuring one piece of plastic takes just a few seconds. However, coated or painted pieces can only be measured by breaking up the surface. The limit of identification of a sliding spark spectrometer is 1 000 mg/kg (Stockholm Convention et al., 2015, Myllymaa et al., 2015).

X-ray transmission (XRT) has been developed for separating materials with different optical densities. It involves an electric source of X-rays that generates broadband radiation, which is directed through the material to be analysed at an X-ray camera. The analyser can be installed as part of the treatment line (Myllymaa et al., 2015).

The sink-float method is based on the differences in density between different types of plastic. The plastic waste is placed in saline solutions with different salinities; as a result, the plastics with a density higher than that of the saline solution sink, while the lighter plastics float. The method is suitable for separating plastic containing bromine from shredded material (Leslie et al., 2013, Baxter et al., 2014). This method can be used to separate ABS, HIPS and PS plastics without flame retardant from flame-retarded ABS and PS plastic. Certain other plastics with a density close to that of ABS plastic treated with brominated flame retardants may affect the purity of plastic fractions containing brominated flame retardants. Such plastics include PC/ABS plastic that contains phosphorus-based flame retardants and PC-ABS without flame retardant (Leslie et al., 2013). The use of the sink-float method to separate plastics containing brominated flame retardants from other plastics has been described in a U.S. patent (Schlummer and Mäurer, 2012).

Sliding spark spectrometry, X-ray transmission or the sink-float method can be combined with near-infrared analysis (NIR), which can be used to identify the type of plastic. Different types of plastic polymers absorb and reflect the different wavelengths of infrared light in a variety of ways, and focused streams of air can be used to separate the plastic pieces with the desired spectrum from the line. The method is suitable as a continuously operating measurement method on a separation line. It makes it possible to separate the types of plastic most likely to contain POPs (PUR, ABS and HIPS plastics) from the plastics that contain bromine.

However, NIR is not particularly well suited to identifying black plastic (Gardner et al., 2010, Baxter et al., 2014, Stockholm Convention et al., 2015).

Fourier Transform Infrared Spectroscopy (FTIR) can also be used to identify the type of plastic (Taurino et al., 2010, Stenvall et al., 2013).

Several methods have been developed to remove bromine from plastic, but at the moment, they mainly involve pilot facilities that do not function on a commercial scale. The CreaSolv® method, based on solvents, has been estimated to be potentially commercially viable (Schlummer et al., 2006, Stockholm Convention et al., 2015). In the future, these methods may provide a practicable option for separating certain plastics containing brominated flame retardants.

Appendix 6: Issues related to the treatment options of plastic that contains bromine

This appendix discusses in more detail issues related to the three options for the treatment of plastic containing bromine, presented in Chapter 9.

Option 1: Separating plastics containing brominated flame retardants manually before treatment

When plastics containing brominated flame retardants are manually disassembled and removed from end-of-life vehicles or electrical and electronic equipment, POPs are not released from the flame-retarded material in the same way as when materials are shredded in a shredder plant. However, manual separation carries a greater risk of the workers being exposed to brominated flame retardants. Workers in treatment plants for waste electrical and electronic equipment and end-of-life vehicles have been found to have elevated PBDE levels (e.g. Thuresson et al., 2006, Sakai et al., 2007, Schecter et al., 2009). Therefore, special attention must be paid to the occupational safety and health of workers.

Identifying parts that contain brominated flame retardants is difficult, because the use of flame retardants in vehicles and electrical and electronic equipment varies, depending on the manufacturer and model. In principle, according to the ELV Directive and the WEEE Directive, the producers of vehicles and EEE have an obligation to inform the authorities and the treatment companies of the harmful substances and parts in the products. However, such information is not usually provided about the brominated flame retardants in the plastic parts. Because no model-specific information about the use of flame retardants classified as POPs is available from the industry, it is not possible to give detailed instructions on separating the parts of EEE and vehicles. In practice, a practicable method should include all materials containing brominated flame retardants in the separation.

Manual separation would be especially suitable for a producer responsibility system that only pre-treats products manufactured by a certain producer or producers. In that case, there is usually more detailed information on the composition of the original products available in the scrap processing chain, provided by the manufacturer.

Separation based only on the workers' experience of the flame retardants contained by individual parts is vulnerable to errors, in which case plastic containing POPs ends up in material streams considered suitable for recycling. Therefore, separation should be complemented by measuring the bromine content of the plastics. The models and parts of electrical and electronic equipment or vehicles most likely to contain bromine should be determined based on comprehensive sampling, and the personnel carrying out the separation should be instructed based on these statistics. The quality of the separation instructions should be monitored by control measurements taken by random sampling. This requires that the producer corporations and their business partners have a systematic measurement programme and a practice for recording the measurement results. A rather large number of measurements would be necessary at the start of the operation if the producers failed to provide detailed additional information about the flame retardants in the equipment or vehicles.

Plastics containing bromine can be identified during manual separation by using e.g. an X-ray fluorescence analyser (XRF) (see Appendix 5); handheld models exist. In the guidelines of the Basel Convention, it has also been proposed as the simplest method for identifying parts containing brominated flame retardants.

In separation, the concentration limit used for bromine in the plastic part is 750 mg/kg (see Chapter 9).

The whole plastic fraction containing brominated flame retardants that is generated in the separation must be treated as POP waste in the manner required by the POP Regulation.

On which parts of electrical and electronic equipment should manual separation focus?

Electrical and electronic equipment have been divided into ten equipment categories in Appendix 1 of the Government Decree on Waste Electrical and Electronic Equipment. Equipment categories 1–4 cover 93 % of all collected plastic in EEE by weight (Baxter et al., 2014). According to the literature, equipment category 1 (large household appliances) does not usually contain brominated flame retardants (Ministry of Ecology, Sustainable Development and Energy, 2012, WEEE Forum, 2013, Baxter et al., 2014), excluding the polystyrene inner linings of refrigerating equipment (Stockholm Convention, 2010a). In the standard on removing harmful substances from WEEE (SFS, 2015), refrigerating equipment that contains volatile hydrocarbons or volatile hydrofluorocarbons are not assumed to contain brominated flame retardants.

Small household appliances in categories 2 (small household appliances), 3 (IT and telecommunications equipment) and 4 (consumer equipment and solar panels) constitute a total of 47 % of the collected WEEE and 54 % of the WEEE plastic (Baxter et al., 2014). In equipment category 2, brominated flame retardants have rarely been used (Wäger et al., 2010). Attention should be paid mainly to small appliances that heat up and may have been flame-retarded. Important for plastic separation are especially the equipment categories 3 and 4, in which brominated flame retardants have been found to be a significant problem (Wäger et al., 2010, Baxter et al., 2014, Myllymaa et al., 2015). Brominated flame retardants have been discovered especially in TV and computer casings, office equipment and circuit boards as well as domestic telecommunications equipment.

Equipment categories 6 (electrical and electronic tools) and 7 (toys, leisure and sports equipment) may also contain brominated flame retardants. Their share of the total amount of WEEE collected is small, approximately 3 % (Baxter et al., 2014).

In order to separate plastics containing flame retardants classified as POPs from EEE, the bromine content measurements should be focused especially on the following equipment (Myllymaa et al., 2015):

- TV and computer casings, office equipment and small devices that heat up, manufactured before 2005
- Electrical and electronic tools as well as toys, leisure and sports equipment, manufactured before 2005
- Refrigerating equipment manufactured before 2016

Usually circuit boards do not contain flame retardants classified as POPs; instead, they contain tetrabromobisphenol A (TBBPA). Circuit boards are usually treated in metal smelting plants, where the plastic in the circuit boards is used as energy. At the same time, the POPs they may contain are treated in an acceptable manner, provided that the treatment plant fulfils the requirements of the Government Decree on Waste Incineration.

On which parts of end-of-life vehicles should manual separation focus?

In order to separate plastics containing flame retardants classified as POPs from end-of-life vehicles, the bromine content measurements should be focused especially on the following parts (Myllymaa et al., 2015)::

- Vehicle seats and their rear sections (out of polyurethane), manufactured before 2005
- Engine room sound insulation, dashboards, parcel shelves, electronic parts and their casings, etc. in vehicles manufactured before 2005. (Parts manufactured out of ABS and HIPS plastics)
- Interior upholstery of vehicles manufactured before 2016, such as door panels, ceilings, safety belt, seat upholstery textiles, etc. (Parts manufactured out of HIPS plastic and polystyrene, textiles)

Tetra-, penta-, hexa- and hepta-BDE should no longer be found in vehicle models from 2005 or later. It is estimated that vehicles manufactured before 2005 will be scrapped in Finland by 2025 at the earliest.

The use of hexabromocyclododecane (HBCDD) in vehicle interior materials ended in August 2015. Vehicle models from 2015 and older will be scrapped in Finland by the mid-2030s.

Deca-BDE, which will probably be added to the POP Regulation in 2018, can still be used as a flame retardant in vehicle parts. After deca-BDE has been approved and added to the POP Regulation, the measurements should be expanded to cover vehicles manufactured before 2019. Plastics and textiles likely to contain deca-BDE will be found in end-of-life vehicles until around 2040.

Option 2: Separating plastics that contain brominated flame retardants from shredded material and treating the separate fraction as POP waste

Several commercially available technical solutions exist for identifying and separating plastics containing brominated flame retardants from shredded material. Methods suitable for separation are described in more detail in Appendix 5. For example, Stena Technoworld in Sweden uses the sink-float method to separate plastics containing bromine, and the purity of the fraction is monitored with regular XRF measurements (Stenvall et al., 2013).

Separation from shredded material usually requires a combination of several methods to separate different plastic types into clean fractions. The technology used is quite expensive (Baxter et al., 2014). In fact, separating plastics containing brominated flame retardants from shredded material is usually only commercially viable if BFR-free plastic fractions are separated for material recycling at the same time.

During separation, 750 mg/kg should be used as the concentration limit for bromine (see Chapter 9). The procedure in accordance with the recycling standards of the electrical and

electronic industry (see Section 8.3), in which plastic is considered free from brominated flame retardants if it contains less than 2 000 mg/kg of bromine, does not fulfil the requirements of the POP Regulation. The concentration should not be determined as the average bromine concentration of unseparated shredded material, either, because the POP concentration is significantly diluted during the shredding process. Treating wastes that contain brominated flame retardants intentionally in a way that leads to the concentration of compounds in the waste becoming diluted under the POP concentration limit is not considered environmentally sound (Basel Convention, 2015b, JRC, 2015).

The whole fraction containing brominated flame retardants generated during separation must be treated as POP waste in the manner required by the POP Regulation.

Option 3: Treating shredded material as POP waste, if it is not possible to separate brominated flame retardants from other waste

If the plastic that contains bromine is not separated during the pre-treatment phase of EEE or end-of-life vehicles, or isolated from the material generated by shredding, the resulting waste fraction containing plastics as a whole must be treated as POP waste, unless the producers can provide certain knowledge that the equipment or vehicles treated do not contain prohibited flame retardants. This may increase the amount of waste treated as POP waste considerably. Even though the average concentration of bromine in the fraction created by cutting up or shredding was under the concentration limit of 750 mg/kg for bromine, in practice the low concentration is due to the dilution of the concentration of compounds that has occurred during the process. The treatment of wastes that contain brominated flame retardants intentionally in a way that leads to the concentration of the compounds in the waste being diluted under the POP concentration limit is not considered environmentally sound (Basel Convention, 2015b, JRC, 2015).

Shredder light fractions or other shredded material that contain POPs must be treated by incinerating it in an incineration plant that fulfils the requirements of the Government Decree on Waste Incineration. At the moment, there is not enough research data on whether an environmentally sound destruction efficiency of brominated flame retardants classified as POPs could be achieved by any other treatment method. According to the instructions of the Basel Convention, the destruction efficiency rate should be at least 99.999 %.

If the materials in the light fraction or other shredded material are to be treated further for material recycling, the recycling process must be organised so that the plastics and textiles containing brominated flame retardants end up in a fraction treated in a manner approved by the POP Regulation (incineration).

Appendix 7: Environmental considerations related to shredding plastic containing brominated flame retardants and the resulting fractions

Possible disadvantages of shredding waste that contains brominated flame retardants include the contamination of equipment by POPs, workers being exposed to the substances, and the release of brominated flame retardants into the environment.

Electronics disassembly sites, and sites in which waste plastics from e.g. electronics or vehicles are treated, are high risk areas with regard to brominated flame retardants classified as POPs. In Annex C of the Stockholm Convention, shredder plants for the treatment of end-of-life vehicles have also been identified as operations, in which POPs such as dioxins and furans can be generated unintentionally (Basel Convention, 2015b, Basel Convention, 2015c, Stockholm Convention et al., 2015). In shredding, brominated dioxins and furans (PBDD/F) may be created from brominated flame retardants, most likely due to the frictional energy created during shredding and the rise of the plastic particles' surface temperature, or as a result of a chemical reaction started by the molecules torn during shredding (Schlummer, 2007, Retegan et al., 2010). This should be taken into account in protecting workers.

An update of the Best Available Techniques (BAT) Reference Document for Waste Treatment (BREF) is currently being prepared by the EU. For the first time, the BREF for Waste Treatment also discusses the best available techniques for shredder plants for waste with metal content (JRC, 2015). According to the BREF draft, the emissions management at shredder plants should be carried out primarily through feed quality management. If this approach is also applied to POPs, plastics containing brominated flame retardants should be removed from the scrap before shredding end-of-life vehicles or other metal containing wastes. The current BREF draft has not yet paid attention to the emissions management of the new substances added to the POP Regulation. In the future, the upcoming BREF on treatment plants and its binding BAT conclusions may affect the treatment of POP waste in shredder plants.

If materials containing brominated flame retardants are not removed from end-of-life vehicle, EEE or other waste to be shredded before feeding them into the process, special attention must be paid to the management of POP emissions in the operation of shredder plants, especially emissions into the air and dust control.

Dust control should be taken into account both in the shredding process itself as well as in the transport and storage of the shredded material. The shredding process and the conveyor belts should be equipped with sufficient protective covers and dust collectors to prevent the dust from spreading. The dust created in emission control should be treated in a way accepted by the POP Regulation, so that the POPs are destroyed. If the plant uses a wet process to control dust, BDEs may also end up in the sludge and process water of the Venturi scrubber; destroying the POPs should be taken into account in their treatment.

The waste should be stored on an impermeable base, and shredded material as well as material generating dust, such as light fraction, should be stored in covered areas. Dust containing POPs should be prevented from spreading into the environment with rainwater and other water or transport equipment.

If necessary, rules regarding mapping the emissions during the process and the emissions into the environment of brominated flame retardants classified as POPs as well as dioxins and furans should be included in the environmental permits of high risk facilities, such as shredder plants for EEE plastics and shredder plants for the treatment of end-of-life vehicles.

If it is not possible to ascertain that the shredder feed does not contain brominated flame retardants, the waste fractions containing plastics created in the treatment of vehicles and electrical and electronic equipment, from which plastic containing BFRs has not been separated, must be treated as POP waste even if the concentration of the compounds in the waste fraction do not exceed the concentration limit for POP waste. The low concentration is probably due to the concentration of compounds becoming diluted during the shredding process. Treatment of wastes that contain brominated flame retardants intentionally in a way that leads to the concentration of the compounds in the waste being diluted under the POP concentration limit is not considered environmentally sound, because it does not diminish the overall POP load on the environment (Stockholm Convention, 2010b, Basel Convention, 2015b, JRC, 2015). In the draft BREF for Waste Treatment, it has been considered that the operation of shredder plants and screens can also be seen as mixing waste (JRC, 2015).

However, diluting or mixing POP waste with other waste could be allowed, if it is necessary for the appropriate treatment of waste. For example, dilution may be necessary if the chosen treatment method only reaches the required POP destruction efficiency, if the POP concentration of the waste being treated remains lower than a certain maximum concentration. For example, it is known that a sufficient destruction efficiency in incinerating EPS and XPS plastics containing HBCDD in a municipal waste incineration plant can only be achieved if plastics containing 6 000–21 000 mg/kg of HBCDD constituted 1–2 % of the total amount of waste processed (Mark et al., 2015). This would correspond to a maximum concentration of 420 mg/kg of HBCDD in the feed of the incineration plant. There is no research data on the destruction of HBCDD in a municipal waste incineration plant at higher concentrations in the feed than this.

According to a literature survey carried out in 2015 (Bipro, 2015), the concentrations of bromodiphenyl ethers in the shredder light fractions found in measurements taken around the world have varied between 0 % and 13.8 % in the 1990s and the 2000s. The highest concentrations have been found in the light fractions from shredder plants specialised in the treatment of waste electrical and electronic equipment, and the next highest have been found in the light fractions from plants in which end-of-life vehicles, electrical and electronic equipment and other waste with metal content are treated together. The lowest concentrations were found in shredder plants treating only end-of-life vehicles. The congeners of deca-BDE were the most common in shredder light fractions. The concentration of deca-BDE in the shredder fractions of WEEE varied between 0 and 138 000 mg/kg, while the variation in light fractions from plants carrying out joint treatment was 0–820 mg/kg and that of automotive shredder light fractions was 10–2,160 mg/kg. The concentrations of commercial octa-BDE in light fractions were 0–4 400 mg/kg in the treatment of WEEE alone, 0–280 mg/kg in joint treatment and 0–190 mg/kg in the treatment of end-of-life vehicles. In the measurements carried out, commercial penta-BDE had the lowest concentrations; approx. 0–30 mg/kg in the light fractions from the treatment

of EEE, 0–25 mg/kg in light fractions from joint treatment, and approx. 0–60 mg/kg in light fractions from end-of-life vehicle shredder plants.

The concentrations of PBDEs in light fractions have diminished in the 2000s, as the use of the substances has been reduced. For example, in measurements carried out in Japan, the total concentration of PBDEs in light fractions from the shredding of vehicles manufactured before 1996 varied from approx. 200 to 620 mg/kg, while the concentrations in shredding vehicles manufactured after 2000 were approx. 40–190 mg/kg (Bipro, 2015).

In Sweden, the bromine content measured from automotive shredder light fractions by Stena Metall AB was 100–300 mg/kg and the concentration in finer material was 100 mg/kg (Naturvårdsverket, 2012). In Finland, too, total bromine concentrations in light fractions measured at a single plant have varied from 100 to 600 mg/kg. At least a part of this concentration comes from the brominated flame retardants in plastics.

In practice, the only applicable treatment method for destroying brominated flame retardants is incineration. The incineration must be carried out in a facility that fulfils the requirements on waste incineration laid down in the Government Decree on Waste Incineration (151/2013), such as the emission limit values on dioxins and furans. Section 4.1 has more information about the suitability of different incineration processes for destroying POPs.

Before alternative methods to incineration in the treatment of waste fractions containing brominated flame retardants can be approved, it should be comprehensively investigated as to whether the process achieves an environmentally sound destruction efficiency of brominated flame retardants classified as POPs. According to the instructions of the Basel Convention, the destruction efficiency should be at least 99.999 %. In addition, it should be ensured that new POPs, such as chlorinated or brominated dioxin or furan compounds, are not created in the process.

For example, there seem to be problems linked to manufacturing pyrolysis oil from plastics containing brominated flame retardants. Pyrolysis oil manufactured out of plastics from electrical and electronic equipment has been found to contain significant amounts of brominated organic compounds regardless of the pyrolysis temperature. PBDEs are not completely destroyed in relatively low temperatures and oxygen-free process conditions, which may lead to the creation of other congeners, dioxins and furans (Weber and Kuch, 2003, Retegan, 2010, Li et al., 2013, Bipro, 2015).

In addition to brominated flame retardants, the light fractions created in the treatment of end-of-life vehicles and waste electrical and electronic equipment also contain other materials such as PVC plastic, which may participate in the formation of dioxins and furans. The waste may also contain small amounts of copper, which may act as a catalyst in the formation process of dioxins and furans. Large amounts of chlorinated aromatic compounds, including PCDD/Fs, have been found to be created in the pyrolysis of such waste (Weber and Sakurai, 2001). In waste incineration, a copper content as low as 0.007 % has been found to be sufficient to catalyse the formation of dioxins. Many other metals and metal oxides (such as aluminium, nickel, lead, zinc and chromium) can act as catalysts in the formation of dioxins, but they are weaker catalysts than copper (Johansson, 2008).

Workers in treatment plants for waste electrical and electronic equipment and end-of-life vehicles have been found to have elevated PBDE levels (e.g. Thuresson et al., 2006, Sakai et al., 2007, Schecter et al., 2009). In the United States, it has been estimated that the exposure of workers at recycling plants is 6–33 times higher than the rest of the population (Schecter et al., 2009). Workers are exposed to brominated flame retardants by air and dust. However, advanced occupational health and safety methods can reduce the exposure of workers considerably (Sjödin et al., 1999).

In addition to dust emissions and emissions into the air, waste treatment operations can also result in emissions of brominated flame retardants into waste water and landfill leachate (Basel Convention, 2015b). There are large landfill-specific differences in the concentrations of PBDEs in the leachate. For example, the PBDEs measured from the leachate of municipal waste and industrial waste landfills in five different studies[12] amount to 0–1 357 ng/l (Canada), 25–160 ng/l (Minnesota, USA), 0–2 ng/l (Sweden), 0–50 ng/l (Japan) and 2–19 ng/l (South Africa) (Danon-Schaffer et al., 2014). Concentrations of BDEs high enough to cause concern have been found in Norway in the soil and environment of landfills and industrial areas, such as sediments in the seabed (Fjeld et al., 2004, Stockholm Convention, 2006).

In Finland, concentrations of PBDEs and HBCDD in landfill leachate have only been studied in individual samples from two landfills. In the leachate of a landfill still in operation, the PBDE concentrations were approx. 11 and 16 ng/l[13] while the concentrations in the leachate from a closed landfill were 0.6 and 0.8 ng/l[14]. In one sample from the operational landfill, there was 3 ng/l of HBCDD. In Finland, e.g. automotive shredder light fractions have previously been placed mostly in the industry's own landfills. Fine light fractions (less than 9 mm) are still being placed into one landfill. In addition, e.g. waste electrical and electronic equipment as well as construction waste containing flame-retarded plastic may have previously been placed in municipal landfills. Emissions of brominated flame retardants classified as POPs should be investigated, especially at landfills in which significant amounts of automotive shredder light fraction, EEE or their plastic parts or construction waste may have been placed.

[12] For purposes of comparability, the congeners BDE-47, BDE-99, BDE-100, BDE-154, BDE-207, BDE-209 have been taken into account (Danon-Schaffer et al., 2014)

[13] The total concentration of twelve congeners (BDE-17, BDE-28, BDE-47, BDE-66, BDE-85, BDE-99, BDE-100, BDE-153, BDE-154, BDE-183, BDE-203, BDE-209)

[14] The total concentration of ten congeners (BDE-28, BDE-47, BDE-66, BDE-85, BDE-99, BDE-100, BDE-153, BDE-154, BDE-183, BDE-209)

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<tr><td>Abstract</td><td colspan="3">Persistent organic pollutants are toxic chemical compounds that persist in the environment, bioaccumulate through the food chain, and are transported far from their sources via the air, water or migratory species.

Provisions on the management of waste containing POP compounds are laid down in Regulation (EC) No 850/2004. Several substances have been added to the POP Regulation since its adoption in 2004. Now the Regulation contains 25 persistent organic compounds or groups of compounds. The most recently added new substances are significant in terms of waste management because these compounds are also present in regular consumer goods that end up in municipal waste management. Earlier the Regulation was mainly concerned with waste management relating to industrial chemicals and pesticides.

The guide gives the instructions on types of waste to be classified as POP waste and presents the requirements for the management of such waste laid down in the Regulation. The guide presents in more detail how the management of end-of-life vehicles (ELV) and waste electrical and electronic equipment (WEEE) containing brominated flame retardants should be organised in order that the requirements of the POP Regulation are fulfilled.

The guide is intended for the municipal and state environmental permit and supervisory authorities, companies in whose operations POP waste may be generated, waste management companies, and waste management consultants.

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<tr><td>Tiivistelmä</td><td colspan="3">Pysyvät orgaaniset yhdisteet (Persistent Organic Pollutants, POP) ovat myrkyllisiä, hitaasti hajoavia kemiallisia yhdisteitä, jotka kertyvät eliöihin ravintoketjussa ja kulkeutuvat kauas päästöpaikastaan ilman, veden tai muuttavien eläinlajien välityksellä.

POP-yhdisteitä sisältävien jätteiden käsittelystä on säädetty EU:ssa ns. POP-asetuksella (EY N:o 850/2004). POP-asetukseen on sen voimassaoloaikana lisätty lukuisia uusia aineita. Tällä hetkellä asetus sisältää 25 pysyvää orgaanista yhdistettä tai yhdisteryhmää. Asetuksen viimeisimmät uudet aineet ovat jätehuollon kannalta merkityksellisiä sen vuoksi, että näitä yhdisteitä esiintyy myös tavallisissa yhdyskuntajätehuoltoon päätyvissä kulutushyödykkeissä. Aiemmin asetus koski lähinnä erilaisten teollisuuskemikaalien ja torjunta-aineiden jätehuoltoa.

Oppaan tarkoituksena on antaa ohjeet siitä, milloin jäte on luokiteltava POP-jätteeksi ja mitä vaatimuksia asetuksessa säädetään POP-jätteiden käsittelylle. Ohjeessa käsitellään tarkemmin kuinka POP-yhdisteiksi luokiteltuja bromattuja palonsuoja-aineita sisältävien romuajoneuvojen ja sähkö- ja elektroniikkalaiteromun käsittely tulisi järjestää, jotta se täyttäisi POP-asetuksen vaatimukset.

Opas on tarkoitettu kuntien ja valtionhallinnon ympäristölupa- ja valvontaviranomaisille, yrityksille, joiden toiminnassa voi syntyä POP-jätteitä, jätehuoltoalan yrityksille, sekä jätteen käsittelyn suunnittelua tekeville konsulteille.</td></tr>
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<tr><td>Sammandrag</td><td colspan="4">Långlivade organiska föroreningar (Persistent Organic Pollutants, POP) är giftiga, kemiska föreningar som bryts ned långsamt och som ansamlas i organismerna i näringskedjan och som transporteras långt bort från utsläppsstället via luften, vattnet eller flyttande djurarter.

Bestämmelser om behandlingen av avfall som innehåller POP-föroreningar har inom EU utfärdats genom den s.k. POP-förordningen, (EG) nr 850/2004. Under den tid förordningen gällt har många nya ämnen tagits in i förordningen. För närvarande innehåller förordningen 25 långlivade organiska föroreningar eller grupper av föroreningar. De nya ämnen som senast införlivats är viktiga med tanke på avfallshanteringen, eftersom dessa föroreningar också påträffas i vanliga konsumtionsvaror som i slutändan blir kommunalt avfall. Tidigare gällde förordningen främst hantering av avfall i form av olika industrikemikalier och bekämpningsmedel.

Syftet med denna handledning är att utfärda anvisningar om när avfall bör klassificeras som POP-avfall och vilka krav förordningen anger för behandlingen av POP-avfall. I anvisningen behandlas mer ingående hur skrotfordon och el- och elektronikavfall som innehåller bromerade flamskyddsmedel klassificerade som POP-föroreningar bör behandlas för att kraven i POP-förordningen ska uppfyllas.

Handledningen är avsedd för kommunernas och statsförvaltningens miljötillstånds- och tillsynsmyndigheter, företag inom vars verksamhet POP-avfall kan uppstå, företag inom avfallshanteringssektorn och konsulter som planerar hur avfallet ska behandlas.</td></tr>
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Persistent organic pollutants (POPs) are toxic chemical substances that degrade slowly, bioaccumulate in the food chain and travel far from the sources of the pollution via air, water, or migrating animal species. Such chemicals may cause significant health and environmental hazards far away from the source of the pollution. For this reason, their use has been restricted by international conventions. Persistent organic pollutants have been used in a great variety of products, such as industrial chemicals, pesticides and construction materials, as well as consumer products such as textiles, electrical and electronic equipment and vehicles.

This guide provides instructions on issues such as when waste should be classified as POP waste, and what kind of requirements the regulation sets on treating this kind of waste. The guide discusses in more detail how the treatment of end-of-life vehicles and waste electrical and electronic equipment containing brominated flame retardants classified as POPs should be organised so that it would fulfil the requirements of legislation.

The guide is aimed at the environmental permit and supervisory authorities at municipalities and central government, businesses whose activities may generate POP waste, waste management companies, and consultants planning the treatment of waste.

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