



**Conference of the Parties to the Basel Convention
on the Control of Transboundary Movements of
Hazardous Wastes and Their Disposal
Thirteenth meeting**

Geneva, 24 April–5 May 2017

Item 4 (b) (i) of the provisional agenda*

**Matters related to the implementation of the Convention:
scientific and technical matters: technical guidelines**

Technical guidelines

Addendum

Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with polychlorinated biphenyls, polychlorinated terphenyls, polychlorinated naphthalenes or polybrominated biphenyls including hexabromobiphenyl

Note by the Secretariat

1. As referred to in document UNEP/CHW.13/6, the annex to the present note sets out the draft updated technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with polychlorinated biphenyls, polychlorinated terphenyls, polychlorinated naphthalenes or polybrominated biphenyls including hexabromobiphenyl.
2. The draft updated technical guidelines referred to above, which were prepared by Japan in consultation with the small intersessional working group on the development of technical guidelines on persistent organic pollutant wastes, are an amended version of the technical guidelines adopted by the Conference of the Parties at its twelfth meeting¹ to include polychlorinated naphthalenes and take into account comments received by Parties and others pursuant to paragraph 4 of decision OEWG-10/4.² The changes made to the technical guidelines adopted by the Conference of the Parties at its twelfth meeting have been tracked so that the revisions can be easily identified. The present note, including its annex, has not been formally edited.

* UNEP/CHW.13/1.

¹ UNEP/CHW.12/5/Add.5/Rev.1

² <http://www.basel.int/Implementation/POPsWastes/TechnicalGuidelines/tabid/5052/Default.aspx>.

Annex

Draft updated technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with polychlorinated biphenyls, polychlorinated terphenyls, polychlorinated naphthalenes or polybrominated biphenyls including hexabromobiphenyl

~~Revised final version (15 May 2015)~~

(Draft of 31 October 2016)

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Abbreviations and acronyms

ABS	acrylonitrile-butadiene-styrene copolymers (plastics)
ABNT	Associação Brasileira de Normas Técnicas (Brazilian National Standards Organization)
AMAP	Arctic Monitoring and Assessment Programme
AOAC	Association of Official Agricultural Chemists (United States of America)
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry (United States of America)
CAS	Chemical Abstracts Service
DIN	Deutsches Institut für Normung e.V. (German Institute for Standardization)
EN	European Standards
EPA	Environmental Protection Agency (United States of America)
ESM	environmentally sound management
HBB	hexabromobiphenyl
HCB	hexachlorobenzene
IARC	International Agency for Research on Cancer
IPCS	International Programme on Chemical Safety (of WHO)
ISO	International Organization for Standardization
JIS	Japanese Industrial Standards
NEN	The Netherlands Standardization Institute
NVN	Dutch standards
OEWG	Open-ended Working Group of the Basel Convention
PBB	polybrominated biphenyl
PBDD	polybrominated dibenzo- <i>p</i> -dioxin
PBDF	polybrominated dibenzofuran
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo- <i>p</i> -dioxin
PCDF	polychlorinated dibenzofuran
PCN	polychlorinated naphthalene
PCT	polychlorinated terphenyl
PeCB	pentachlorobenzene
POP	persistent organic pollutant
POPRC	Persistent Organic Pollutants Review Committee
TEF	toxic equivalency factor
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
WHO	World Health Organization

Units of measurement

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

I. Introduction

A. Scope

1. The present document supersedes the *Updated technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with polychlorinated biphenyls (PCBs), polychlorinated terphenyls (PCTs) or polybrominated biphenyls (PBBs) of March 2007 including hexabromobiphenyl (HBB) of May 2015.*
2. The present technical guidelines provide guidance on the environmentally sound management (ESM) of wastes consisting of, containing or contaminated with hexabromobiphenyl (HBB), polybrominated biphenyls (PBBs), polychlorinated biphenyls (PCBs) or, polychlorinated terphenyls (PCTs), polychlorinated naphthalenes (PCNs) or polybrominated biphenyls (PBBs) including hexabromobiphenyl (HBB), pursuant to several decisions of two multilateral environmental agreements on chemicals and wastes.³ PCB was listed in Annex A to the Stockholm Convention at the time of its adoption. HBB was listed in Annex A to the Stockholm Convention in 2009, through the adoption of an amendment that entered into force in 2010. PCNs, including dichlorinated naphthalenes (di-CN), trichlorinated naphthalenes (tri-CN), tetrachlorinated naphthalenes (tetra-CN), pentachlorinated naphthalenes (penta-CN), hexachlorinated naphthalenes (hexa-CN), heptachlorinated naphthalenes (hepta-CN) and octachlorinated naphthalene (octa-CN), were listed in Annex A of the Stockholm Convention in 2015 through the adoption of an amendment that entered into force in 2016.
3. The present technical guidelines address PCBs, PCNs and HBBs together with PCTs and PBBs other than HBB as a class or category of substances, owing to similarities in the physico-chemical and toxicological properties of all of these substances. Among other topics, the guidelines address all activities pertaining to waste management. It should be noted that PCTs and PBBs other than HBB are not currently subject to the Stockholm Convention. It should also be noted that monochlorinated naphthalenes (mono-CN) are not subject to the Stockholm Convention.
4. Unintentionally produced PCBs and PCNs listed in Annex C to the Stockholm Convention are not covered by the present technical guidelines. They are covered instead by the *Technical guidelines on the environmentally sound management of wastes containing or contaminated with unintentionally produced polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), hexachlorobenzene (HCB), polychlorinated biphenyls (PCBs), pentachlorobenzene (PeCB) or polychlorinated naphthalenes (PCNs)* (Unintentional POPs technical guidelines) (UNEP, 2015-[]).
5. The present document should be used in conjunction with the *General technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants*” (UNEP, 2015a-[]) (hereinafter referred to as “general technical guidelines”). The general technical guidelines are intended to serve as an umbrella guide for the ESM of wastes consisting of, containing or contaminated with persistent organic pollutants (POPs) and provide more detailed information on the nature and incidence of wastes consisting of, containing or contaminated with PCBs, PCTs or PBBs, including HBB, for purposes of their identification and management.

B. Description, production, use and wastes

1. Description

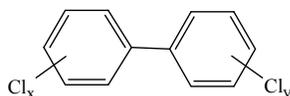
(a) PCBs

6. PCBs are synthetic aromatic compounds formed in such a manner that the hydrogen atoms on the biphenyl molecule (two benzene rings bonded together by a single carbon-carbon bond) may be

³ Decisions V/8, VI/23, VII/13 and VIII/16, BC-10/9, BC-11/3, BC-12/3 and BC-12/3/[...] of the Conference of the Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal; decisions OEWG-I/4, OEWG-II/10 OEWG-III/8, OEWG-IV/11, OEWG-V/12, OEWG-8/5, OEWG-9/3 and OEWG-9/3/10/4 of the Open-ended Working Group (OEWG) of the Basel Convention; resolution 5 of the Conference of Plenipotentiaries of the Stockholm Convention on Persistent Organic Pollutants; decisions INC-6/5 and INC-7/6 of the Intergovernmental Negotiating Committee for an International Legally Binding Instrument for Implementing International Action on Certain Persistent Organic Pollutants; and decisions SC-1/21, SC-2/6, SC-4/13 and SC-4/37/14 of the Conference of the Parties to the Stockholm Convention on Persistent Organic Pollutants.

replaced by up to 10 chlorine atoms. The basic chemical structure of PCBs is shown in figure 1 below; the general molecular formula for PCBs is $C_{12}H_{10-n}Cl_n$, where $n=1-10$ (CAS No. 1336-36-3). In theory there are 209 congeners, although only about 130 congeners have actually been found in commercial chemical formulations (Holoubek, 2000). Typically, four to six of the 10 possible substitution sites are occupied by a chlorine atom (Environment Canada, 1988). In case of dielectric fluids, PCB mixtures mainly containing either tri-, tetra-, or pentachlorinated homologues are used. The physical properties are, for instance, regarding trade named Aroclor 1254 which is one of the popular commercial PCB products consisting most of pentachlorobiphenyls, the boiling point is of 365°C -390°C, the specific gravity (at 25°C) is 1.54 g/cm³, the vapour pressure (at 25°C) is 0.010 Pa, the water solubility (at 24°C) is 0.057 mg/L, and it is viscous liquid at an ordinary temperature (US-ATSDR, 2000). The more highly chlorinated PCB congeners are virtually insoluble in water and highly resistant to degradation.

Figure 1: Chemical structure of PCBs



7. Since PCBs are stable to heat and biodegradation, once released into the environment they are persistent and accumulate in the organic components of soils, sediments, biological tissues and organic carbons dissolved in aquatic systems, thereby entering the ecological food chain. PCBs especially accumulate in fish and marine mammals, reaching levels that may be many thousands of times higher than in water. The general population may be exposed to PCBs by ingesting contaminated food and by inhaling contaminated air. PCBs are transported from soil and sediment to the atmosphere and can easily cycle between air, water and soil and enter the air by evaporation from both soil and water. In air, PCBs can be carried long distances and have been found in snow and seawater in areas far away from where they were released, such as the Arctic (ATSDR, 2000).

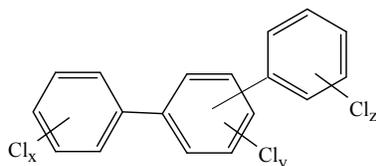
8. PCBs include 12 congeners to which the World Health Organization (WHO) has assigned toxicity equivalency factors (TEFs) because they exhibit dioxin-like toxicity (Van den Berg et al, 2006).

9. PCBs, including the abovementioned 12 dioxin-like congeners, have been classified as carcinogenic to humans (Group 1) by the International Agency for Research on Cancer (IARC, 2014).

(b) PCTs

10. PCTs also constitute a group of halogenated hydrocarbons. They are very similar to PCBs in terms of chemical structure, except that they contain three phenyl rings instead of two and therefore can have up to 14 chlorine atoms attached. The number of possible PCT congeners is large; however, only a few occur in commercial chemical formulations. PCTs and PCBs have similar chemical and physical properties. PCTs are virtually insoluble in water and highly resistant to degradation. One difference between PCTs and PCBs is that PCTs are generally less volatile. The basic chemical structure of PCTs is shown in figure 2 below; PCTs have the general molecular formula $C_{18}H_{14-n}Cl_n$, where $n=1-14$ (CAS No: 61788-33-8).

Figure 2: Chemical structure of PCTs

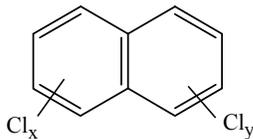


(c) PCNs

11. PCNs are a group of compounds based on the naphthalene ring system, but where one or more hydrogen atoms have been replaced by chlorine. The basic structure of the PCNs is shown in figure 3 below and has the molecular formula $C_{10}H_{8-n}Cl_n$, where $n=1-8$ (CAS no: 70776-03-3). PCNs comprise of 75 possible congeners in eight homologue groups with one to eight chlorine atoms substituted around the planar aromatic naphthalene molecule. Almost all congeners have actually been found in commercial formulations (Noma et al. 2004). All 75 PCN congeners and 8 homologues have different CAS numbers. The system of nomenclature for PCN is similar to that of PCB. The homologue groups

are mono-CN_s, di-CN_s, tri-CN_s, tetra-CN_s, penta-CN_s, hexa-CN_s, hepta-CN_s and octa-CN. However, mono-CN_s are not subject to the Stockholm Convention. Physical-chemical properties vary considerably due to the degree of chlorine substitution. The physical state ranges from thin liquids to hard waxes. Tri- through octa-CN_s are very lipophilic with high log K_{ow} (>5) and their water solubility and vapour pressure decrease with the degree of chlorination. Mono-CN_s and di-CN_s are slightly soluble in water while the higher CN_s have a water solubility of a few µg/L. For example, Halowax 1001 (the trade name of PCN mixture) consisting most of tetra-CN_s and penta-CN_s has a boiling point of 308 °C, a melting point of 98 °C and physical form of flakes, while Halowax 1000 consisting most of mono-CN_s and di-CN_s has a boiling point of 250 °C, a melting point of 33 °C and physical form of liquid (US EPA, 1975; Brinkman et al. 1976; Crookes et al. 1993; IPCS, 2001).

Figure 3: The structural formula of PCNs



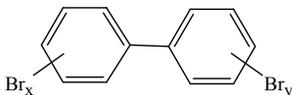
* For PCNs listed as POPs (x + y) varies from 2 to 8

12. Although two publications on the WHO TEF schemes recommend to include certain PCN, no TEFs have been proposed through the WHO experts so far (van den Berg et al., 2006; van den Berg et al., 2013).

(d) PBBs

11-13. PBBs are the bromine analogues of PCBs and thus there are 209 possible PBB congeners. Only a few, however, occur in commercial chemical formulations (IPCS, 1994). They are solids or waxy substances at room temperature. They are virtually insoluble in water and highly resistant to degradation. The basic chemical structure of PBBs is shown in figure 34 below; PBBs have the general molecular formula $C_{12}H_{10-n}Br_n$, where n=1-10.

Figure 34: Structural formula of PBBs



12-14. HBB belongs to a wider group of PBBs. HexabromoHexabrominated congeners possibly exist in 42 isomeric forms, which are listed under a variety of CAS numbers, e.g., CAS No. 36355-01-8 for all HBB isomers and CAS No. 59080-40-9 for 2,2',4,4',5,5'-HBB. HBB is white and solid at normal temperatures and has a vapour pressure of 6.9×10^{-6} Pa and a melting point of 72°C (ATSDR, 2004).

13-15. Some PBBs have been assigned toxicity equivalency factors similar to those of PCBs (Van den Berg et al., 2013).

14-16. PBBs have been classified by IARC as probably carcinogenic to humans (Group 2A) (IARC, 2014).

2. Production

(a) PCBs

15-17. PCBs have excellent dielectric properties, longevity, non-flammability and resistance to thermal and chemical degradation. For this reason, prior to national bans they were manufactured for use in electrical equipment, heat exchangers, hydraulic systems and several other specialized applications.

~~16-18.~~ The main period of manufacture of PCBs was from 1930 to late 1977 in the United States of America, up to 1983 in China, up to the mid-1980s in Europe, up to 1993 in the Russian Federation and from 1954 to 1972 in Japan.⁴

~~17-19.~~ Chlorination of PCBs was conducted continuously until a certain target percentage of chlorine based on weight was achieved. Manufactured PCBs were used as insulating oils and as heat media. Electric equipment can contain notably high concentrations of PCBs. For example, capacitors may be filled with up to 100 per cent PCBs and transformers with approximately 60-70 per cent PCBs. In addition, PCBs were added in small quantities to inks, plastics, paints, sealants, adhesives and dye solvents for carbonless paper. At room temperature, most of the PCBs added to these products were oily liquids or waxy solids.

~~18-20.~~ Prominent trade names of PCB products include those listed below (see annex I to the present guidelines for a more detailed list of PCB trade names and synonyms, and section IV.D for a discussion of trade names in inventory identification):

- (a) Apirolio (Italy);
- (b) Aroclor (United States of America and United Kingdom ~~of Great Britain and Northern Ireland~~);
- (c) Askarel (United States and United Kingdom);
- (d) Clophen (Germany);
- (e) Delor (Czechoslovakia);
- (f) Elaol (Germany);
- (g) Fenchlor (Italy);
- (h) Inerteen (United States);
- (i) Kanechlor (Japan);
- (j) Phenoclor (France);
- (k) Pyralene (France);
- (l) Pyranol (United States);
- (m) Pyroclor (United States and United Kingdom);
- (n) Santotherm (Japan);
- (o) Sovol (former Union of Soviet Socialist Republics (USSR));
- (p) Sovtol (former USSR).

~~19-21.~~ In the Aroclor series, a four-digit number follows the word Aroclor. The first two digits of the number are either 10 or 12. The number 12 indicates a normal Aroclor while the number 10 indicates a distillation product of an Aroclor. The second two digits of the four-digit code indicate the percentage of chlorine in the mixture by weight. Therefore, Aroclor 1254 contains approximately 54 per cent chlorine by weight.

~~20-22.~~ Commercial PCB products and articles were sold for their industrial properties rather than for their chemical composition (IPCS, 1992). They contained a number of impurities and were often mixed with solvents, such as tri- and tetrachlorobenzenes. PCBs mixed with tri- and tetrachlorobenzenes were called ~~askarel~~ Askarel. Contaminants in commercial mixtures include PCDFs and ~~chlorinated naphthalenes~~ PCNs. Studies have found from 0.8 mg/kg to 40 mg/kg of PCDFs in PCB commercial mixtures (IPCS, 1992). PCBs are also formed unintentionally in some thermal and chemical processes.

~~21-23.~~ The cumulative worldwide production of PCBs has been estimated to be 1-1.5 million tonnes.⁵

⁴ The estimated production amount and the period of manufacture of PCBs are summarized in table 1 of UNEP/POPS/COP.7/INF/9.

⁵ <http://chm.pops.int/Implementation/PCBs/Overview/tabid/273/Default.aspx>

(b) PCTs

24. PCTs were manufactured in much smaller quantities than PCBs and were given the same or similar trade names. They were used for the same sorts of applications as PCBs, although most were used in waxes, plastics, hydraulic fluids, paints and adhesives (Jensen and Jørgensen, 1983). In the 22-25. Prominent trade names of PCT products are Aroclor (United States-) and Kanechlor KC-C (Japan). Aroclor series PCTs were identified by the digits 54 in the first two spaces of the four-digit code, e.g., Aroclor 5432, 5442 and 5460 (IPCS, 1992). See (see annex I to the present guidelines for examples a more detailed list of PCT trade names and synonyms, and section IV.D for a discussion of trade names in inventory identification-).

23. Examples of PCB trade names are Aroclor (United States) and Kanechlor KC-C (Japan).

24-26. PCTs were produced in the United States, France, Germany, Italy and Japan until the early 1980s, when all production is thought to have ceased. The cumulative world production is estimated to have been 60,000 tonnes between 1955 and 1980 (UNECE, 2002).

(c) PCNs

27. Parties to the Stockholm Convention must prohibit and/or eliminate the production of PCNs. The specific exemption for production of PCNs is intermediates in production of polyfluorinated naphthalenes, including octafluoronaphthalene (see paragraph 65).

28. PCNs were produced for technical use in the first decade of the 20th century, e.g. as dielectrics, for flame proofing or for the protection of paper and fabrics – including for paper inlays for gas masks in World War I. After the Second World War, their production began to decline with the advent of plastic substances for insulation and the use of PCBs for dielectrics in transformers, partly due to severe occupational exposure problems. Still, PCNs remained high volume chemicals until the 1970s. Their production decreased significantly since 1977. (US EPA, 1975; Brinkman et al. 1976; Crookes et al., 1993; Falandysz, 1998; Hayward, 1998; Plassche et al., 2003; AMAP, 2004).

29. The production data are limited, and the original data on the quantum of PCNs produced worldwide are not available.

30. Estimates for the total global PCNs production so far vary between 200,000–400,000 tonnes (AMAP, 2004) and 150,000 tonnes (about one tenth of the PCBs ever produced (Falandysz, 1998). In the United States of America, approximately a total of between 50,000 and 150,000 tonnes of PCNs have been produced from 1910 until 1960. The production of PCNs in the United States of America stopped in 1980. The production of technical PCNs by Koppers Company, main producer of Halowax, ceased in 1977, and the last producer of the United States of America of PCNs (Chemispheres Company) stopped manufacture in 1980 (US EPA, 1975; US EPA, 1983). In Germany, the production of PCNs started around 1910 and ceased in the mid-1980s. A cumulative total of around 75,000 tonnes of PCNs were manufactured up to 1972 and around 300 tonnes were produced in 1984. Bayer produced PCNs (Nibren waxes) in a range of 100 to 200 tonnes per year between 1980 and 1983 and ceased PCNs production in 1983 (IPCS, 2001; Plassche et al., 2003). In France, small amounts of PCNs were produced by Prodelec (Brinkman et al., 1976). In the United Kingdom, PCNs were produced from around 1919 until the mid-1960s. No data as to the amounts produced appear to be available (Crookes et al., 1993). In Japan, the production of PCNs from 1940 to 1976 was of approximately 4,000 tonnes, and manufacture was banned from 1979 (Japan Ministry of Economy, Trade and Industry, 1979). In China, there is no information available about the production (Pan et al., 2011), however a small quantity production (not specified) of octa-CN for scientific purposes was reported in Jiangsu province (UNEP, 2012). In the former USSR, PCNs or Halowax was produced by Chimprom enterprises, while volumes were not assessed or reported. To date, intentional production of PCNs is assumed to have ended. PCNs are unintentionally generated in some thermal and chemical processes (UNEP, 2012).

31. Commercial PCBs also contained traces of PCNs (0.01–0.09%) (Falandysz, 1998; Kannan et al., 2000; Yamashita et al., 2000). Studies have found the impurity PCDDs (1.5 to 370 ng/g), PCDFs (250 to 16,000 ng/g), and PCBs (220 to 640,000 ng/g) in all Halowax formulations investigated (Noma et al., 2005, 2005a).

32. Prominent trade names of PCNs products include those listed below (see annex I for a more detailed list of PCNs trade names and synonyms and section IV.D for a discussion of trade names in inventory identification) (Nomura, 1951; US EPA, 1975; Brinkman et al., 1976; Crookes et al., 1993; Plassche et al., 2003; Falandysz, 2008):

(a) Basileum (Germany);

- [\(b\) Cerifal \(Italy\):](#)
- [\(c\) Chlonacire wax \(France\):](#)
- [\(d\) Halowax \(United States of America\)⁶:](#)
- [\(e\) Hodogaya Amber wax \(Japan\),](#)
- [\(f\) Nankai wax \(Japan\),](#)
- [\(g\) Nibren wax \(Germany\):](#)
- [\(h\) N-Oil, N-Wax \(United States of America\):](#)
- [\(i\) Perna wax \(Germany\)](#)
- [\(j\) Seekay wax \(United Kingdom\):](#)
- [\(k\) Tokyo Ohka wax \(Japan\):](#)
- [\(l\) Woskol: Zakady Azotowe \(Poland\).](#)

(d) PBBs

25-33. PBBs exhibit unusual chemical stability and are stable in acids, bases, heat, and reducing and oxidizing agents. However, in chemical reactions, bromine is better than chlorine as a leaving group (IPCS, 1994). For this reason, PBBs were manufactured mainly for use as flame retardants.

26-34. It is estimated that at least 11,000 tonnes of PBBs were produced worldwide, but the amounts of production of some PBB-producing countries are not available (IPCS, 1994). In the United States, the commercial production of PBBs began in 1970, and about 6,000 tonnes were produced from 1970 to 1976. The first PBB compound produced in the United States was HBB, but its production was discontinued in 1975. HBB was commercially called FireMaster in the United States and its production constituted about 88 per cent of total PBB production (ATSDR, 2004). PBBs were also manufactured in the United Kingdom until 1977, and in Germany until the mid-1980s. Although PBBs were never produced in Japan, they were imported into that country until 1978. It has been reported that PBB production ended worldwide with the cessation of decabromobiphenyl production in France in 2000 (UNEP, 2006).

27-35. PBBs produced for commercial uses include mixtures of various brominated biphenyls, mainly containing HBB and octa-, nona- and decabromobiphenyls, as well as other PBB congeners (IPCS, 1994). All commercial PBB mixtures were relatively highly brominated, with bromine contents ranging from about 76 per cent HBB to 81-85 per cent octa- to decabromobiphenyl mixtures (IPCS, 1994; IARC, 2014).

28-36. Prominent trade names of PBB products include those listed in table 1 below (see annex I to the present guidelines for a more detailed list of PBB trade names and synonyms, and section IV.D for a discussion of trade names in inventory identification).

⁶ In the Halowax series, a four-digit number follows the word Halowax. They exhibit a wide range from nearly pure mono-CNs (Halowax 1031) to nearly pure octa-CN (Halowax 1051) and from 22% to 70% of the chlorine content, respectively.

Table 1: Main constituents, trade names and country of origin⁷

Main PBB congener	Trade name	Country in which the chemical has been produced
Hexabromobiphenyls	FireMaster FF-1	United States
	FireMaster BP-6	United States
Octabromobiphenyls	BB-8	
	Bromkal 80	Germany
	Bromkal 80-9D	Germany
	Octabromobiphenyl FR 250 13A	United States
	Technical octabromobiphenyl	United States
Decabromobiphenyl	Adine 0102	France
	Berkflam B-10	United Kingdom
	Flammex B-10	United Kingdom
	HFO 101	United Kingdom
	Technical decabromobiphenyl	United States

⁷ IPCS, 1994 and IARC, 2014.

3. Use

(a) PCBs

~~29-37.~~ PCBs were used in a very wide variety of industrial and consumer applications. Such applications have been categorized by WHO as completely closed, nominally closed, and open-ended (IPCS, 1992), and included the following:

- (a) Completely closed systems:
 - (i) Electrical transformers;
 - (ii) Electrical capacitors (including lamp ballasts);
 - (iii) Electrical switches, relays, breakers, reclosers and others;
 - (iv) Electrical cables;
 - (v) Electrical bushings;
 - (vi) Electrical reactors;
 - (vii) Electrical regulators;
 - (viii) Electric motors and magnets (very small amounts);
- (b) Nominally closed systems:
 - (i) Hydraulic systems;
 - (ii) Heat transfer systems (heaters, heat exchangers);
 - (iii) Vacuum pumps;
 - (iv) Vapour diffusion pumps;
- (c) Open-ended systems:
 - (i) Plasticizer in polyvinyl chloride, neoprene and other artificial rubbers;
 - (ii) Ingredient in paint and other coatings;
 - (iii) Ingredient in ink and carbonless copy paper;
 - (iv) Ingredient in adhesives;
 - (v) Pesticide extender;
 - (vi) Ingredient in sealants and caulking material;
 - (vii) Fire retardant in fabrics, carpets, polyurethane foam, etc.;
 - (viii) Lubricants (microscope oils, brake linings, cutting oils, bridge bearings, other lubricants).

~~30-38.~~ Although electrical transformers containing PCBs are defined as a “completely closed” application, industrial practices caused these PCBs to be transferred to other types of equipment, thus creating additional points of contact with the environment. A common practice was to top up or recharge non-PCB (mineral oil) transformers with PCBs when no other fluid was available.

~~31-39.~~ PCB oils were also added to or disposed of with non-PCB fluids such as heating or cooling fluids, hydraulic fluids, brake fluids, engine oils and off-specification fuels. There are numerous anecdotal reports of employees in electrical utilities using PCB fluids to wash their hands and taking PCB fluids home for use as lubricants in home heaters, hydraulic systems and motors. Since most of the fluorescent lamp ballasts that were made before PCBs were banned contained PCBs, many homes and businesses that installed fluorescent lamps unknowingly acquired PCBs.

(b) PCTs

~~32-40.~~ PCTs were used in almost exactly the same applications as PCBs but in much smaller amounts. Little is known, however, about remaining quantities of PCTs because PCT inventories have not been developed (UNECE, 2002). It is known that very small amounts of PCTs were used in electrical equipment (Jensen and Jørgensen, 1983).

(c) PCNs

41. Parties to the Stockholm Convention must prohibit and/or eliminate the use of PCNs. The specific exemption for use of PCNs is production of polyfluorinated naphthalenes, including octafluoronaphthalene (see paragraph 65).

42. PCNs have been used mainly for their chemical inertness, including low flammability, their electrically insulating properties and recalcitrance including resistance to biodegradation and biocidal function; they share these properties and their scope of application with the PCBs (Hayward, 1998).

43. PCNs were used for the same applications as PCBs with a wide variety because of their structural similarity. The uses were industrial and consumer applications in completely closed, nominally closed and open-ended systems similar to PCBs. PCNs were gradually substituted by PCBs in many applications. Major uses are shown below (US EPA, 1975; Brinkman et al., 1976; US EPA, 1983; Crookes et al., 1993; IPCS, 2001; UNEP, 2012).

44. Mono-CN and mixtures of mono- and di-CN have been used for chemical-resistant gauge fluids and instrument seals, as heat exchange fluids, as high boiling specialty solvents, for colour dispersions, as engine crankcase additives, and as ingredients in motor tune-up compounds. Mono-CN have also been used as a raw material for dyes and as a wood preservative with fungicidal and insecticidal properties.

45. The tri- and higher chlorinated naphthalene products have been used as impregnants for condensers and capacitors and dipping encapsulating compounds in electronic and automotive applications, as temporary binders in paper coating and impregnation, binders for ceramic components, in precision casting of alloys, in electroplating stop-off compounds, as additives in gear oils and cutting compounds, in flame-proofing and insulation of electrical cable and conductors, as moisture-proof sealants and caulking material, as separators in batteries, in refractive index testing oils, as masking compounds in electroplating, in grinding wheel lubricants, and ingredient in paint and other coatings.

46. The most important uses, in terms of volume, have been cable insulation and flame-proofing, wood preservation, engine and gear oil additives, electroplating masking compounds, feedstock for dye production, dye carriers, dielectric impregnates for capacitors/condensers, and refractive index testing oils. The use of PCNs as wood preservatives was popular in the 1940s and 1950s, but they are no longer used for this purpose in the United States of America. The US Environmental Protection Agency stated that only very small amounts of PCNs (about 15 tons/year in 1981) were still being used in the United States of America, mainly as refractive index testing oils and as capacitor dielectrics. It did note that the most likely possible new uses for PCNs would be as intermediates for polymers and as flame retardants in plastics. (Crookes et al., 1993).

(d) PBBs

~~33-47.~~ The principal use of PBBs was as flame retardants. PBBs are an additive type flame retardant. Mixed with a dry solid or liquid polymeric material, PBB provides a filter-type, flame retardant action by chemically releasing hydrogen bromide when ignited. Other uses of PBBs are: as color activators in light sensitive compositions; as relative molecular mass control agents for polybutadiene; as wood preservatives; as voltage stabilizing agents in electrical insulation; and as functional fluids, such as dielectric media (IPCS, 1994).

~~34-48.~~ In the United States and Canada, FireMaster was used as a flame retardant in three main commercial products: acrylonitrile-butadienestyrene (ABS) thermoplastics (10 per cent PBBs) for housing business machines, industrial equipment (e.g., motor housing) and electronic products (e.g., radio and TV parts); as a flame retardant in coatings and lacquers; and in polyurethane foams for auto upholstery. Of the estimated 2,200 tonnes of HBB produced in 1974, about 900 tonnes were used in ABS plastic products and an even larger amount was used in cable coatings. Decabromobiphenyl Adine 0102 was used as a flame retardant in thermoplastics and thermosets (e.g., in polyesters, epoxy resins, polystyrene, ABS, polyolefinespolyolefin and PVC), elastomers (e.g., in PU-elastomers and India rubber) and cellulosescellulosic (e.g., in chip-boards), as well as in paints and varnishes (IPCS, 1994).

~~35-49.~~ More recently, PBBs of predominantly low bromine content were found in electronic waste such as cable coatings, stuffing powder for electronic components and circuit boards, suggesting that it was used in such equipment (Zhao et al., 2008; IARC, 2014).

4. Wastes

~~36-50.~~ Wastes consisting of, containing or contaminated with PCBs, PCTs, PCNs or PBBs (hereinafter referred to as “PCB, PCT, PCN or PBB wastes”) can be found in:

- (a) Equipment containing or contaminated with PCBs or PCNs (capacitors, circuit breakers, electrical cables, electric motors, electromagnets, heat transfer equipment, hydraulic equipment, switches, transformers, vacuum pumps, voltage regulators);
- (b) Solvents contaminated with PCBs, PCTs or PCTsPCNs;
- (c) Waste vehicles and shredder light fraction (fluff) containing or contaminated with PCBs or PCNs;
- (d) Demolition wastes containing or contaminated with PCBs or PCNs (painted materials, resin-based floorings, sealants, sealed glazing units);
- (e) Oils consisting of, containing or contaminated with PCBs or PCNs (dielectric fluids, heat transfer fluids, hydraulic fluids, motor oil);
- (f) Electrical cables isolated by polymers containing or contaminated with PCBs, PCNs or PBBs;
- (g) Soils and sediments, rock and aggregates (e.g., excavated bedrock, gravel, rubble) contaminated with PCBs, PCTs, PCNs or PBBs;
- (h) Sludge contaminated with PCBs, PCTs, PCNs or PBBs;
- (i) Plastics containing or contaminated with PCNs or PBBs and equipment containing such materials;
- (j) Fire suppression equipment containing or contaminated with PBBs; ~~and~~
- (k) Containers and absorbent materials contaminated through the handling, packaging, transportation or storage of PCB, PCT, PCN or PBB wastes; ~~and~~
- (l) Wood contaminated with PCNs.

~~37-51.~~ It should be noted that the abovementioned categories apply mainly to PCBs, which were produced in much larger quantities than PCTs, PCNs and PBBs and are stored as wastes awaiting disposal. ~~PCTs and PBBs are rarely found. It should also be noted that PCNs may be contained in large quantities and therefore do not have the potential to form large amounts of traces in waste. However, since consisting of, containing or contaminated with PCBs (see paragraph 31). Since~~ PBBs were used in electrotechnical products and automotive parts, it is possible that such products, if manufactured prior to 2000, contain PBBs. PBBs may also be present in shredder residue generated during the recycling process of waste vehicles and waste electrical and electronic equipment (WEEE).

II. Relevant provisions of the Basel and Stockholm conventionsConventions

A. Basel Convention

~~38-52.~~ Article 1 (“Scope of Convention”) defines the types of waste that are subject to the Basel Convention. Subparagraph 1 (a) of that Article sets forth a two-step process for determining whether a “waste” is a “hazardous waste” subject to the Convention: first, the waste must belong to any category contained in Annex I to the Convention (“Categories of wastes to be controlled”), and second, the waste must possess at least one of the characteristics listed in Annex III to the Convention (“List of hazardous characteristics”).

~~39-53.~~ Annex I to the Convention lists some of the wastes that may consist of, contain or be contaminated with PCBs, PCTs or PCTsPCNs. These include:

- ~~(a)~~ Y5: Wastes from the manufacture, formulation and use of wood preserving chemicals;
- (b) Y6: Wastes from the production, formulation and use of organic solvents;
- ~~(c)~~ Y8: Waste mineral oils unfit for their originally intended use;
- ~~(d)~~ Y9: Waste oils/water, hydrocarbons/water mixtures, emulsions;
- ~~(e)~~ Y10: Waste substances and articles containing or contaminated with polychlorinated biphenyls (PCBs) and/or polychlorinated terphenyls (PCTs) and/or polybrominated biphenyls (PBBs);

- (ef) Y11: Waste tarry residues arising from refining, distillation and any pyrolytic treatment;
- (fg) Y12: Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish;
- (gh) Y13: Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives;
- (hi) Y14: Waste chemical substances arising from research and development or teaching activities which are not identified and/or are new and whose effects on man and/or the environment are not known;
- (ij) Y18: Residues arising from industrial waste disposal operations;
- (jk) Y39: Phenols; phenol compounds including chlorophenols;
- (kl) Y41: Halogenated organic solvents;
- (lm) Y42: Organic solvents excluding halogenated solvents;
- (mn) Y45: Organohalogen compounds other than substances referred to in this Annex (e.g. Y39, Y41, Y42, Y43, Y44).

40-54. Annex I to the Convention lists some of the wastes that may consist of, contain or be contaminated with PBBs. These include:

- (a) Y10: Waste substances and articles containing or contaminated with polychlorinated biphenyls (PCBs) and/or polychlorinated terphenyls (PCTs) and/or polybrominated biphenyls (PBBs);
- (b) Y12: Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish;
- (c) Y13: Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives;
- (d) Y14: Waste chemical substances arising from research and development or teaching activities which are not identified and/or are new and whose effects on man and/or the environment are not known;
- (e) Y18: Residues arising from industrial waste disposal operations;
- (f) Y41: Halogenated organic solvents;
- (g) Y42: Organic solvents excluding halogenated solvents;
- (h) Y45: Organohalogen compounds other than substances referred to in this Annex (e.g. Y39, Y41, Y42, Y43, Y44).

41-55. Annex I wastes are presumed to exhibit one or more Annex III hazardous characteristics, which may include H4.1 "Flammable solids", H6.1 "Poisonous (Acute)", H11 "Toxic (Delayed or chronic)", H12 "Ecotoxic", or H13 "Capable after disposal of yielding another hazardous material" unless, through "national tests", they can be shown not to exhibit such characteristics. National tests may be useful for identifying a particular hazardous characteristic listed in Annex III until such time as the hazardous characteristic is fully defined. Guidance papers for Annex III hazardous characteristics H11, H12 and H13 were adopted on an interim basis by the Conference of the Parties to the Basel Convention at its sixth and seventh meetings.

42-56. List A of Annex VIII describes wastes that are "characterized as hazardous under Article 1, paragraph 1 (a) of this Convention" although "their designation on this Annex does not preclude the use of Annex III [hazard characteristics] to demonstrate that a waste is not hazardous" (Annex I, paragraph (b)). The following Annex VIII waste categories in particular are applicable to PCBs, PCTs, PCNs or PBBs:

- (a) A1180: Waste electrical and electronic assemblies or scrap⁸ containing components such as accumulators and other batteries included on list A, mercury-switches, glass from cathode-ray tubes and other activated glass and PCB-capacitors, or contaminated with Annex I constituents (e.g.,

⁸ This entry does not include scrap assemblies from electric power generation.

cadmium, mercury, lead, polychlorinated biphenyl) to an extent that they possess any of the characteristics contained in Annex III (note the related entry on list B B1110)⁹;

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

~~(c)~~ A3180: Wastes, substances and articles containing, consisting of or contaminated with polychlorinated biphenyl (PCB), polychlorinated terphenyl (PCT), polychlorinated naphthalene (PCN) or polybrominated biphenyl (PBB), or any other polybrominated analogues of these compounds, at a concentration level of 50 mg/kg or more¹⁰.

~~43-57.~~ List A of Annex VIII includes a number of wastes or waste categories that have the potential to contain or be contaminated with PCBs, PCTs or PCTsPCNs, including:

- (a) A1090: Ashes from the incineration of insulated copper wire;
- (b) A1100: Dusts and residues from gas cleaning systems of copper smelters;
- (c) A2040: Waste gypsum arising from chemical industry processes, when containing Annex I constituents to the extent that it exhibits an Annex III hazardous characteristic (note the related entry on list B B2080);
- (d) A2060: Coal-fired power plant fly-ash containing Annex I substances in concentrations sufficient to exhibit Annex III characteristics (note the related entry on list B B2050);
- (e) A3020: Waste mineral oils unfit for their originally intended use;
- (f) A3040: Waste thermal (heat transfer) fluids;
- (g) A3050: Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives excluding such wastes specified on list B (note the related entry on list B B4020);
- (h) A3070: Waste phenols, phenol compounds including chlorophenol in the form of liquids or sludges;
- (i) A3120: Fluff - light fraction from shredding;
- (j) A3150: Waste halogenated organic solvents;
- (k) A3160: Waste halogenated or unhalogenated non-aqueous distillation residues arising from organic solvent recovery operations;
- (l) A4040: Wastes from the manufacture, formulation and use of wood-preserving chemicals¹¹;
- ~~(m)~~ A4070: Wastes from the production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish excluding any such waste specified on list B (note the related entry on list B B4010);
- ~~(n)~~ A4100: Wastes from industrial pollution control devices for cleaning of industrial off-gases but excluding such wastes specified on list B;
- ~~(n)~~ ~~o~~ A4130: Waste packages and containers containing Annex I substances in concentrations sufficient to exhibit Annex III hazard characteristics;
- ~~(op)~~ A4140: Wastes consisting of or containing off specification or outdated¹² chemicals corresponding to Annex I categories and exhibiting Annex III hazard characteristics;
- ~~(pq)~~ A4150: Waste chemical substances arising from research and development or teaching activities which are not identified and/or are new and whose effects on human health and/or the environment are not known;
- ~~(qr)~~ A4160: Spent activated carbon not included on list B (note the related entry on list B B2060).

⁹ PCBs are at a concentration level of 50 mg/kg or more.

¹⁰ The 50 mg/kg level is considered to be an internationally practical level for all wastes. However, many individual countries have established lower regulatory levels (e.g., 20 mg/kg) for specific wastes.

¹¹ This entry does not include wood treated with wood preserving chemicals.

¹² "Outdated" means unused within the period recommended by the manufacturer.

44-58. List A of Annex VIII includes a number of wastes or waste categories that have the potential to contain or be contaminated with PBBs, including:

- (a) A3050: Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives excluding such wastes specified on list B (note the related entry on list B B4020);
- (b) A3150: Waste halogenated organic solvents;
- (c) A3160: Waste halogenated or unhalogenated non-aqueous distillation residues arising from organic solvent recovery operations;
- (d) A4070: Wastes from the production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish excluding any such waste specified on list B (note the related entry on list B B4010);
- (e) A4100: Wastes from industrial pollution control devices for cleaning of industrial off-gases but excluding such wastes specified on list B;
- (f) A4130: Waste packages and containers containing Annex I substances in concentrations sufficient to exhibit Annex III hazard characteristics;
- (g) A4140: Wastes consisting of or containing off specification or ~~outdated~~⁸ ~~outdated~~¹² chemicals corresponding to Annex I categories and exhibiting Annex III hazard characteristics;
- (h) A4150: Waste chemical substances arising from research and development or teaching activities which are not identified and/or are new and whose effects on human health and/or the environment are not known;
- (i) A4160: Spent activated carbon not included on list B (note the related entry on list B B2060).

45-59. List B of Annex IX to the Convention lists wastes that “will not be wastes covered by Article 1, paragraph 1 (a), of this Convention unless they contain Annex I material to an extent causing them to exhibit an Annex III characteristic.”

46-60. List B of Annex IX includes a number of wastes or waste categories that have the potential to contain or be contaminated with PCBs ~~or~~, PCTs or PCNs and its related substances, including:

- (a) B1100: Metal-bearing wastes arising from melting, smelting and refining of metals.¹³

47-61. List B of Annex IX includes a number of wastes or waste categories that have the potential to contain or be contaminated with PBBs, including:

- (a) B3010: Cured waste resins or condensation products and fluorinated polymer wastes;¹⁴
- (b) B3030: Textile wastes.¹⁵

48-62. For further information, see section II.A of the general technical guidelines.

B. Stockholm Convention¹⁶

49-63. The present technical guidelines cover intentionally produced PCBs, PCNs, including di-through octa-CNs, and HBB whose production and use are to be eliminated in accordance with Article 3 of, and Annex A to, the Stockholm Convention.

50-64. Annex A, part I, to the Convention does not include any exemption for the production or use of HBB.

65. Annex A, part I for PCNs, including di- through octa-CNs, allow specific exemptions for production of those chemicals as intermediates in production of polyfluorinated naphthalenes, including octafluoronaphthalene, and the use of those chemicals for the production of polyfluorinated naphthalenes, including octafluoronaphthalene.

51-66. Annex A, part II (“Polychlorinated biphenyls”) outlines specific requirements for PCBs, as follows:

¹³ Refer to Annex IX to the Basel Convention for a full description of this entry.

¹⁴ *Ibid* 11.

¹⁵ *Ibid* 911.

¹⁶ This section does not apply to PCTs ~~or~~, to mono-CNs and to PBBs other than HBB.

“Each Party shall

- (a) With regard to the elimination of the use of polychlorinated biphenyls in equipment (e.g. transformers, capacitors or other receptacles containing liquid stocks) by 2025, subject to review by the Conference of the Parties, take action in accordance with the following priorities:
 - (i) Make determined efforts to identify, label and remove from use equipment containing greater than 10 per cent polychlorinated biphenyls and volumes greater than 5 litres;
 - (ii) Make determined efforts to identify, label and remove from use equipment containing greater than 0.05 per cent polychlorinated biphenyls and volumes greater than 5 litres;
 - (iii) Endeavour to identify and remove from use equipment containing greater than 0.005 per cent polychlorinated biphenyls and volumes greater than 0.05 litres;
- (b) Consistent with the priorities in subparagraph (a), promote the following measures to reduce exposures and risk to control the use of polychlorinated biphenyls:
 - (i) Use only in intact and non-leaking equipment and only in areas where the risk from environmental release can be minimised and quickly remedied;
 - (ii) Not use in equipment in areas associated with the production or processing of food or feed;
 - (iii) When used in populated areas, including schools and hospitals, take all reasonable measures to protect from electrical failure which could result in a fire, and regular inspection of equipment for leaks;
- (c) Notwithstanding paragraph 2 of Article 3, ensure that equipment containing polychlorinated biphenyls, as described in subparagraph (a), shall not be exported or imported except for the purpose of environmentally sound waste management;
- (d) Except for maintenance and servicing operations, not allow recovery for the purpose of reuse in other equipment of liquids with polychlorinated biphenyls content above 0.005 per cent;
- (e) Make determined efforts designed to lead to environmentally sound waste management of liquids containing polychlorinated biphenyls and equipment contaminated with polychlorinated biphenyls having a polychlorinated biphenyls content above 0.005 per cent, in accordance with paragraph 1 of Article 6, as soon as possible but no later than 2028, subject to review by the Conference of the Parties;
- (f) In lieu of note (ii) in Part I of this Annex, endeavour to identify other articles containing more than 0.005 per cent polychlorinated biphenyls (e.g. cable-sheaths, cured caulk and painted objects) and manage them in accordance with paragraph 1 of Article 6;
- (g) Provide a report every five years on progress in eliminating polychlorinated biphenyls and submit it to the Conference of the Parties pursuant to Article 15”.

~~52-67.~~ For further information, see section II.B of the general technical guidelines.

III. Issues under the Stockholm Convention to be addressed cooperatively with the Basel Convention¹⁷

A. Low POP content

~~53-68.~~ The provisional definition of low POP content for PCBs and HBB is 50 mg/kg for each.¹⁸ [The provisional definition of low POP content for PCNs is \[10 mg/kg or 50mg/kg\].](#)

¹⁷ This section does not apply to PCTs, [to mono-CNs](#) and [to PBBs](#) other than HBB.

¹⁸ Determined in accordance with national or international methods and standards.

~~54-69.~~ The low POP content described in the Stockholm Convention is independent from the provisions on hazardous waste under the Basel Convention.

~~55-70.~~ Wastes with a content of PCBs or HBB above 50 mg/kg, [and of PCNs above \[10 mg/kg or 50mg/kg\]](#) must be disposed of in such a way that the POP content is destroyed or irreversibly transformed in accordance with the methods described in section IV.G.2. Otherwise, they may be disposed of in an environmentally sound manner when destruction or irreversible transformation does not represent the environmentally preferable option in accordance with the methods described in section IV.G.3.

~~56-71.~~ Wastes with a content of PCBs or HBB at or below 50 mg/kg, [and of PCNs at or below \[10 mg/kg or 50mg/kg\]](#) should be disposed of in accordance with the methods referred to in subsection IV.G.4 outlining disposal methods when POP content is low and sections IV.I.1 and IV.I.2 addressing pertinent higher and lower risk situations.

~~57-72.~~ For further information on low POP content, refer to section III.A of the general technical guidelines.

B. Levels of destruction and irreversible transformation

~~58-73.~~ For the provisional definition of levels of destruction and irreversible transformation, see section III.B of the general technical guidelines.

C. Methods that constitute environmentally sound disposal

~~59-74.~~ See section IV.G below and section IV.G of the general technical guidelines.

IV. Guidance on environmentally sound management (ESM)

A. General considerations

~~60-75.~~ For further information, see section IV.A of the general technical guidelines.

B. Legislative and regulatory framework

~~61-76.~~ Parties to the Basel and Stockholm conventions should examine their national strategies, policies, controls,¹⁹ standards and procedures to ensure that they are in agreement with the two conventions and their obligations under them, including those that pertain to ESM of wastes consisting of, containing or contaminated with PCBs, [PCNs](#) and HBB.

~~62-77.~~ Elements of a regulatory framework applicable to PCBs, PCTs, [PCNs](#) and PBBs should include measures to prevent the generation of wastes and to ensure the environmentally sound management of generated wastes. Such elements could include the following:

- (a) Environmental protection legislation establishing a regulatory regime, setting release limits and establishing environmental quality criteria;
- (b) Prohibitions on the production, sale, use, import and export of PCBs, PCTs, [PCNs](#) and PBBs;
- (c) Phase-out dates for PCBs that remain in service, inventory or storage;
- (d) Transportation requirements for hazardous materials and waste;
- (e) Specifications for containers, equipment, bulk containers and storage sites;
- (f) Specification of acceptable analytical and sampling methods for PCBs, PCTs, [PCNs](#) and PBBs;
- (g) Requirements for waste management and disposal facilities;
- (h) Definitions of hazardous waste and conditions and criteria for the identification and classification of PCB, PCT, [PCN](#) and PBB wastes as hazardous wastes;

¹⁹ In these guidelines, national legislation and control measures include sub-national and other applicable forms of governance.

- (i) A general requirement for public notification and review of proposed government waste-related regulations, policy, certificates of approval, licences, inventory information and national emissions data;
- (j) Requirements for identification, assessment and remediation of contaminated sites;
- (k) Requirements concerning the health and safety of workers; and
- (l) Other legislative measures on, e.g., waste prevention and minimization, inventory development and emergency response.

~~63-78.~~ The timing of the phase-out of PCBs (and, to a lesser extent, of PCTs ~~and PCNs or PBBs~~) will probably be the most critical legislative concern for most countries, given that most of them already have some form of legislative framework dealing with PCBs.

~~64-79.~~ For further information, see section IV.B of the general technical guidelines.

C. Waste prevention and minimization

~~65-80.~~ Both the Basel and Stockholm conventions advocate waste prevention and minimization, and PCB compounds, PCNs and HBB are targeted for a complete phase-out in the Stockholm Convention. PCBs, PCTs, PCNs and PBBs should be taken out of service and disposed of in an environmentally sound manner.

~~66-81.~~ Quantities of waste containing these compounds should be minimized through isolation and source separation to prevent mixing and contamination of other waste streams. For example, electrical equipment, painted materials, resin-based floorings, sealants and sealed glazing units containing PCBs can contaminate large amounts of demolition waste and should be separated where practicable prior to demolition.

~~67-82.~~ The mixing and blending of wastes with a PCB or HBB content above a ~~50mg/kg~~ 50 mg/kg, or with a PCN content above [10 mg/kg or 50mg/kg] with other materials solely for the purpose of generating a mixture with a PCB or HBB content at or below 50 mg/kg, or a PCN content at or below [10 mg/kg or 50mg/kg], respectively, is not environmentally sound. Nevertheless, the mixing or blending of materials before waste treatment may be necessary in order to enable treatment or to optimize treatment efficiency.

~~68-83.~~ To facilitate the reuse of electrical equipment containing insulation oil contaminated with PCBs, such as transformers, a procedure called retrofilling may be implemented in which the equipment is emptied of the insulation oil contaminated with PCBs and refilled with PCB-free insulating oil, such as mineral oil. In retrofilling procedures, care should be taken to avoid cross-contamination of retrofilled oils with any PCBs that may have penetrated the porous parts of the equipment, such as wood, cardboard, insulating paper and resins, and may gradually leach into retrofilled oils. As a preventive measure, some countries have enacted regulations whereby, in the absence of analyses to determine the presence or absence of PCBs in electrical equipment oils, such oils are presumed to contain PCBs until proven otherwise.²⁰ Decontamination methods should be planned carefully to reduce the number of times that retrofilling procedures are conducted by requiring that initial PCB levels be considered and that every effort be made to empty equipment entirely. Retrofilled equipment should be periodically tested for PCBs and, when PCB levels exceed the low POP content, retrofilling should be performed again.

~~69-84.~~ For further information, see section IV.C of the general technical guidelines.

D. Identification of wastes

~~70-85.~~ Article 6, paragraph 1 (a), of the Stockholm Convention requires each party to, *inter alia*, develop appropriate strategies for the identification of products and articles in use and wastes consisting of, containing or contaminated with POPs. The identification of POPs wastes is the starting point for their effective ESM.

~~71-86.~~ For general information on identification of waste, see section IV.D of the general technical guidelines.

²⁰ For example, see Argentina's 2002 *Law 25.670*.

1. Identification

72-87. PCBs, PCTs and PCTsPCNs have historically been found in a number of locations, as follows:

- (a) In completely closed or nominally closed systems, including:
 - (i) Electrical utilities: transformers, capacitors, switches, voltage regulators, circuit breakers, light ballasts, and waste electrical and electronic equipment (WEEE) containing small capacitors and cables;
 - (ii) Industrial facilities: transformers, capacitors, voltage regulators, circuit breakers, light ballasts, heat transfer fluids and hydraulic fluids;
 - (iii) Railroad systems: transformers, capacitors, voltage regulators and circuit breakers;
 - (iv) Mining operations: hydraulic fluids and earthing coils;
 - (v) Military installations: transformers, capacitors, voltage regulators and hydraulic fluids;
 - (vi) Residential/commercial buildings: capacitors, circuit breakers and light ballasts;
 - (vii) Research laboratories: vacuum pumps, light ballasts, capacitors and circuit breakers;
 - (viii) Electronics manufacturing plants: vacuum pumps, light ballasts, capacitors and circuit breakers;
 - (ix) Wastewater discharge facilities: vacuum pumps and well motors;
 - (x) Automotive service stations: reused oil;
- (b) In open-ended systems, including:
 - (i) Residential/commercial buildings: elastic joints and fillers, sealants,²¹ paints, concrete ~~and plaster~~, plaster, carbonless copy paper, fabrics, polyurethane foam, lubricants, synthetic rubber, adhesives and wood preservatives;
 - (ii) Steel structures such as bridges, tanks, ships or laying pipes: paints and coatings.

73-88. When identifying wastes, parties may containing or contaminated with PCBs, PCTs and PCNs, parties may use an approach developed for PCBs inventorying and find it is useful to refer to *the Guidelines for the identification of PCBs and materials containing PCBs* (UNEP, 1999) ~~and~~ the *PEN magazine, Issue "Inventories of PCBs – The Place to Start"* (UNEP, 2010).

74-89. For closed electrical equipment such as transformers and capacitors, generally it is possible to identify whether such equipment contains PCBs, PCTs or PCTsPCNs by inspecting the type designation on the equipment name plates and the product labels or literature issued by the manufacturer, and by referring to the date of production of the equipment. It should be noted that even recently manufactured equipment could be contaminated with PCB/PCTPCBs above 50 mg/kg or PCNs above [10mg/kg or 50mg/kg] through retrofilling or maintenance work. The insulating oils in all closed electrical equipment should therefore be analysed for possible PCB-~~or~~, PCT or PCN content. In the case of light ballasts and WEEE equipped with small capacitors, it is difficult to determine whether they contain PCBs or PCTs as dielectric fluids. The PCB, PCT or PCTPCN content of such equipment should be carefully determined by referring to equipment type designations and production dates.

75-90. For open-ended materials such as joint sealants or paints separated from demolition waste, it is impossible to judge whether these contain PCBs, PCTs or PCTsPCNs solely from their appearance. Therefore, the time when such materials were applied should be verified and, if the materials were produced during the time when PCBs, PCTs or PCTsPCNs were used as plasticizers, a test for the presence of PCBs, PCTs or PCTsPCNs in the waste should be performed.

76-91. It is difficult even for experienced technicians to identify the characteristics of effluents, substances, containers or equipment solely from their external appearance or labels. With respect to electrical equipment such as transformers and capacitors, it is possible to identify the brand of the

²¹ Buildings built mainly between 1950 and 1980 may contain PCBs in joint sealants.

equipment and thus confirm the year and country where it was manufactured, as well as its manufacturer. By referring to available information or by contacting the manufacturer, it is possible to determine whether the equipment contains PCBs. If PCB-containing equipment does not have any label pertaining to its insulating oil, experienced investigators can obtain information on the original contents and other information through labels of similar equipment, by referring to relevant guidance manuals, such as the Guidelines for the Identification of PCBs and Materials Containing PCBs (UNEP, 1999), or by contacting the manufacturer.

77-92. PBBs have historically been found in a number of consumer products where they were used as flame retardants, including a variety of plastic products such as computer monitors, televisions, textiles and plastic foams (including those in WEEE and shredder residue generated during the recycling process of waste vehicles).

78-93. Parties may find the information on production, use and waste types provided in section I.B of the present guidelines useful in identifying PCBs, PCTs, [PCNs](#) and PBBs.

2. Inventories

79-94. Inventories are an important tool for identifying, quantifying and characterizing wastes. A step-by-step approach for the development of national inventories of PCBs, PCTs, [PCNs](#) and PBBs generally includes the following steps:

- (a) Step 1: planning (i.e., identifying relevant sectors of use and production of PCBs, PCTs, [PCNs](#) and PBBs);
- (b) Step 2: choosing data collection methodologies using a tiered approach;
- (c) Step 3: collecting and compiling data from national statistics on the production, use, import and export of PCBs, PCT, [PCNs](#) and PBBs;
- (d) Step 4: managing and evaluating the data obtained in step 3 using an estimation method;
- (e) Step 5: preparing an inventory report; and
- (f) Step 6: periodically updating the inventory report.

80-95. For further information, refer to the *Guidelines for the identification of PCBs and materials containing PCBs* (UNEP, 1999).

E. Sampling, analysis and monitoring

81-96. For general information on sampling, analysis and monitoring, see section IV.E of the general technical guidelines.

1. Sampling

82-97. It is difficult to extract dielectric fluid samples from sealed waste electrical equipment such as capacitors. To obtain such samples, a small hole should carefully be drilled on the top of the equipment. After taking the sample, the hole should be plugged and repaired.

83-98. During sampling of shredder residue, efforts should be made to ensure sample homogeneity.

84-99. The types of matrices that are of special interest for analysis of PCBs, PCTs, [PCNs](#) and PBBs include:

- (a) Industrial synthetic [PCBs](#), [PCT](#) and [PCTPCN](#)-containing oils from transformers or other equipment or in bulk storage;
- (b) Mineral oils from retrofilled transformers contaminated with PCBs or in bulk storage;
- (c) Waste motor oils and other waste oils, fuels and organic liquids;
- (d) Elastic joints and fillers, sealants and paints; and
- (e) Fire suppressants and retardants (PBBs).

2. Analysis

85-100. Analysis refers to the extraction, purification, separation, identification, quantification and reporting of POP concentrations in the matrix of interest. The development and dissemination of reliable analysis methods and the accumulation of high-quality analytical data are important to understand the environmental impact of hazardous chemicals, including POPs.

86-101. As with all polybrominated flame retardants, samples should not be exposed to sunlight prior to analysis, since PBBs are unstable when exposed to ultraviolet radiation (IARC, 2014).

87-102. Methods of analysing the various matrices for POPs have been developed by ISO, the European Committee for Standardization (CEN – EN standards), ABNT, AOAC, ASTM, DIN, EPA, JIS, NEN and NVN. Some examples of analytical methods for PCBs include the following:

- (a) Methods for oils or insulating liquids:
 - (i) EN 12766-1 (2000): Petroleum products and used oils - Determination of PCBs and related products - Part 1: Separation and determination of selected PCB congeners by gas chromatography (GC) using an electron capture detector (ECD);
 - (ii) EN 12766-2 (2002): Petroleum products and used oils - Determination of PCBs and related products - Part 2: Calculation of polychlorinated biphenyl (PCB) content;
 - (iii) EN 61619 (1997): Insulating liquids - Contamination by polychlorinated biphenyls (PCBs) - Method of determination by capillary column gas chromatography;
 - (iv) EPA Method 4020: Screening for polychlorinated biphenyls by immunoassay (www.epa.gov/solidwaste/hazard/testmethods/sw846/pdfs/4020.pdf);
 - (v) EPA Method 8082A: Polychlorinated biphenyls (PCBs) by gas chromatography (www.epa.gov/osw/hazard/testmethods/sw846/pdfs/8082a.pdf);
 - (vi) EPA Method 9079: Screening test method for polychlorinated biphenyls in transformer oil (www.epa.gov/solidwaste/hazard/testmethods/sw846/pdfs/9079.pdf);
 - (vii) ABNT NBR 13882:2005: Electrical Insulating Liquids - Determination of PCB contents;
- (b) Methods for solid materials:
 - (i) EN 15308 (2008): Characterization of waste - Determination of selected polychlorinated biphenyls (PCBs) in solid waste by using capillary gas chromatography with electron capture or mass spectrometric detection;
 - (ii) EPA Method 8080: Organochlorine Pesticides and PCBs;
 - (iii) Methods for Examining Standards of General Wastes under Special Control and Industrial Waste under Special Control, Notice 192 of the Japan Ministry of Welfare and Labour, 3 July 1992;
- (c) Methods for water, sludge, gases and others:
 - (i) DIN 38414-20 (1996): German standard methods for the examination of water, waste water and sludge - Sludge and sediments (group S) - Part 20: Determination of 6 polychlorinated biphenyls (PCBs) (P 20);
 - (ii) EN 1948 (2006): Stationary source emissions - determination of the mass concentration of PCDDs/PCDFs and dioxin-like PCBs. Part 1 Sampling, Part 2: Extraction and clean-up of PCDDs/PCDFs, Part 3: Identification and quantification of PCDDs/PCDFs;
 - (iii) EPA Method 1668, Revision A: Chlorinated Biphenyl Congeners in Water, Soil, Sediment, and Tissue by HRGC/HRMS, United States Office of Water, EPA No. EPA 821-R-00-002, Environmental Protection Agency (4303), December 1999;
 - (iv) EPA Method 8275A: Semivolatile organic compounds (PAHs and PCBs) in soils/sludges and solid wastes using thermal extraction/gas chromatography/mass spectrometry (TE/GC/MS), EPA analytical chemistry guidance SW-846;
 - (v) EPA Method 9078: Screening test method for polychlorinated biphenyls in soil (www.epa.gov/epaoswer/hazwaste/test/pdfs/9078.pdf);
 - (vi) ISO 6468 (1996): Water quality - Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzenes - Gas chromatographic method after liquid-liquid extraction;

- (vii) ISO 10382 (2002): Soil quality - Determination of organochlorine pesticides and polychlorinated biphenyls - Gas-chromatographic method with electron capture detection;
- (viii) JIS K 0093 (2006): Testing method for polychlorinated biphenyls in industrial water and wastewater;
- (ix) NEN 7374 (2004): Leaching characteristics - Column test for the determination of the leaching of PAH, PCB, OCP and EOX, phenol and cresoles from granular materials - Solid earthy and stony materials;
- (x) Norwegian Institute for Water Research method no. H 3-2: Determination of organochlorine compounds in sediments, water and biological material by gas chromatography;
- (xi) NVN 7350 (1997): Leaching characteristics of solid earthy and stony building and waste materials - Leaching tests - Determination of the leaching of PAH, PCB and EOX from granular materials with the cascade test;
- (xii) NVN 7376 (2004): Leaching characteristics - Determination of the leaching of PAH, PCB, OCP and EOX, phenol and cresoles from building and monolithic waste materials with a diffusion test - Solid earthy and stony materials.

103. Methods of analyzing water for PCNs have been developed by the International Organization for Standardization (ISO), as follows:

- (a) ISO/TS 16780 (2015) Water quality– Determination of polychlorinated naphthalenes (PCN)—Method using gas chromatography (GC) and mass spectrometry (MS)

104. PCNs analysis is commonly based on fractionation and carbon clean-up followed by GC/MS. It should be noted that there are some problems in PCNs analysis. A problem is the limited commercial availability of authentic standards and quite limited commercially available C13-labeled PCN congeners as internal standards. Another problem is the co-elution of some PCN congeners in capillary gas chromatographic separation. Further problem is that PCBs could co-elute with PCNs and interfere with their detection, if gas chromatography alone was used. However, useful knowledge can be obtained from the following literature regarding the method of analysis of various matrices for PCNs:

- (a) Abad E. et al., 1999. "Dioxin like compounds from municipal waste incinerator emissions: assessment of the presence of polychlorinated naphthalenes", *Chemosphere*, vol. 38, pp. 109-120;
- (b) Falandysz J., et al., 2006. "HRGC/HRMS analysis of chloronaphthalenes in several batches of Halowax 1000, 1001, 1013, 1014 and 1099", *Journal of Environmental Science & Health, Part A*, vol. 41, pp. 2237-2255;
- (c) Helm P.A., 1999. "Complete separation of isomeric penta- and hexachloronaphthalenes by capillary gas chromatography", *Journal of High Resolution Chromatography*, vol. 22, pp. 639-643;
- (d) Järnberg U., et al., 1994. "Gas chromatographic retention behaviour of Polychlorinated naphthalenes on non-polar, polarizable, polar and smectic capillary columns", *Journal of Chromatography A*, vol. 783, pp. 385-396;
- (e) Liu G., et al., 2014. "Sources of unintentionally produced polychlorinated naphthalenes", *Chemosphere*, vol. 94, pp. 1-12;
- (f) Noma Y., et al., 2006. "Behavior of PCNs, PCDDs, PCDFs, and Co-PCBs in the thermal destruction of wastes containing PCNs", *Chemosphere*, vol. 62, pp. 1183-1195;
- (g) Taniyasu S., et al., 2003. "Isomer-specific analysis of chlorinated biphenyls, naphthalenes and dibenzofurans in Delor: polychlorinated biphenyl preparations from the former Czechoslovakia", *Environmental Pollution*, vol. 126, pp. 169-178.

105. Methods of analysing electrotechnical products for PBBs have been developed by the International Electrotechnical Commission (IEC), as follows:

- (a) IEC 62321 (2008): Electrotechnical products – Determination of levels of six regulated substances (lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls, polybrominated diphenyl ethers).

89-106. Furthermore, useful knowledge can be obtained from the following literature regarding the method of analysis of various matrices for PBBs:

- (a) US Agency for Toxic Substances and Disease Registry, 2004. *Toxicological profile for polybrominated biphenyls and polybrominated diphenyl ethers*;
- (b) Kemmlein, S. et al., 2009. "Brominated flame retardants in the European chemicals policy of REACH-Regulation and determination in materials", *Journal of Chromatography A*, vol. 1216 No. 3, pp. 320-333;
- (c) Clarke, B. et al., 2008. "Polybrominated diphenyl ethers and polybrominated biphenyls in Australian sewage sludge", *Chemosphere*, vol. 73, pp. 980-989;
- (d) Covaci, A. et al., 2003. "Determination of brominated flame retardants, with emphasis on polybrominated diphenyl ethers (PBDEs) in environmental and human samples: A review", *Environment International*, vol. 29, pp. 735-756;
- (e) Hanari, N. et al., 2006. "Occurrence of polybrominated biphenyls, polybrominated dibenzo-p-dioxins, and polybrominated dibenzofurans as impurities in commercial polybrominated diphenyl ether mixtures", *Environmental Science & Technology*, vol. 40, pp. 4400-4405.

90-107. To determine dioxin-like PCBs and PBBs, which could be of special interest to parties, internationally accepted methods such as those for analysing PCDDs/PCDFs should be applied.

94-108. For screening purposes, test kits are available for the quantification of PCBs in oils and soils (based on immunoassays or chlorine determinations). If the result is negative, a confirmatory PCB analysis is not necessary. If the result is positive, confirmatory chemical analysis should be performed, or the waste may be regarded as waste containing or contaminated with PCBs.

3. Monitoring

92-109. Monitoring and surveillance serve as elements for identifying and tracking environmental concerns and human health risks. Information collected from monitoring programs feeds into science-based decision-making processes and is used for the evaluation of the effectiveness of risk management measures, including regulations.

93-110. Monitoring programmes should be implemented in facilities managing PCB, PCT, [PCN](#) or PBB wastes.

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

94-111. For general information on handling, collection, packaging, labelling, transportation and storage, see section IV.F of the general technical guidelines.

1. Handling

95-112. Special attention should be paid to possible PCB [or PCN](#) leakages due to corrosion or defects of PCB [or PCN](#)-containing electrical equipment such as transformers and capacitors, as such equipment generally has a lifetime of several decades. Special attention should also be paid to damages that may result from moving such equipment. Heavy electrical machineries require caution in handling bushings, as these are prone to breakage under heavy loads. When dealing with highly concentrated PCBs [or PCNs](#), operators should use masks and rubber gloves to avoid inhalation of volatilized PCBs or skin contact with PCBs [or PCNs](#).

96-113. When conducting repairs in or renovation or demolition of older buildings, renovators and contractors should pay attention to the possibility of PCBs [or PCNs](#) being contained in building joints, window or door sealants or fillers, and paint coatings on steel bridges or structures. Should these materials contain PCBs [or PCNs](#), they should be carefully removed and isolated to prevent PCB [or PCN](#)-containing dust from spreading to surrounding areas. The work should be conducted wearing appropriate protective equipment such as suitable gloves, disposable coveralls, protective goggles and respiratory protection masks that meet international standards.

2. Collection

97-114. A significant fraction of total national inventories of PCBs, PCTs, [PCNs](#) and PBBs may be held in small quantities by small business owners or homeowners (for example, in PCB fluorescent light ballasts; small electrical devices, heat exchangers and heaters containing PCB, [PCT](#) or [PCTPCN](#)

fluids; fire suppression systems containing PBBs; and small containers and small stockpiles of those substances). It is difficult for those who own small quantities of PCBs, PCTs, [PCNs](#) or PBBs to dispose of such materials. For example, regulations may require them to be registered as waste generators, logistical considerations may prevent or discourage pick-up (e.g., no industrial waste pick-up is allowed or available in their neighbourhood), and disposal costs may be prohibitive. National, regional and municipal governments should consider establishing collection stations for those small quantities so that each small-quantity owner does not have to make individual transport and disposal arrangements.

~~98-115.~~ In cases where PCBs, [PCTs](#) and [PCTs/PCNs](#) are found when conducting repairs in, or renovation or demolition of, older buildings (e.g., elastic joints and fillers, sealants, paints, concrete and plaster containing PCBs, [PCTs](#) and [PCTs/PCNs](#)), the safety of workers should be ensured and wastes should be carefully removed and collected separately to prevent dust containing PCBs, [PCTs](#) and [PCTs/PCNs](#) from spreading to surrounding areas.

~~99-116.~~ Collection arrangements and collection depots for PCB, PCT, [PCN](#) and PBB wastes should provide for the separation of those wastes from other wastes.

~~100-117.~~ It is imperative that collection depots do not become long-term storage facilities for PCB, PCT, [PCN](#) or PBB wastes. Large amounts of wastes, even if properly stored, pose a higher risk to the environment and human health than small quantities scattered over large areas.

3. Packaging

~~101-118.~~ PCB, PCT, [PCN](#) and PBB wastes should be properly packaged before storage for ease of transport and as a safety measure to reduce the risk of leaks and spills:

(a) With regard to transformers whose insulating oils have been drawn out, drained oils and carcasses should be packed separately. The risk of leakage during transport to a treatment facility may be lowered by separating insulating oils from transformers. Such separation should ideally be taken into account when evaluating packaging methods. Separation procedures should be performed by professional operators using special tools;

(b) Liquid wastes should be placed in double-bung steel drums or other approved containers;

(c) Solid wastes such as sealants and paints should be placed in steel drums or other approved containers lined with plastic bags;

(d) Regulations governing the transport of hazardous materials often require the use of containers that meet certain specifications (e.g., 16-gauge, made of steel, internally coated with epoxy). Containers used for storage should meet such specifications given that they may be transported in the future;

(e) Large drained equipment may be stored as is or may be placed inside large containers (overpack drums) or heavy plastic wraps if leakage is a concern;

(f) Small pieces of equipment, whether drained or not, should be placed in drums with an absorbent material, where appropriate, to prevent excessive movement of container contents and enable any free liquids and spills to be absorbed. Numerous small pieces of equipment may be placed in the same drum so long as an adequate amount of absorbent material is present in the drum. Loose absorbents may be purchased from safety suppliers;

(g) Drums and equipment may be placed on pallets for movement by forklift truck and for storage. Drums and equipment should be strapped to the pallets before they are moved.

4. Labelling

~~102-119.~~ Every container and piece of equipment containing or contaminated with PCBs, PCTs, [PCNs](#) or PBBs should be clearly labelled with a hazard-warning label and a label giving details of the equipment or container. Such details should include the contents of the container or equipment (e.g., exact counts of equipment, volume of liquid, type of waste carried), the name of the site from which the container or equipment originated so as to allow its traceability and, if applicable, the date of repackaging and the name and telephone number of the person responsible for the repackaging operation.

5. Transportation

~~103.120.~~ Since PCBs are transported mostly in liquid form, measures should be taken to prevent leakage during transport. Transformers and capacitors, for example, should be secured in metallic containers to reduce the risk of breakage of equipment bushings from impact during transport, and include absorbent materials in their packaging.

6. Storage

~~104.121.~~ While many countries have adopted storage regulations or developed storage guidelines concerning PCBs, most do not have specific storage regulations or guidance concerning PCTs, PCNs and PBBs. Although PCBs, PCTs, PBBs, PCNs and PCBs/PBBs have similar toxicity, PCBs are liquid at room temperature, while PCTs, PCNs other than mono-CN and PBBs are solid at room temperature and have a lower vapour pressure. The storage conditions required for PCTs, PCNs and PBBs may therefore differ from those required for PCBs.

~~105.122.~~ An oil pan (steel tray) should be laid underneath stored equipment. Storage sites should be maintained and inspected to verify whether there have been any releases of PCBs, PCTs, PCNs or PBBs into the environment.

~~106.123.~~ In order to prevent the spillage of PCBs or PCNs from equipment that has tumbled down during disasters such as earthquakes, tornadoes and heavy rains, or from leakage due to equipment corrosion, storage sites should have structures to prevent underground leakage. Moreover, it should be taken into account that PCBs or PCNs might be released into the environment through vaporization during storage. It should be noted that PCNs are usually more volatile than PCBs because of the higher vapour pressure.

G. Environmentally sound disposal

1. Pre-treatment

~~107.124.~~ Cutting and milling of capacitors or disassembling of external parts such as radiators, conservators and bushings of transformers for the purpose of size reduction should be carried out before destruction in dedicated facilities. Caution should be taken during disassembling and dismantling operations, since such operations increase the risk of operator exposure to PCBs or PCNs and of PCBs or PCNs releases into the environment.

~~108.125.~~ When destroying PCBs in waste oils or liquid wastes through alkali metal reduction, dewatering or oil-water separation should be done as a pre-treatment procedure in order to avoid the violent reaction of water with, and the excessive consumption of, alkali metals.

~~109.126.~~ Since wastes containing PCBs from open-ended systems such as joint sealants or paints are generally bulky, crushing or shredding should be done as a pre-treatment to reduce them into smaller pieces and, when necessary, thermal desorption or vacuum thermal desorption should be implemented to effectively treat the PCBs in the wastes.

~~110.127.~~ For further information on pre-treatment, see subsection IV.G.1 of the general technical guidelines.

2. Destruction and irreversible transformation methods

~~111.128.~~ For information on destruction and irreversible transformation methods relating to PCBs, PCNs and HBB; see subsection IV.G.2 of the general technical guidelines.

~~112.129.~~ It should be noted that PCDDs/PCDFs can be generated from the combustion and incineration of PCB or PCN wastes, while the combustion and incineration of PBB wastes can generate PBDDs/PBDFs.

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

~~113.130.~~ For information, see subsection IV.G.3 of the general technical guidelines.

4. Other disposal methods when the POP content is low

~~114.131.~~ When cleansing or decomposing PCB-contaminated transformer insulating oils on site the spilling or leakage of effluents should be prevented even if the level of PCBs in the oils is relatively low.

~~115-132.~~ For further information, see subsection IV.G.4 of the general technical guidelines.

H. Remediation of contaminated sites

~~116-133.~~ For information, see subsection IV.H of the general technical guidelines.

I. Health and safety

~~117-134.~~ For further information, including on the distinction between higher- and lower-risk situations, see section IV.I of the general technical guidelines.

1. Higher-risk situations

~~118-135.~~ For information on higher-risk situations, see subsection IV.I.1 of the general technical guidelines. Potential higher-risk situations specific to PCBs, PCTs, [PCNs](#) or PBBs may include:

- (a) In electrical rooms with large or multiple PCB transformers, circuit breakers or capacitors;
- (b) At sites at which PCB-containing transformers, circuit breakers, hydraulic equipment or vacuum pumps have been used or maintained;
- (c) At sites where PCBs are separated from equipment and transferred to another container or where pre-handling measures such as disassembling of equipment are carried out. Caution should be taken at those sites, since they present increased risk of exposure for operators; and
- (d) In buildings in which PCBs have been used in elastic joints and fillers, paints or sealants.

2. Lower-risk situations

~~119-136.~~ For information on lower risk situations, see subsection IV.I.2 of the general technical guidelines. Lower-risk situations specific to PCBs, PCTs, [PCNs](#) or PBBs may include:

- (a) Those that involve only products or articles that contain or are contaminated with PCBs in small quantities or at low concentrations (e.g., some electrical and electronic equipment and waste equipment); and
- (b) Those that involve electrical transformers or other equipment with low-level PCB-contaminated mineral oils.

J. Emergency response

~~120-137.~~ Emergency response plans should be in place for PCBs, ~~PBBs~~[PCTs](#), [PCNs](#) and [PCTs](#)~~PBBs~~ that are in service, in storage, in transport and at disposal sites. Further information on emergency response plans is given in section IV.J of the general technical guidelines and in *Preparation of a national environmentally sound plan for PCBs and PCB-contaminated equipment: training manual* (UNEP, 2003).

K. Public participation

~~121-138.~~ Parties to the Basel or Stockholm Convention should have open public participation processes.

~~122-139.~~ For further information see section IV.K of the general technical guidelines.

Annex I to the technical guidelines

Synonyms and trade names for PCBs, PCTs, PCNs, PBBs other than HBB, and HBB

Chemical	Some synonyms and trade names ¹
PCBs	Abestol, Aceclor, Adkarel, ALC, Apirolio (Italy), Apiorlio, Areclor, Arochlor, Arochlors, Aroclor/Arochlor(s) (USA), Arubren, Asbestol (USA), Ask/Askarel/Askael, Auxol, Bakola, Biclor, Blacol (Germany), Biphenyl, Clophen (Germany), Cloresil, Chlophen, Chloretol, Chlorextol (USA), Chlorfin, Chlorinal/Chlorinol, Chlorinated biphenyl, Chlorinated diphenyl, Chlorobiphenyl, Chlorodiphenyl, Chlorofen (Poland), Chlorphen, Chorextol, Chorinol, Clophen/Clophenharz (Germany), Cloresil, Clorinal, Clorphen, Crophene (Germany), Decachlorodiphenyl, Delofet O-2, Delor (Czechoslovakia), Delor/Del (Czechoslovakia), Delorene, Delorit, Delotherm DK/DH (Czechoslovakia), Diaclor (USA), Diarol, Dicolor, Diconal, Disconon, DK (Italy), Ducanol, Duconal, Duconol, Dykanol (USA), Dyknol, Educarel, EEC-18, Elaol (Germany), Electrophenyl, Elemex (USA), Elinol, Eucarel, Euracel, Fenchlor (Italy), Fenclor (Italy), Fenocloro, Gilotherm, Hexol, Hivar, Hydeler, Hydol, Hydrol, Hyrol, Hyvol (USA), Inclor, Inerteen (USA), Inertenn, Kanechlor (Japan), Kaneclor, Kennechlor (Japan), Kenneclor, Leromoll, Magvar, MCS 1489, Montar, Monter, Nepoli, Nepolin, Niren, NoFlamol, No-Flamol (USA), <u>Nitrosovol (USSR)</u> , Non-Flamol, Olex-sf-d, Orophene, Pheaclor, Pheneclor, Phenochlor, Phenoclor (France), Plastivar, Polychlorinated diphenyl, Polychlorinated diphenyls, Polychlorobiphenyl, Polychlorodiphenyl, Prodelec, Pydraul, Pyraclor, Pyralene (France), Pyranol (USA), Pyroclor (USA), Pyrochlor, Pyronol, Safe-T-Kuhl, Saft-Kuhl, Saf-T-Kohl, Saf-T-Kuhl (USA), Santosol, Santotherm (Japan), Santothern, Santovac, Sat-T-America, Siclonyl, Solvol, Sorol, Soval, Sovol (USSR), Sovtol, Tarnol (Poland), Terphenychlore, Thermanol, Therminol, Turbinol
PCTs	Aroclor (USA), Clophen Harz (W <u>(Germany)</u>), Cloresil (A, B, <u>and 100 (Italy)</u>), Electrophenyl T-50 and T60, <u>(France)</u> , Kanechlor KC-C (Japan), Leromoll, <u>(Germany)</u> , Phenoclor, <u>(France)</u> , Pydraul <u>(USA)</u>
<u>PCNs</u>	<u>Basileum SP-70 (Germany), Cerifal (Italy), Chlonacire wax 90, 115 and 130 (France), Halowax 1000, 1001, 1013, 1014, 1031, 1051, 1099, 1099B, 2141 and 2148 (USA), Halowax (USSR), Hodogaya Amber wax (Japan), Nankai wax (Japan), Nibren wax D88, D116N and D130 (Germany), N-Oil (USA), N-Wax (USA), Perna wax (Germany), Seekay wax R68, R93, R123, R700, RC93 and RC123 (United Kingdom), Tokyo Ohka wax (Japan), Woskol (Poland)</u>
PBBs other than HBB	Adine 0102 (France), Berkflam B ₁₀ (United Kingdom of Great Britain and Northern Ireland), Bromkal 80 (Germany), Bromkal 80-9D (Germany), Octabromobiphenyl FR250 13A (USA), Flammex B-10 (United Kingdom of Great Britain and Northern Ireland), HFO 101 (United Kingdom of Great Britain and Northern Ireland), BB-8, BB-9, OBB, Technical octabromobiphenyl (USA), DBB, Technical hexabromobiphenyl <u>decabromobiphenyl</u> (USA)
HBB	FireMaster BP-6 (USA), FireMaster FF-1 (USA)

¹ The list of trade names provided in annex I is not intended to be exhaustive.

Annex II to the technical guidelines

Bibliography

[AMAP, 2004. *Arctic Monitoring and Assessment Programme 2002: Persistent Organic Pollutants in the Arctic*. Oslo, Norway, 2004. Available at: \[www.amap.no/documents/doc/amap-assessment-2002-persistent-organic-pollutants-in-the-arctic/96\]\(http://www.amap.no/documents/doc/amap-assessment-2002-persistent-organic-pollutants-in-the-arctic/96\).](#)

ATSDR, 2000. *Toxicological Profile for Polychlorinated Biphenyls (PCBs)*. Available at: www.atsdr.cdc.gov/toxprofiles/tp17-c4.pdf.

ATSDR, 2004. *Toxicological Profile for Polybrominated Biphenyls and Polybrominated Diphenyl Ethers (PBBs and PBDEs)*. Available at: www.atsdr.cdc.gov/toxprofiles/tp68.pdf.

[Blankenship A., Kannan K., Villalobos S.A., Villeneuve D.L., Falandysz J., Imagawa T., 2000. "Relative potencies of individual polychlorinated naphthalenes and Halowax mixtures to induce Ah receptor-mediated responses", *Environmental Science and Technology*, vol. 34, pp. 3153–3158.](#)

[Brinkman U.A.Th., Reymer H.G.M., 1976. "Polychlorinated naphthalenes", *Journal of Chromatography*, vol. 127, pp 203-243.](#)

[Crookes M.J., Howe P.D., 1993. "Environmental hazard assessment: Halogenated naphthalenes", Building Research Establishment, Toxic Substances Division, Directorate for Air, Climate and Toxic Substances, Department of the Environment Report No TSD/13.](#)

Environment Canada, 1988. *Polychlorinated biphenyls (PCB) - Fate and effects in the Canadian environment*. Environment Canada report EPS 4/HA/2, May 1988.

[Environment Canada, 2011. *Ecological Screening Assessment Chlorinated Naphthalenes*. Available at: \[www.ec.gc.ca/ese-ees/835522FE-AE6C-405A-A729-7BC4B7C794BF/CNs_SAR_En.pdf\]\(http://www.ec.gc.ca/ese-ees/835522FE-AE6C-405A-A729-7BC4B7C794BF/CNs_SAR_En.pdf\).](#)

[Falandysz J., 1998. "Polychlorinated naphthalenes: An environmental update", *Environmental Pollution*, vol. 101, pp. 77–90.](#)

[Falandysz J., Chudzynski K., Takekuma M., Yamamoto T., Noma Y., Hanari N., Yamashita N., 2008. "Multivariate analysis of identity of imported technical PCN formulation", *Journal of Environmental Science & Health, Part A*, vol. 43, pp. 1381-1390](#)

[Hayward D., 1998. "Identification of bioaccumulating polychlorinated naphthalenes and their toxicological significance", *Environmental Research*, vol. A76 No.1, pp. 1–18.](#)

Holoubek, 2000. *Polychlorinated biphenyls (PCB): World-wide contaminated sites*. TOCOEN report No. 173. Available at: recetox.muni.cz/res/file/reporty/tocoen-report-173-id438.pdf.

IARC, 2014. *Polychlorinated Biphenyls and Polybrominated Biphenyls: IARC Monographs on the Evaluation of Carcinogenic Risks to Humans*, vol. 107. Lyon, France.

IPCS, 1992. *Environmental Health Criteria 140: Polychlorinated biphenyls and polychlorinated terphenyls*. Published by UNEP, ILO and WHO, Geneva. Available at: www.inchem.org/documents/ehc/ehc/ehc140.htm.

IPCS, 1994. *Environmental Health Criteria 152: Polybrominated biphenyls*. Published by UNEP, ILO and WHO, Geneva. Available at: www.inchem.org/documents/ehc/ehc/ehc152.htm.

[IPCS, 2001. *Concise International Chemical Assessment Document 34 CHLORINATED NAPHTHALENES*. World Health Organization, Geneva, 2001. ISBN 92-4-153034-0 Available at: \[www.inchem.org/documents/cicads/cicads/cicad34.htm\]\(http://www.inchem.org/documents/cicads/cicads/cicad34.htm\).](#)

[Japan Ministry of Economy, Trade and Industry, Chemical council, Safety guideline section, 1979. *The regulation of polychlorinated naphthalenes and hexa-chlorobenzenes* \(in Japanese\).](#)

Jensen, A.A. and Jørgensen, K.F., 1983. "Polychlorinated terphenyls (PCT) uses, levels and biological effects", *Science of the Total Environment*, vol. 27, pp. 231-250.

- [Kannan K., Yamashita N., Imagawa T., Decoen W., Khim, J. S., Day R. M., Summer C. L., Giesy J. P., 2000. "Polychlorinated naphthalenes and polychlorinated biphenyls in fishes from Michigan waters including the Great Lakes", *Environmental Science & Technology*, vol. 34, pp. 566–572](#)
- [NICNAS \(National Industrial Chemicals Notification and Assessment Scheme\), 2002. *Polychlorinated Naphthalenes*. GPO Box 58, Sydney NSW 2001, Australia. Available at: \[www.nicnas.gov.au/Publications/CAR/Other/S48_CN_July02.pdf\]\(http://www.nicnas.gov.au/Publications/CAR/Other/S48_CN_July02.pdf\).](#)
- [Noma Y., Yamamoto T., Sakai S., 2004. "Congener-specific composition of polychlorinated naphthalenes, coplanar PCBs, dibenzo-*p*-dioxins, and dibenzofurans in the Halowax series", *Environ. Sci. Technol.*, 38, pp.1675-1680.](#)
- [Noma Y., Minetomatsu K., Falandysz J., Flisak M., Świętojańska A., Jęcek L., Miyaji K., Sakai S., 2005. "By-side impurities in chloronaphthalene mixtures of the Halowax series: all 135 chlorodibenzofurans", *Journal of Environmental Science & Health, Part A.*, vol. 40, pp. 63-76.](#)
- [Noma Y., Minetomatsu K., Falandysz J., Świętojańska A., Flisak M., Miyaji K., Sakai S., 2005a. "By-side impurities in chloronaphthalene mixtures of the Halowax series: all 75 chlorodibenzo-*p*-dioxins", *Journal of Environmental Science & Health, Part A*, vol. 40, pp. 77-89.](#)
- [Noma Y., Yamamoto T., Giraud R., Sakai S., 2006. "Behavior of PCNs, PCDDs, PCDFs, and dioxin-like PCBs in the thermal destruction of wastes containing PCNs", *Chemosphere*, vol. 62, pp. 1183-1195.](#)
- [Nomura S., 1951. "Experimental studies on the pathogenesis and prevention of Chlorinated Naphthalene poisoning", *Journal of Science of Labour*, vol. 28, pp. 847-857 \(in Japanese\)](#)
- [Pan X., Tang J., Chen Y., Li J., Zhang G., 2011. "Polychlorinated naphthalenes \(PCNs\) in riverine and marine sediments of the Laizhou Bay area, North China", *Environmental Pollution*, vol. 159 No. 12, pp. 3515-3521](#)
- [Plassche E., Schwegler A., 2003. *Polychlorinated naphthalenes*. Available at: \[www.unece.org/fileadmin/DAM/env/lrtap/TaskForce/popsxg/2000-2003/pcn.pdf\]\(http://www.unece.org/fileadmin/DAM/env/lrtap/TaskForce/popsxg/2000-2003/pcn.pdf\)](#)
- UNECE, 2002. *Report on production and use of PCT (draft)*. Prepared for the UNECE Expert Group on POPs.
- UNEP, 1999. *Guidelines for the identification of PCBs and materials containing PCBs*. Available from: www.chem.unep.ch/org/publications.
- UNEP, 2003. *Preparation of a national environmentally sound plan for PCBs and PCB-contaminated equipment: Training manual*. Available from: www.basel.int.
- UNEP, 2006. UNEP/POPS/POPRC.2/17/Add.3. *Risk profile on hexabromobiphenyl*. Available from: chm.pops.int.
- UNEP, 2015-2010. *PEN Magazine, Issue "Inventories of PCBs – The Place to Start"*. Available at: chm.pops.int/Implementation/PCBs/PEN/PENmagazine/tabid/738/Default.aspx
- UNEP, 2012. UNEP/POPS/POPRC.8/16/Add.1. *Risk profile on polychlorinated naphthalenes*. Available at: chm.pops.int/Convention/POPsReviewCommittee/LatestMeeting/POPRC8/POPRC8ReportandDecisions/tabid/2950/Default.aspx.
- UNEP, 2013. UNEP/POPS/POPRC.9/13/Add.1. *Risk management evaluation on polychlorinated naphthalenes*. Available at: chm.pops.int/TheConvention/POPsReviewCommittee/ReportsandDecisions/tabid/3309/Default.aspx
- UNEP, 2015. *Report of the Conference of the Parties to the Stockholm Convention on Persistent Organic Pollutants on the work of its seventh meeting*. Available at: chm.pops.int/TheConvention/ConferenceoftheParties/ReportsandDecisions/tabid/208/Default.aspx
- UNEP, 2015a. *General technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants*.

[UNEP, 2015b](#). *Technical guidelines on the environmentally sound management of wastes containing or contaminated with unintentionally ~~unintentionally~~-produced polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, hexachlorobenzene, polychlorinated biphenyls or pentachlorobenzene.*

~~UNEP, 2015a. *General technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants.*~~ [US EPA, Kover F.D., 1975. *Environmental Hazard Assessment Report: Chlorinated Naphthalenes.* EPA-560/8-75-001; Environmental Protection Agency, Washington DC. Available at: \[nepis.epa.gov/Exe/ZyPDF.cgi/9100ARI9.PDF?Dockey=9100ARI9.PDF\]\(http://nepis.epa.gov/Exe/ZyPDF.cgi/9100ARI9.PDF?Dockey=9100ARI9.PDF\)](#)

[US EPA, 1983. *Category of chemical substances known as chlorinated naphthalenes proposed determination of significant new uses.* Federal register 1983; 48: 20668-20679.](#)

~~Van den Berg, M. et al, 2013. “Polybrominated Dibenzo p Dioxins, Dibenzofurans, and Biphenyls: Inclusion in the Toxicity Equivalency Factor Concept for Dioxin-Like Compounds”, *Toxicological Sciences*, vol. 133 No. 2, pp. 197-209~~ [Van den Berg, M. et al, 2006. “The 2005 World Health Organization ~~Rere~~-evaluation of ~~Human~~human and mammalian toxic equivalency factors for dioxins and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like ~~Compounds~~compounds”, *Toxicological Sciences*, vol. 93, pp 223-241. Available at: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2290740/>.](#)

[Van den Berg, M. et al, 2013. “Polybrominated dibenzo-p-dioxins, dibenzofurans, and biphenyls: Inclusion in the toxicity equivalency factor concept for dioxin-like compounds”, *Toxicological Sciences*, vol. 133 No. 2, pp. 197-208.](#)

[Villeneuve D.L., Kannan K., Khim J.S., 2000. “Relative potencies of individual polychlorinated naphthalenes to induce dioxin-like responses in fish and here have been any releases of PCBs, PCTs, PCNs or PBBs into the environment mammalian in vitro bioassays”, *Archives of Environmental Contamination Toxicology*, vol. 39, pp. 273-281.](#)

[Yamashita N., Kannan K., Imagawa T., Miyazaki A., Giesy J. P., 2000. “Concentrations and profiles of polychlorinated naphthalene congeners in eighteen technical polychlorinated biphenyl preparations”, *Environmental Science & Technology*, vol. 34, pp. 4236–4241.](#)

[Yamashita N., Taniyasu S., Hanari N., Falandysz J., 2003. “Polychlorinated naphthalene contamination of some recently manufactured industrial products and commercial goods in Japan”, *Journal of Environmental Science & Health, Part A.*, vol. 38, pp. 1745–59.](#)

[Zhao, G. et al., 2008. “PBBs, PBDEs, and PCBs levels in hair of residents around e-waste disassembly sites in Zhejiang Province, China, and their potential sources”, *Science of the Total Environment*, vol. 397, pp. 46-57.](#)