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Item 6 (c) of the provisional agenda\*

**Matters for consideration or action by the Conference  
of the Parties: measures to reduce or eliminate releases from wastes:  
technical guidelines for the environmentally sound management  
of persistent organic pollutants**

**Technical guidelines for the environmentally sound management of  
persistent organic pollutant wastes developed under the Basel  
Convention on the Control of Transboundary Movements of  
Hazardous Wastes and their Disposal \*\***

**Note by the Secretariat**

1. Annex I to the present note contains a letter from Ms. Sachiko Kuwabara-Yamamoto, Executive Secretary of the Secretariat of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, to Mr. John Buccini, acting Executive Secretary of the Stockholm Convention on Persistent Organic Pollutants, regarding the submission to the Conference of the Parties of the Stockholm Convention the guidelines pertaining to persistent organic pollutant wastes adopted by the Conference of the Parties of the Basel Convention at its seventh meeting.
2. Annex II to the present note contains the general technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants adopted by Conference of the Parties to the Basel Convention at its seventh meeting.

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\* UNEP/POPS/COP.1/1.

\*\* Stockholm Convention on Persistent Organic Pollutants, Article 6, paragraphs 1 (d) and 2; Final Act of the Conference of Plenipotentiaries on the Stockholm Convention on Persistent Organic Pollutants, Stockholm, Sweden, 22 and 23 May 2001 (UNEP/POPS/CONF/4), appendix I, resolution 5; Report of the Intergovernmental Negotiating Committee for an International Legally Binding Instrument for Implementing International Action on Certain Persistent Organic Pollutants on the work of its sixth session (UNEP/POPS/INC.6/22), annex I, decision INC-6/5; Report of the Intergovernmental Negotiating Committee on the work of its seventh session (UNEP/POPS/INC.7/28), annex I, decision INC-7/6.

3. Annex III to the present note contains the technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with polychlorinated biphenyls, polychlorinated terphenyls or polybrominated biphenyls adopted by Conference of the Parties to the Basel Convention at its seventh meeting.

**Annex I**

**Letter from the Executive Secretary of the Secretariat of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, to the acting Executive Secretary of the Stockholm Convention on Persistent Organic Pollutants, regarding the submission to the Conference of the Parties of the Stockholm Convention of the guidelines pertaining to persistent organic pollutant wastes adopted by the Conference of the Parties of the Basel Convention at its seventh meeting**

28 February 2005

**Subject: Submission of Technical Guidelines for the Environmentally Sound Management of Persistent Organic Pollutants (POPs)**

Dear Mr. Buccini,

I am pleased to inform you that by decision VII/13 the seventh meeting of the Conference of the Parties to the Basel Convention which took place in October 2004 in Geneva, has adopted the following technical guidelines:

- (i) General technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants (POPs); and
- (ii) Technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with polychlorinated biphenyls, polychlorinated terphenyls or polybrominated biphenyls.

In fulfilment of paragraph 3 of Decision VII/13, I am submitting the above Technical Guidelines to the first meeting of the Conference of the Parties to the Stockholm Convention on POPs through the Secretariat of the Stockholm Convention for its consideration, in accordance with article 6, paragraph 2 of the Stockholm Convention.

In this connection, I wish to inform you that work is still progressing in the Basel Convention on the preparation of the following Technical Guidelines, with the view of their finalization and adoption by the eighth meeting of the Conference of the Parties in 2006:

- (i) Technical Guidelines for Environmentally Sound Management of Wastes consisting of, containing or contaminated with the pesticides Aldrin, Chlordane, Dieldrin, Endrin, Heptachlor, Hexachlorobenzene, Mirex or Toxaphene;
- (ii) Technical Guideline for Environmentally Sound Management of Wastes Consisting of, Containing or Contaminated with Polychlorinated Dibenzop-dioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs); and
- (iii) Technical Guidelines for Environmentally Sound Management of Wastes Consisting of, Containing or Contaminated with Dichlorodiphenyltrichloroethane (DDT).

I would like to take this opportunity to sincerely thank all Parties to the Stockholm Convention and the Secretariat of the Stockholm Convention and UNEP Chemicals for their active participation and invaluable contribution towards the development of these technical guidelines. With their involvement, coherence in contents and high quality products were ensured. We welcome their continuous

involvement and cooperation in this area including the effective implementation of these technical guidelines at the national and regional levels.

Yours sincerely,



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## **Annex II**

### **General technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants (POPs)**

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## Abbreviations and acronyms

BAT	best available techniques
BCD	base catalysed decomposition
BEP	best environmental practices
CHD	catalytic hydro-dechlorination
CSIRO	Commonwealth Scientific Industrial Research Organization (Australia)
DDT	1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane
DE	destruction efficiency
DRE	destruction removal efficiency
ESM	environmentally sound management
FAO	Food and Agriculture Organization
FRTR	Federal Remediation Technologies Roundtable (United States of America)
GPCR	gas phase chemical reduction
HCB	hexachlorobenzene
IATA	International Air Transport Association
IMO	International Maritime Organization
IPA	isopropyl alcohol
ISO	International Organization for Standardization
LWPS	liquid waste pre-heater system
OECD	Organization for Economic Cooperation and Development
OEWG	Open-ended Working Group of the Basel Convention
PBB	polybrominated biphenyl
PCB	polychlorinated biphenyl
PCD	photo-chemical dechlorination
PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzo-furan
PCT	polychlorinated terphenyl
Pd/C	palladium on carbon
POP	persistent organic pollutant
SCWO	super-critical water oxidation
t-BuOK	potassium tert-butoxide
TEQ	toxic equivalent
TRBP	thermal reduction batch processor
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme

## Units of concentration

mg/kg	milligram(s) per kilogram. Corresponds to parts per million (ppm) by mass.
µg/kg	microgram(s) per kilogram. Corresponds to parts per billion (ppb) by mass.
ng/kg	nanogram(s) per kilogram. Corresponds to parts per trillion (ppt) by mass.
Mg	megagram (1,000 kg or 1 ton)
kg	kilogram
mg	milligram
ng	nanogram
Nm <sup>3</sup>	normal cubic metre; refers to dry gas, 101.3 kPa and 273.15 K
kW	kilowatt
kWh	kilowatt-hours
MJ	megajoule
million	10 <sup>6</sup>
billion	10 <sup>9</sup>
trillion	10 <sup>12</sup>
ppm	parts per million
ppb	parts per billion
ppt	parts per trillion

# I. Introduction

## A. Scope

1. The present general technical guidelines provide guidance for the environmentally sound management (ESM) of wastes consisting of, containing or contaminated with persistent organic pollutants (POPs), in accordance with decisions V/8, VI/23 and VII/13 of the Conference of the Parties to the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal, I/4, II/10 and III/8 of the Open-ended Working Group of the Basel Convention (OEWG), resolution 5 of the Conference of Plenipotentiaries to the Stockholm Convention on Persistent Organic Pollutants, and decisions INC-6/5 and INC-7/6 of the Intergovernmental Negotiating Committee for an International Legally Binding Instrument for Implementing Action on Certain Persistent Organic Pollutants. The Conference of the Parties to the Stockholm Convention will consider the guidelines in accordance with article 6, paragraph 2, of that Convention.
2. Specific technical guidelines on wastes consisting of, containing or contaminated with the following categories of POPs have been or will be developed:
  - (a) Polychlorinated biphenyls (PCBs); this technical guideline also covers polychlorinated terphenyls (PCTs) and polybrominated biphenyls (PBBs), which are subject to the Basel Convention but which are not POPs subject to the Stockholm Convention;
  - (b) The pesticide POPs aldrin, chlordane, dieldrin, endrin, heptachlor, hexachlorobenzene (HCB), mirex and toxaphene;
  - (c) HCB as an industrial chemical<sup>1</sup>;
  - (d) 1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane (DDT); and
  - (e) Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), as well as unintentionally produced PCBs and hexachlorobenzene (HCB).
3. The guidance provided within this document is intended to serve as a stand-alone general guidance and also as what might be termed an “umbrella” guide to be used in conjunction with the specific technical guidelines.
4. To these ends, these present general technical guidelines provide:
  - (a) General guidance on the management of wastes consisting of, containing or contaminated with POPs; and
  - (b) A framework for addressing issues referred to in article 6, paragraph 2 of the Stockholm Convention (see subsection 2 of chapter II, section B of the present guidelines on waste-related provisions of the Stockholm Convention).
5. Considerations pertaining to the environmentally sound disposal of wastes consisting of, containing or contaminated with POPs discussed in these guidelines include pre-treatment since it may be important when determining the disposal method. The guidelines also provide guidance on reducing or eliminating releases to the environment from waste disposal and treatment processes.
6. It is noted that guidance on best available techniques (BAT) and best environmental practices (BEP) as they apply to prevention or minimization of the formation and release of unintentional POPs from anthropogenic sources listed in Annex C of the Stockholm Convention is provided in the Stockholm Convention and is under development by an expert group that was appointed for this purpose by the Intergovernmental Negotiating Committee of the Stockholm Convention at its sixth session.

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<sup>1</sup> HCB features three times in the list to reflect its status as an industrial chemical, a pesticide (fungicide) and an unintentionally produced POP.

## **B. About POPs<sup>2</sup>**

7. Most of the quantities of POPs are of anthropogenic origin. For some POPs, such as those listed in Annex C of the Stockholm Convention, some quantities are also generated by natural processes.
8. The characteristics of POPs (toxicity, persistence and bioaccumulation), the potential for their long-range transport, and their ubiquitous presence throughout the world in ecosystems and in humans were the impetus for the creation of the Stockholm Convention. As well, as noted in chapter II, section A, subsection 2, below, wastes consisting of, containing or contaminated with POPs are listed as wastes in Annexes I and VIII of the Basel Convention.
9. Improper treatment or disposal of a waste consisting of, containing or contaminated with POPs can lead to releases of POPs. Some disposal technologies can also lead to the unintentional formation and release of POPs.

## **II. Relevant provisions of the Basel and Stockholm conventions**

10. In addition to the Basel and Stockholm conventions there are other international instruments related to POPs. These are listed in annex I below.

### **A. Basel Convention**

#### **1. General provisions**

11. The Basel Convention, which entered into force on 5 May 1992, stipulates that any transboundary movement of wastes (export, import, or transit) is permitted only when the movement itself and the disposal of the concerned hazardous or other wastes are environmentally sound.
12. In its article 2 (“Definitions”), paragraph 1, the Basel Convention defines wastes as “substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law.” In paragraph 4, it defines disposal as “any operation specified in Annex IV” to the Convention. In paragraph 8, it defines ESM of hazardous wastes or other wastes as “taking all practicable steps to ensure that hazardous wastes or other wastes are managed in a manner which will protect human health and the environment against the adverse effects which may result from such wastes.”
13. Article 4 (“General obligations”), paragraph 1, establishes the procedure by which Parties exercising their right to prohibit the import of hazardous wastes or other wastes for disposal shall inform the other Parties of their decision. Paragraph 1 (a) states: “Parties exercising their right to prohibit the import of hazardous or other wastes for disposal shall inform the other Parties of their decision pursuant to Article 13.” Paragraph 1 (b) states: “Parties shall prohibit or shall not permit the export of hazardous or other wastes to the Parties which have prohibited the import of such waste when notified pursuant to subparagraph (a).”
14. Article 4, paragraphs 2 (a)–(d), contains key provisions of the Basel Convention pertaining to ESM, waste minimization, and waste disposal practices that mitigate adverse effects on human health and the environment:

“Each Party shall take appropriate measures to:

- (a) Ensure that the generation of hazardous wastes and other wastes within it is reduced to a minimum, taking into account social, technological and economic aspects;
- (b) Ensure the availability of adequate disposal facilities, for the environmentally sound management of hazardous wastes and other wastes, that shall be located, to the extent possible, within it, whatever the place of their disposal;
- (c) Ensure that persons involved in the management of hazardous wastes or other wastes within it take such steps as are necessary to prevent pollution due to hazardous wastes and other wastes arising from such management and, if such

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<sup>2</sup> Further information on the characteristics of POPs is available from several sources, including the Agency for Toxic Substances and Disease Registry, Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, and the World Health Organization International Programme on Chemical Safety (1995) (see annex V “References” below).

pollution occurs, to minimize the consequences thereof for human health and the environment;

- (d) Ensure that the transboundary movement of hazardous wastes and other wastes is reduced to the minimum consistent with the environmentally sound and efficient management of such wastes, and is conducted in a manner which will protect human health and the environment against the adverse effects which may result from such movement”.

## 2. POPs-related provisions

15. Article 1 (“Scope of the Convention”) outlines the waste types subject to the Basel Convention. Article 1, paragraph 1 (a), of the Basel Convention contains a two-step process for determining if a “waste” is a “hazardous waste” subject to the Convention. First, the waste must belong to any category contained in Annex I of the Convention (“Categories of wastes to be controlled”). Second, the waste must possess at least one of the characteristics listed in Annex III of the Convention (“List of hazardous characteristics”).

16. Examples of Annex I wastes which may consist of, contain or be contaminated with POPs include:

- Y2 Wastes from the production and preparation of pharmaceutical products
- Y3 Waste pharmaceuticals, drugs and medicines
- Y4 Wastes from the production, formulation and use of biocides and phytopharmaceuticals
- Y5 Wastes from the manufacture, formulation and use of wood preserving chemicals
- Y6 Wastes from the production, formulation and use of organic solvents
- Y7 Wastes from heat treatment and tempering operations containing cyanides
- Y8 Waste mineral oils unfit for their originally intended use
- Y9 Waste oils/water, hydrocarbons/water mixtures, emulsions
- Y10 Waste substances and articles containing or contaminated with polychlorinated biphenyls (PCBs) and/or polychlorinated terphenyls (PCTs) and/or polybrominated biphenyls (PBBs)
- Y11 Waste tarry residues arising from refining, distillation and any pyrolytic treatment
- Y12 Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish
- Y13 Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives
- 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
- Y16 Wastes from production, formulation and use of photographic chemicals and processing materials
- Y17 Wastes resulting from surface treatment of metals and plastics
- Y18 Residues arising from industrial waste disposal operations
- Y39 Phenols; phenol compounds including chlorophenols
- Y40 Ethers
- Y41 Halogenated organic solvents
- Y42 Organic solvents excluding halogenated solvents
- Y43 Any congener of polychlorinated dibenzo-furan
- Y44 Any congener of polychlorinated dibenzo-p-dioxin
- Y45 Organohalogen compounds other than substances referred to in this Annex (e.g. Y39, Y41, Y42, Y43, Y44)

17. PCDDs and PCDFs, for example, can be formed unintentionally during the manufacture of chlorophenols, which have been used in the preservation of wood, paints and glues, as well as during the manufacture of other industrial chemicals and pesticides. PCDDs and PCDFs can also be found in slags and fly ashes produced during industrial waste disposal operations. Several of the pesticide POPs have been or are being used as biocides. PCBs have been widely used in the past in paint additives, adhesives and plastics. HCB has been used as an intermediate or additive in various manufacturing processes, including the production of synthetic rubber, pyrotechnics and ammunition, dyes and pentachlorophenol. In addition, both PCBs and HCB are known to be formed through the same processes that create PCDDs and PCDFs.

18. Wastes contained in Annex I are presumed to exhibit one or more Annex III hazard characteristics, which may include H11 "Toxic (delayed or chronic)"; H12 "Ecotoxic"; and H6.1 "Poisonous (acute)," unless, through "national tests," they can be shown to not exhibit these characteristics. National tests may be useful for identifying a particular hazard characteristic in Annex III of the Convention until such time as the hazardous characteristic is fully defined. Guidance papers for each Annex III hazard characteristic currently are being developed under the Basel Convention.

19. List A of Annex VIII of the Convention describes wastes that are "characterized as hazardous under article 1, paragraph 1 (a)," although "their designation on this Annex does not preclude the use of Annex III to demonstrate that a waste is not hazardous." List B of Annex IX lists wastes that will not be wastes covered by article 1, paragraph 1 (a), unless they contain Annex I material to an extent causing them to exhibit an Annex III characteristic. In particular the following Annex VIII wastes are applicable to POPs:

(a) PCBs, PCTs and PBBs

A1180 Waste electrical and electronic assemblies or scrap<sup>3</sup> containing components such as accumulators and other batteries included on list A, mercury-switches, glass from cathode-ray tubes and other activated glass and PCB-capacitors, or contaminated with Annex I constituents (e.g., cadmium, mercury, lead, polychlorinated biphenyl) to an extent that they possess any of the characteristics contained in Annex III (note the related entry on list B B1110)<sup>4</sup>

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 more<sup>5</sup>

(b) Pesticide POPs, including aldrin, chlordane, DDT, dieldrin, endrin, HCB, heptachlor, mirex and toxaphene

A4030 Wastes from the production, formulation and use of biocides and phytopharmaceuticals, including waste pesticides and herbicides, which are off-specification, outdated<sup>6</sup>, or unfit for their originally intended use

(c) PCDDs and PCDFs

A4110 Wastes that contain, consist of or are contaminated with any of the following:

- Any congener of polychlorinated dibenzofuran
- Any congener of polychlorinated dibenzodioxin

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

A1090 Ashes from the incineration of insulated copper wire

A1100 Dusts and residues from gas cleaning systems of copper smelters

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)

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)

A3020 Waste mineral oils unfit for their originally intended use

A3040 Waste thermal (heat transfer) fluids

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<sup>3</sup> This entry does not include scrap assemblies from electric power generation.

<sup>4</sup> PCBs are at a concentration level of 50 mg/kg or more.

<sup>5</sup> 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.

<sup>6</sup> Outdated means unused within the period recommended by the manufacturer.

- A3050 Wastes from production, formulation and use of resins, latex, plasticizers, glue/adhesives excluding such wastes specified on list B (note the related entry on list B B4020)
- A3070 Waste phenols; phenol compounds including chlorophenol in the form of liquids or sludges
- A 3090 Waste leather dust, ash, sludges and flours when containing hexavalent chromium compounds or biocides (note the related entry on list B B3100)
- A3100 Waste paring and other waste of leather or of composition leather not suitable for the manufacture of leather articles containing hexavalent chromium compounds or biocides (note the related entry on list B B3090)
- A3110 Fellmongery wastes containing hexavalent chromium compounds or biocides or infectious substances (note the related entry on list B B3110)
- A3120 Fluff – light fraction from shredding
- A3150 Waste halogenated organic solvents
- A3160 Waste halogenated or unhalogenated non-aqueous distillation residues arising from organic solvent recovery operations
- A4010 Wastes from the production, preparation and use of pharmaceutical products but excluding such wastes specified on list B
- A4020 Clinical and related wastes; that is wastes arising from medical, nursing, dental, veterinary, or similar practices, and wastes generated in hospitals or other facilities during the investigation or treatment of patients, or research projects
- A4040 Wastes from the manufacture formulation and use of wood preserving chemicals<sup>7</sup>
- 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)
- A4100 Wastes from industrial pollution control devices for cleaning of industrial off-gases but excluding such wastes specified on list B
- A4130 Waste packages and containers containing Annex I substances in concentrations sufficient to exhibit Annex III hazard characteristics
- A4140 Wastes consisting of or containing off specification or outdated<sup>8</sup> chemicals corresponding to Annex I categories and exhibiting Annex III hazard characteristics
- 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
- A4160 Spent activated carbon not included on list B (note the related entry on list B B2060)

21. As stated in article 1, paragraph 1 (b), “Wastes that are not covered under paragraph (a) but are defined as, or are considered to be, hazardous wastes by the domestic legislation of the Party of export, import or transit” are also subject to the Basel Convention.

## **B. Stockholm Convention**

### **1. General provisions**

22. The objective of the Stockholm Convention, which entered into force on 17 May 2004, is set out in article 1 (“Objective”): “Mindful of the precautionary approach as set forth in Principle 15 of the Rio Declaration on Environment and Development, the objective of this Convention is to protect human health and the environment from persistent organic pollutants.”

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<sup>7</sup> This entry does not include wood treated with wood-preserving chemicals.

<sup>8</sup> “Outdated” means unused within the period recommended by the manufacturer.

23. The Stockholm Convention differentiates between two categories of POPs:
- (a) Intentionally produced POPs, whose production and use are to be:
    - (i) Eliminated in accordance with the provisions of article 3 and Annex A; or
    - (ii) Restricted in accordance with the provisions of article 3 and Annex B;
  - (b) Unintentionally produced POPs, for which Parties are required to take measures, in accordance with article 5 and Annex C, to reduce total releases derived from anthropogenic sources, with the goal of their continuing minimization and, where feasible, ultimate elimination.
24. Under article 7 (“Implementation plans”), paragraph 1, the Convention requires each Party to:
- “(a) Develop and endeavour to implement a plan for the implementation of its obligations under the Convention;
  - (b) Transmit its implementation plan to the Conference of the Parties within two years of the date on which this Convention enters into force for it; and
  - (c) Review and update, as appropriate, its implementation plan on a periodic basis and in a manner to be specified by a decision of the Conference of the Parties.”

## 2. Waste-related provisions

25. Article 6 (“Measures to reduce or eliminate releases from stockpiles and wastes”) sets out waste related provisions as follows:

“1. In order to ensure that stockpiles consisting of or containing chemicals listed either in Annex A or Annex B and wastes, including products and articles upon becoming wastes, consisting of, containing or contaminated with a chemical listed in Annex A, B or C, are managed in a manner protective of human health and the environment, each Party shall:

- (a) Develop appropriate strategies for identifying:
  - (i) Stockpiles consisting of or containing chemicals listed either in Annex A or Annex B; and
  - (ii) Products and articles in use and wastes consisting of, containing or contaminated with a chemical listed in Annex A, B or C;
- (b) Identify, to the extent practicable, stockpiles consisting of or containing chemicals listed either in Annex A or Annex B on the basis of the strategies referred to in subparagraph (a);
- (c) Manage stockpiles, as appropriate, in a safe, efficient and environmentally sound manner. Stockpiles of chemicals listed either in Annex A or Annex B, after they are no longer allowed to be used according to any specific exemption specified in Annex A or any specific exemption or acceptable purpose specified in Annex B, except stockpiles which are allowed to be exported according to paragraph 2 of Article 3, shall be deemed to be waste and shall be managed in accordance with subparagraph (d);
- (d) Take appropriate measures so that such wastes, including products and articles upon becoming wastes, are:
  - (i) Handled, collected, transported and stored in an environmentally sound manner;
  - (ii) Disposed of in such a way that the persistent organic pollutant content is destroyed or irreversibly transformed so that they do not exhibit the characteristics of persistent organic pollutants or otherwise disposed of in an environmentally sound manner when destruction or irreversible transformation does not represent the environmentally preferable option or the persistent organic pollutant content is low, taking into account international rules, standards, and guidelines, including those that may be developed pursuant to paragraph 2, and relevant global and regional regimes governing the management of hazardous wastes;

- (iii) Not permitted to be subjected to disposal operations that may lead to recovery, recycling, reclamation, direct reuse or alternative uses of persistent organic pollutants; and
- (iv) Not transported across international boundaries without taking into account relevant international rules, standards and guidelines;
- (e) Endeavour to develop appropriate strategies for identifying sites contaminated by chemicals listed in Annex A, B or C; if remediation of those sites is undertaken it shall be performed in an environmentally sound manner.

2. The Conference of the Parties shall cooperate closely with the appropriate bodies of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal to, among other things:

- (a) Establish levels of destruction and irreversible transformation necessary to ensure that the characteristics of persistent organic pollutants as specified in paragraph 1 of Annex D are not exhibited;
- (b) Determine what they consider to be the methods that constitute environmentally sound disposal referred to above; and
- (c) Work to establish, as appropriate, the concentration levels of the chemicals listed in Annexes A, B and C in order to define the low persistent organic pollutant content referred to in paragraph 1 (d) (ii)."

26. Article 3, paragraph 2 (a) (i), pertaining to imports, stipulates: "Each Party shall take measures to ensure that a chemical listed in Annex A or Annex B is imported only for the purpose of environmentally sound disposal as set forth in paragraph 1 (d) of Article 6." Similarly, article 3, paragraph 2 (b) (i), requires that: "Each Party take measures to ensure that a chemical listed in Annex A for which any production or use specific exemption is in effect or a chemical listed in Annex B for which any production or use specific exemption or acceptable purpose is in effect, taking into account any relevant provisions in existing international prior informed consent instruments, is exported only for the purpose of environmentally sound disposal as set forth in paragraph 1 (d) of Article 6."

27. Annex C, Part II, outlines industrial source categories that have the potential for comparatively high formation and release to the environment of POPs listed in Annex C. Part III outlines source categories from which POPs listed in Annex C may be unintentionally formed and released. Part V outlines general guidance on BAT and BEP.

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

#### **A. Low POP content**

28. As stated in article 6, paragraph 2 (c), of the Stockholm Convention, the Stockholm Conference of the Parties shall cooperate closely with the appropriate bodies of the Basel Convention to "work to establish, as appropriate, the concentration levels of the chemicals listed in Annexes A, B and C in order to define the low persistent organic pollutant content referred to in paragraph 1 (d) (ii)." Wastes consisting of, containing or contaminated with POPs above the low POP content should, in accordance with article 6, paragraph 1 (d) (ii), be disposed of in such a way that the POP content is destroyed or irreversibly transformed or otherwise disposed of in an environmentally sound manner when destruction or irreversible transformation does not represent the environmentally preferable option.

29. Recognizing the following considerations:

- (a) Disposal of wastes with a high POP content, including waste stockpiles, should be a priority;
- (b) Availability of treatment capacity;
- (c) Limit values within national legislation are relevant;
- (d) Availability of analytical methods; and
- (e) Lack of knowledge and data;



the following provisional definitions for low POP content should be applied:

- (a) PCBs: 50 mg/kg<sup>9</sup>;
- (b) PCDDs and PCDFs: 15 µg TEQ/kg<sup>10</sup>; and
- (c) Aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, HCB, mirex and toxaphene: 50 mg/kg for each of these POPs.<sup>11</sup>

## B. Levels of destruction and irreversible transformation

30. Recognizing the following considerations:

- (a) Both destruction efficiency<sup>12</sup> (DE) and destruction removal efficiency<sup>13</sup> (DRE) are a function of the initial POP content and do not cover formation of unintentionally produced POPs during destruction or irreversible transformation;
- (b) DE is an important criterion for helping to assess technologies for destruction and irreversible transformation, but can be difficult to measure in a reproducible and comparable manner, especially on a regular basis;
- (c) DRE considers only emissions to air;
- (d) BAT and BEP set safe design and operating conditions, including expected destruction efficiencies, in particular circumstances on a technology by technology basis;
- (e) BAT and BEP have not been identified for all disposal methods;
- (f) Existence of pertinent national legislation and international rules, standards and guidelines; and
- (g) Lack of knowledge and data;

The following provisional definition for levels of destruction and irreversible transformation, based upon absolute levels (i.e., waste output streams of treatment processes) should be applied:

- (a) Atmospheric emissions:  
PCDDs and PCDFs: 0.14 ng TEQ/Nm<sup>3</sup>,<sup>14</sup>  
All other POPs: pertinent national legislation and international rules, standards and guidelines, examples of pertinent national legislation can be found in annex II;
- (b) Aqueous releases: pertinent national legislation and international rules, standards and guidelines, examples of pertinent national legislation can be found in annex II; and
- (c) Solid residues: POP contents should be below the low POP contents defined in Section A above of this chapter. However, if the POP content of unintentionally produced PCDD/PCDFs is above the low POP content defined in section A, the solid residues should be treated in accordance with section IV.G.

In addition, technologies for destruction and irreversible transformation should be operated in accordance with BAT and BEP.

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<sup>9</sup> Determined according to national or international methods and standards.

<sup>10</sup> TEQ as referred to in Annex C, Part IV, paragraph 2 of the Stockholm Convention, excluding co-planar PCB.

<sup>11</sup> Determined according to national or international methods and standards

<sup>12</sup> Calculated on the basis of the mass of the POP content within the waste, minus the mass of remaining POP in the gaseous, liquid and solid residues, divided by the mass of the POP content within the waste, i.e.,  
DE = (POP content within waste – POP content within gas, liquid and solid residual) / POP content within the waste.

<sup>13</sup> Calculated on the basis of mass of the POP content within the waste, minus the mass of remaining POP in the gaseous residues (stack emissions), divided by the mass of the POP content within the wastes, i.e.,  
DRE = (POP content within waste – POP content within gas residual) / POP content within the waste.

<sup>14</sup> Toxic equivalents as referred to in Annex C, Part IV, paragraph 2 of the Stockholm Convention, excluding co-planar PCB. Nm<sup>3</sup> refers to dry gas, 101.3 kPa and 273.15 K. Standardization at 11 percent O<sub>2</sub>.

## **C. Methods that constitute environmentally sound disposal**

31. Section G of chapter IV below contains a description of methods that are considered to constitute environmentally sound disposal of wastes consisting of, containing or contaminated with POPs.

## **IV. Guidance on environmentally sound management (ESM)**

### **A. General considerations**

32. ESM is a broad policy concept without a clear universal definition at the current time. However, provisions pertaining to ESM as it applies to wastes consisting of, containing or contaminated with POPs (and more broadly, to hazardous wastes) within the Basel and Stockholm conventions, and also the Organization for Economic Cooperation and Development (OECD) core performance elements (discussed in the next three subsections), provide international direction that is also supportive of ESM efforts under way in different countries and among industrial sectors.

#### **1. Basel Convention**

33. In its article 2, paragraph 8, the Basel Convention defines ESM of hazardous wastes or other wastes as “taking all practicable steps to ensure that hazardous wastes or other wastes are managed in a manner which will protect human health and the environment against adverse effects which may result from such wastes.”

34. In article 4, paragraph 2 (b) the convention requires that each Party take the appropriate measures to “ensure the availability of adequate disposal facilities for the environmentally sound management of hazardous or other wastes, that shall be located, to the extent possible, within it, whatever the place of their disposal,” while in paragraph 2 (c) it requires each Party to “ensure that persons involved in the management of hazardous wastes or other wastes within it take such steps as are necessary to prevent pollution due to hazardous wastes and other wastes arising from such management and, if such pollution occurs, to minimize the consequences thereof for human health and the environment.”

35. In article 4, paragraph 8, the convention requires that “hazardous wastes or other wastes, to be exported, are managed in an environmentally sound manner in the State of import or elsewhere. Technical guidelines for the environmentally sound management of wastes subject to this Convention shall be decided by the Parties at their first meeting.” The present technical guidelines and the specific technical guidelines are intended to provide a more precise definition of ESM in the context of wastes consisting of, containing or contaminated with POPs, including appropriate treatment and disposal methods for these waste streams.

36. Several key principles with respect to ESM of waste have been articulated in the 1994 Framework Document on Preparation of Technical Guidelines for the Environmentally Sound Management of Wastes Subject to the Basel Convention.<sup>15</sup>

37. To achieve ESM of wastes, the Guidance Document recommends that a number of legal, institutional and technical conditions (ESM criteria) be met, in particular that:

- (a) A regulatory and enforcement infrastructure ensures compliance with applicable regulations;
- (b) Sites or facilities are authorized and of an adequate standard of technology and pollution control to deal with hazardous wastes in the way proposed, in particular taking into account the level of technology and pollution control in the exporting country;
- (c) Operators of sites or facilities at which hazardous wastes are managed are required, as appropriate, to monitor the effects of those activities;
- (d) Appropriate action is taken in cases where monitoring gives indications that the management of hazardous wastes has resulted in unacceptable releases; and
- (e) People involved in the management of hazardous wastes are capable and adequately trained in their capacity.

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<sup>15</sup> See Basel Convention 1994 in annex V, References.

38. ESM is also the subject of the 1999 Basel Declaration on Environmentally Sound Management, adopted at the fifth meeting of the Conference of Parties to the Basel Convention. The Declaration calls on the Parties to enhance and strengthen their efforts and cooperation to achieve ESM, including through prevention, minimization, recycling, recovery and disposal of hazardous and other wastes subject to the Basel Convention, taking into account social, technological and economic concerns; and through further reduction of transboundary movements of hazardous and other wastes subject to the Basel Convention.

39. The Declaration states that a number of activities should be carried out in this context, including:

- (a) Identification and quantification of the types of waste being produced nationally;
- (b) Best practice approach to avoid or minimize the generation of hazardous wastes and reduce their toxicity, such as the use of cleaner production methods or approaches; and
- (c) Provision of sites or facilities authorized as environmentally sound to manage wastes and, in particular, hazardous wastes.

## **2. Stockholm Convention**

40. The term ESM is not defined in the Stockholm Convention. Environmentally sound methods for disposal of wastes consisting of, containing or contaminated with POPs are, however, to be determined by the Conference of Parties in cooperation with the appropriate bodies of the Basel Convention.<sup>16</sup>

## **3. Organization for Economic Cooperation and Development**

41. OECD has adopted a recommendation on the ESM of wastes, which includes various items, inter alia core performance elements of ESM guidelines applying to waste recovery facilities, including elements of performance that precede collection, transport, treatment and storage, as well as elements subsequent to storage, transport, treatment and disposal of pertinent residues<sup>17</sup>.

42. The core performance elements are:

- (a) That the facility should have an applicable environmental management system (EMS) in place;
- (b) That the facility should take sufficient measures to safeguard occupational and environmental health and safety;
- (c) That the facility should have an adequate monitoring, recording and reporting programme;
- (d) That the facility should have an appropriate and adequate training programme for its personnel;
- (e) That the facility should have an adequate emergency plan; and
- (f) That the facility should have an adequate plan for closure and after-care.

## **B. Legislative and regulatory framework**

43. Parties to the Basel and Stockholm Conventions should examine national controls, standards and procedures to ensure that they are in line with of the respective conventions and their obligations under them, including those that pertain to ESM of wastes consisting of, containing or contaminated with POPs.

44. Most countries already have in place some form of legislation that outlines broad environmental protection principles, powers and rights. Ideally, a country's environmental legislation should include requirements for protection of both human health and the environment. Such enabling legislation can give a government the power to enact specific rules and regulations, inspect and enforce, and establish penalties for violations.

45. Such legislation relative to hazardous wastes should also define hazardous waste. Wastes consisting of, containing or contaminated with POPs above the low POP contents referred to in section III.A should be included in the definition. The legislation could define ESM and require adherence to ESM principles, ensuring that countries satisfy provisions for ESM of wastes consisting of, containing or contaminated with

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<sup>16</sup> Parties should consult United Nations Environment Programme (UNEP) 2003 in annex V, References.

<sup>17</sup> See OECD 2004 in annex V, References.

POPs, including their environmentally sound disposal as described in these Guidelines and the Stockholm Convention. Specific components or features of a regulatory framework that would meet the Basel and Stockholm Conventions and other international agreements are discussed below<sup>18</sup>.

## 1. Phase-out dates for production and use of POPs

46. A link should be established in legislation between the phase-out date for production and use<sup>19</sup> of a POP substance (including in products and articles) and the disposal of the POP once it has become a waste. This should include a time limit for disposal of the waste consisting of, containing or contaminated with POPs, so as to prevent massive stockpiles from being created that have no clear phase-out date.

## 2. Transboundary movement requirements<sup>20</sup>

47. Hazardous wastes and other wastes should, as far as is compatible with their ESM, be disposed of in the country where they were generated. Transboundary movements of such wastes are only permitted under the following conditions:

- (a) If conducted under conditions that do not endanger human health and the environment;
- (b) If exports are managed in an environmentally sound manner in the country of import or elsewhere;
- (c) If the country of export does not have the technical capacity and the necessary facilities to dispose the wastes in question in an environmentally sound and efficient manner;
- (d) If the wastes in question are required as a raw material for recycling or recovery industries in the country of import; or
- (e) If the transboundary movements in question are in accordance with other criteria decided by the Parties.

48. Any transboundary movements of hazardous and other wastes are subject to prior written notification from the exporting country and prior written consent from the importing and, if appropriate, transit countries. Parties shall prohibit the export of hazardous wastes and other wastes if the country of import prohibits the import of such wastes. The Basel Convention also requires that information regarding any proposed transboundary movement is provided using the accepted notification form and that the approved consignment is accompanied by a movement document from the point where the transboundary movement commences to the point of disposal.

49. Furthermore, hazardous wastes and other wastes subject to transboundary movements should be packaged, labelled, and transported in conformity with international rules and standards.<sup>21</sup>

50. When transboundary movement of hazardous and other wastes to which consent of the countries concerned has been given cannot be completed, the country of export shall ensure that the wastes in question are taken back into the country of export for their disposal if alternative arrangements cannot be made. In the case of illegal traffic (as defined in article 9, paragraph 1), the country of export shall ensure that the wastes in question are taken back into the country of export for their disposal or disposed of in accordance with the provisions of the Basel Convention.

51. No transboundary movements of hazardous wastes and other wastes are permitted between a Party and a non-Party to the Basel Convention unless a bilateral, multilateral or regional arrangement exists as required under Article 11 of the Basel Convention.

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<sup>18</sup> Further guidance on Basel Convention regulatory frameworks can be found in the following documents: Model National Legislation on the Management of Hazardous Wastes and Other Wastes as well as on the Control of Transboundary Movements of Hazardous Wastes and Other Wastes and their Disposal (UNEP, 1995a), Basel Convention: Manual for Implementation (UNEP, 1995b) and Basel Convention: Guide to the Control System (UNEP, 1998a). Parties to the Stockholm Convention should also consult Interim guidance for developing a national implementation plan for the Stockholm Convention (UNEP, 2003). See annex V, References.

<sup>19</sup> Note that Annex A, parts I and II, and Annex B of the Stockholm Convention give references to the elimination and restriction of production and use of POPs.

<sup>20</sup> This applies only to Basel Convention Parties.

<sup>21</sup> In this connection, the United Nations Recommendations on the Transport of Dangerous Goods (Model Regulations) (UNECE, 2003a – see Annex V, References) or later versions should be used.

### **3. Specifications for containers, equipment, bulk containers and storage sites containing POPs**

52. To meet the requirements of ESM and specific clauses in the Basel and Stockholm Conventions (for example, Basel Convention article 4, paragraph 7, and Stockholm Convention article 6, paragraph 1), Parties may need to enact specific legislation that describes the types of containers and storage areas that are acceptable for individual POPs.<sup>22</sup> Parties should ensure that containers that may be transported to another country meet international standards such as those established by the International Air Transport Association (IATA), the International Maritime Organization (IMO) and the International Organization for Standardization (ISO).

### **4. Health and safety<sup>23</sup>**

53. Neither the Basel nor the Stockholm conventions specifically require Parties to have worker health and safety legislation. A legislative approach should be taken, however, to protect workers from possible exposure to POPs. These provisions should include requirements for the proper labelling of products and the identification of appropriate disposal methods.

54. Most countries have existing worker health and safety provisions in either general labour legislation or in specialized human health or environmental legislation. Parties should re-examine their existing legislation to ensure that POPs are adequately addressed and that relevant aspects of international agreements are integrated. Worker health and safety is a relatively mature field and a great deal of guidance and literature is available to assist in the planning and revision of legislation, policy and technical guidance.

55. In its article 10 (“Public information, awareness and education”), paragraph 1 (e), the Stockholm Convention calls upon Parties to promote and facilitate training for workers, scientists, educators and technical and managerial personnel. National health and safety legislation should include provisions for the safe handling and storage of wastes consisting of, containing or contaminated with POPs.

### **5. Specification of acceptable analytical and sampling methods for POPs**

56. Many different sampling and analytical methods have been developed for a variety of purposes. Reliable and useful data can be generated only when sampling and analytical methods appropriate to the waste are used. All Parties to the Basel and Stockholm Conventions should have legislation or strong policy guidelines indicating the acceptable sampling and analytical methods for each POP waste, including the form in which it occurs and the matrix. The procedures specified should be accepted internationally. This should ensure that the reported results are comparable. See section E of this chapter for more detail.

### **6. Requirements for hazardous waste treatment and disposal facilities**

57. Most countries have legislation that requires waste treatment and disposal facilities to obtain some form of approval to commence operations. Approvals can outline specific conditions, which must be maintained in order for approval to remain valid. It may be necessary to add requirements specific to wastes consisting of, containing or contaminated with POPs to meet the requirements of ESM and to comply with specific requirements of the Basel and Stockholm Conventions.

### **7. General requirement for public participation**

58. Public participation is a core principle of the Basel Declaration on Environmentally Sound Management and many other international agreements. Public participation as referred to in section IV.K may be addressed in legislation or policy.

### **8. Contaminated sites**

59. Provisions enabling the development of an inventory of contaminated sites and remediation of sites in an environmentally sound manner (paragraph 1 (e) of Stockholm Convention article 6) may be specified in legislation.

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<sup>22</sup> Parties should consult Food and Agriculture Organization (FAO) guidelines pertaining to the storage of pesticides and pesticide waste (FAO, 1996 – see annex V, References).

<sup>23</sup> See also section IV.I.

## 9. Other legislative controls

60. Examples of other aspects of life-cycle management of wastes consisting of, containing or contaminated with POPs that could be required through legislation include:

- (a) Siting provisions and requirements relative to storage, handling, collection and transport of wastes;
- (b) Decommissioning requirements including:
  - (i) Inspection prior to and during decommissioning;
  - (ii) Procedures to be followed to protect worker and community health and the environment during decommissioning; and
  - (iii) Post-decommissioning site requirements;
- (c) Emergency contingency planning, spill and accident response, including:
  - (i) Cleanup procedures and post-cleanup concentrations to be achieved, and
  - (ii) Worker training and safety requirements; and
- (d) Waste prevention, minimization and management plans.

## C. Waste prevention and minimization

61. The prevention and minimization of wastes consisting of, containing or contaminated with POPs are the first and most important steps in the overall ESM of such wastes. In its article 4, paragraph 2, the Basel Convention calls on Parties to “ensure that the generation of hazardous wastes and other wastes within it is reduced to a minimum.”

62. Elements of a waste prevention and minimization programme include the following:

- (a) Identification of processes unintentionally producing POPs and determination of whether Stockholm Guidelines on BAT and BEP are applicable;
- (b) Identification of processes that use POPs and generate wastes consisting of, containing or contaminated with POPs:
  - (i) To determine whether process modifications, including updating older equipment, could reduce waste generation; and
  - (ii) To identify alternative processes that are not linked to the production of wastes consisting of, containing or contaminated with POPs;
- (c) Identification of products and articles consisting of, containing or contaminated with POPs and non-POP alternatives; and
- (d) Minimization of the volume of waste generated through:
  - (i) Performance of regular maintenance of equipment to increase efficiency and prevent spills and leaks;
  - (ii) Prompt containment of spills and leaks;
  - (iii) Decontamination of containers and equipment containing wastes consisting of, containing or contaminated with POPs; and
  - (iv) Isolation of wastes consisting of, containing or contaminated with POPs in order to prevent contamination of other materials.

63. Generators of wastes and significant downstream industrial users (e.g., pesticide formulators) of products and articles containing POPs could be required to develop waste management plans. Such plans should cover all hazardous wastes, with wastes consisting of, containing or contaminated with POPs wastes treated as one component.

64. Mixing of wastes with POP contents above a defined low POP content with other materials solely for the purpose of generating a mixture with a POP content below the defined low POP content is not environmentally sound. Mixing of materials prior to waste treatment, however, may be necessary in order to optimize treatment efficiencies.

## **D. Identification and inventories**

### **1. Identification**

65. In paragraph 1 of article 6, the Stockholm Convention requires:

- (a) Identification of stockpiles consisting of or containing chemicals listed in Annex A or Annex B; and
- (b) Development of appropriate strategies for the identification of products and articles in use and wastes consisting of, containing or contaminated with POPs.

66. Wastes consisting of, containing or contaminated with POPs occur as solids and liquids (aqueous, semi-aqueous, solvent-based, and emulsions) and can be released as gases (actual gases, as a liquid dispersion or aerosols, or adsorbed onto atmospheric pollutants).

67. Wastes consisting of, containing or contaminated with POPs are mostly generated as a result of human activities, for example:

- (a) During their intentional manufacture;
- (b) As by-products of industrial and other processes;
- (c) Through contamination of materials or the environment as a result of accidents or leakage that may occur during production, sales, use, decommissioning, removal or transfer;
- (d) Through contamination of materials during handling and use of products and articles such as containers, clothing and in some cases equipment (respirators, etc.) that have been contaminated through contact with a pesticide product;
- (e) When products or articles contaminated with POPs become off-specification, are unfit for original use or are discarded; and
- (f) When products have been banned, prohibited or when registrations for such products have been withdrawn.

68. Critical aspects of waste identification require knowledge of products or articles consisting of, containing or contaminated with POPs, including manufacturers, trade names and synonyms, when they were manufactured, how they were used and who used them. Lists of source categories of unintentionally produced POPs provided in the Stockholm Convention should assist industrial managers and government regulators, as well as the general public, in identifying wastes consisting of, containing or contaminated with POPs.

### **2. Inventories**

69. Inventories are an important tool for identifying, quantifying and characterizing wastes. A national inventory may be used to:

- (a) Establish a baseline quantity of products, articles and wastes consisting of, containing or contaminated with POPs;
- (b) Assist with regulatory inspections;
- (c) Assist with the preparation of emergency response plans; and
- (d) Track progress to minimize and phase-out these chemicals.

When developing an inventory, priority should be given to the identification of wastes with high POP concentrations.

70. An inventory should as appropriate include data on:

Production of POPs within the country;

- (a) Import/export of products and articles consisting of or containing POPs;
- (b) Disposal of waste consisting of, containing or contaminated with POPs;
- (c) Import/export of such waste.

71. This requires cooperation by the relevant authority with producers, users, transporters, customs offices, waste disposal facilities and the national focal points for the Basel Convention as well as for the Stockholm Convention. The development of a national inventory requires a long-term commitment by the national government, cooperation from owners and manufacturers of POPs, a sound administrative process for collecting information on an ongoing basis and a computerized database system for storage of information. In some cases, government regulations may be required to ensure that owners report their holdings and cooperate with government inspectors.

72. The first issue to consider developing an inventory is the types of industries and locations that may have been using POPs. This should help provide a sense of the magnitude of the inventory effort and can help to develop a preliminary list of possible owners. If POPs have been produced in or imported into the country, the industries involved should also be part of the initial consultations. These companies may be able to give estimates or even exact figures of the amount of these products that were used in domestic applications. These estimates can be very valuable in determining how much of a chemical has been accounted for by an inventory. Unfortunately, in some cases these records may no longer exist.

73. There are five basic steps in the development of an inventory, as set out below.

74. **Step 1: Consult with key industries and associations:** Government officials should meet with representatives of industries that are likely to own large quantities of products, articles or wastes consisting of, containing or contaminated with POPs, and with former producers and distributors. Since chemical, agricultural, electrical, and other large industries probably own or have knowledge about a large percentage of the country's total amount of POPs, they should be consulted first. Government officials should also meet with non-governmental organizations to seek their assistance.

75. **Step 2: Train personnel:** Government staff who are responsible for the inventory should be trained in all aspects of products, articles and wastes. The key training elements should include the identification of products, articles and wastes consisting of, containing or contaminated with POPs; audits and inspections; health and safety; and procedures for setting up and maintaining inventories.

76. **Step 3: Conduct several trial audits:** Several facilities should be visited by government personnel. These visits should serve three purposes. First, they will familiarize government staff with the inventory process and actual on-site conditions. Second, they will serve as another form of consultation with industry. Third, they will produce some inventory information that can be used as trial data for the development of the national inventory.

77. **Step 4: Develop policy or regulations requiring owners to report POPs:** A draft policy or regulation regarding the tracking of POPs and reporting to the Government for inventory purposes should be developed. The policy or regulation should require initial reporting by a certain date and subsequent reporting when changes to inventories are made by owners or when disposal occurs. The reporting requirement should request specific information for each distinct inventory item, including:

- (a) Name or description of product, article or waste;
- (b) Physical state (liquid, solid, sludge, gas);
- (c) Mass of container or equipment (if applicable);
- (d) Mass of material consisting of, containing or contaminated with POPs;
- (e) Number of similar containers or pieces of equipment;
- (f) Concentration of POPs in the product, article or waste;
- (g) Other hazards associated with the material (combustible, corrosive, flammable, etc);
- (h) Location;
- (i) Owner information;
- (j) Identifying labels, serial numbers, marks, etc.;
- (k) Date entered inventory; and
- (l) Date removed from inventory and fate (if applicable).



78. **Step 5: Implement the plan:** Before implementing the requirement to report inventories, a national inventory database should be set up. The Government's central inventory should be kept up to date as new information comes in. Governments can assist owners by providing information and advice. Site inspections should help to ensure that the inventory information is correct.<sup>24</sup>

79. In addition, it should be noted that the 2003 Protocol on Pollutant Release and Transfer Register to the 1998 United Nations Economic Commission for Europe (UNECE) Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environment Matters includes provisions pertaining to the inventories that may be applicable to POPs.

## **E. Sampling, analysis and monitoring**

80. Sampling, analysis and monitoring are critical components in the management of wastes consisting of, containing or contaminated with POPs and should be given high priority with respect to both capacity building in developing countries and implementation. Sampling, analysis and monitoring should be conducted by trained professionals, according to a well-constructed plan and using internationally accepted and nationally approved methods, carried out using the same method each time over the time span of the programme. They should also be subjected to rigorous quality assurance and quality control measures. Mistakes in sampling, analysis or monitoring, or deviation from accepted methods, can result in meaningless data or even programme-damaging data. Each Party should therefore ensure that training, protocols, and laboratory capability are in place for sampling, monitoring and analytical methods and these standards are enforced.

81. Because there are numerous reasons to sample, analyse and monitor, and also because there are so many different physical forms of waste, there are hundreds of different methods that can be used for sampling, monitoring and analysis. It is beyond the scope of this document to discuss even a few of the actual methods. In the next three sections, however, the key points of sampling, analysis and monitoring are considered..

### **1. Sampling<sup>25</sup>**

82. Sampling, as used in the present guidelines, is the process of selecting and obtaining a small amount of a waste gas, liquid or solid from a larger quantity of waste for later analysis either in the field or in a laboratory. Many wastes, including those consisting of, containing or contaminated with POPs, can be heterogeneous. Obtaining a waste sample that adequately represents the whole waste can therefore be challenging. Obtaining representative samples, however, is a critical goal of waste sampling.

83. Elements of a sampling programme that should be undertaken in all cases are:

- (a) Reviewing relevant legislative requirements and international standards;
- (b) Researching the site and materials to be sampled;
- (c) Obtaining the sample supplies and preparing for the field or laboratory work;
- (d) Laying out the sample locations and equipment at the site;
- (e) Reviewing and revising the sample plan in the field if necessary;
- (f) Collecting samples;
- (g) Placing the samples in the sample container and sealing them with an appropriate seal;
- (h) Labelling and tracking of samples;
- (i) Preserving the samples in a manner that will prevent degradation of the material;
- (j) Cleaning the sampling equipment before collecting the next sample (to prevent cross-contamination);
- (k) Completing the sample submission and, if applicable, chain of custody forms;

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<sup>24</sup> Further information on inventories can be found in the Methodological Guide for the Undertaking of National Inventories of Hazardous Wastes Within the Framework of the Basel Convention (see UNEP 2000a in annex V, References).

<sup>25</sup> Further information on sampling is available in RCRA Waste Sampling Draft Technical Guidance (United States Environmental Protection Agency, 2002, and Nordtest method. See annex V, References).

- (l) Documenting the sampling work with notes, photographs, and videos;
- (m) Transporting the samples to the analytical equipment (field or laboratory); and
- (n) Transferring the samples to the custody of the analytical personnel.

84. All of these steps should be followed for a successful sampling programme. Similarly, documentation should be thorough and rigorous. For example, it should include information regarding sample collection equipment, the name of the person who collected the sample, sample numbers, sample location description and diagram or map, sample description, time of collection, climatic conditions, and observations of any unusual events. Samples should be accompanied by a chain of custody form that keeps a record of all people, who have handled the samples.

## 2. Analysis

85. Analysis refers to the determination of the physical, chemical or biological properties of a material using documented, peer-reviewed and accepted laboratory methods. Typically, accepted laboratory methods have been published by agencies and organizations that specialize in the development of standards, such as the American Society for Testing and Materials (ASTM), the European Committee for Standardization (CEN) and the International Organization for Standardization (ISO). Some examples of these methods as well as selected country-specific methods are listed in annex III, below. Individual countries may also develop and approve their own particular methods for certain types of analysis. This is acceptable provided the accuracy and precision are comparable to existing published methods and the methods are validated against relevant international standards to ensure compatibility

86. While excellent methods and equipment have been developed for analysis, and laboratory staff are usually well-trained, there are still sources of error and imprecision in analytical work. Some of these sources of error and imprecision can be reduced by implementing national standards for analytical work related to POPs, taking into account the considerations discussed below.

### (a) Elements of national standards

87. Each country should specify in guidelines or legislation the standard methods required for each POP and the situations in which the method should be used. In the absence of such specifications, samples submitted to a laboratory could be analysed using the most convenient or cheapest method, resulting in poor data. Similarly, while many countries recommend a method for the actual quantification of the sample, they should also specify the other elements of the analytical process. National standards should cover all the following quality assurance and quality control and other elements for analysing the waste:

- (a) Chemical analysis or bioassay test method;
- (b) Waste related sample handling and storage;
- (c) Sample preparation (drying, weighing, grinding, chemical digestion, etc.);
- (d) Extraction of contaminants;
- (e) Clean-up;
- (f) Separation, identification and quantification;
- (g) Quality assurance and quality control, e.g. calibration of equipment;
- (h) Reporting of results.

88. The preceding steps should be completed in a repeatable, acceptable manner for results to be meaningful. There are numerous methods available for each step of the process. The key for any country is to adopt standard methods and then to require their use by commercial, government and research laboratories.

89. Parties should ensure that they have the appropriate capability and capacity for the analysis of each type of sample. If a country does not have capability and capacity for a certain POP or certain types of samples, it should ensure it has access to laboratories in other countries that do possess such capability and capacity.

90. Certification and testing of laboratories are additional important aspects of a national analysis programme. All laboratories should be able to meet certain quality standards as set and tested by the Government, by an independent body such as ISO or by an association of laboratories.

**(b) Field tests**

91. Field-testing refers to the determination of physical, chemical or biological properties of a material or site using portable, real-time instruments or devices. Field test instruments and devices typically collect a sample and analyse it within a very short period of time. Generally, field test instruments and devices also have a lower degree of accuracy and precision than sampling and analysis equipment used in a laboratory.

92. Field-test instruments, however, are extremely valuable for field work in identifying materials that are likely to be wastes consisting of, containing or contaminated with POPs. They are also useful in assisting with decisions about where to take additional samples, in detecting dangerous atmospheres (explosive, flammable, toxic) and in locating the sources of spills and leaks. Portable units with photo-ionization detectors or flame ionization detectors are available to detect total organic vapours or even individual organic substances. For PCB, test kits are accepted by some countries as reliable in determining whether a waste contains PCBs over the regulatory limit or not. Such tests are likely to produce only “false positive” results, however. Accordingly, where there is any doubt about the results of the field test instrument, or if the result is to be used for scientific or legal purposes, samples should also be collected for chemical analysis according to standard methods.

**3. Monitoring**

93. In paragraph 2 (b) of its article 10 (“International Cooperation”), the Basel Convention requires Parties to “cooperate in monitoring the effects of the management of hazardous wastes on human health and the environment”. In paragraph 1 of its article 11, the Stockholm Convention requires Parties to encourage and/or undertake appropriate monitoring pertaining to the POPs. A monitoring programme should provide an indication of whether a hazardous waste management operation is functioning in accordance with its design, and should detect changes in environmental quality caused by the operation. The information from a monitoring programme should be used to ensure that the proper types of hazardous wastes are being managed by the waste management operation, discover and repair any damage and determine if an alternative management approach might be appropriate. By implementing a monitoring programme, facility managers can identify problems and take appropriate measures to remedy them.<sup>26</sup>

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

94. Handling, collection, packaging, labelling, transportation and storage are critically important steps as the risk of a spill, leak or fire (for example in preparation for storage or disposal) is equal to or greater than that during the normal operation of the equipment. The Basel Convention: Manual for Implementation (UNEP 1995a), the International Maritime Dangerous Goods Code (IMO 2002), the “International Air Transport Association (IATA) Dangerous Goods Regulations” and the “United Nations Recommendations on the Transport of Dangerous Goods: Model Regulations (Orange Book)” should be consulted to determine specific requirements for transport and transboundary movement of hazardous wastes.

95. Wastes consisting of, containing or contaminated with POPs above the low POP contents referred to in section III.A should be managed as hazardous waste, to prevent spills and leaks leading to worker exposure, releases to the environment and exposure to the community.

**1. Handling<sup>27</sup>**

96. The main concerns when handling wastes consisting of, containing or contaminated with POPs are human exposure, accidental release to the environment and contamination of other waste streams with POPs. Such wastes should also be handled separately from other waste types in order to prevent contamination of these other waste streams. A set of procedures should be prepared by each organization that handles such wastes and workers should be trained in the procedures.

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<sup>26</sup> Further information on monitoring is available in Reference Document on the General Principles of Monitoring (European Commission, 2003) and Guidance for a Global Monitoring Programme for Persistent Organic Pollutants (UNEP, 2004a). See annex V “References”.

<sup>27</sup> Examples of guidelines on the safe handling of hazardous materials and accident prevention include those prepared by the International Labour Organization (1999a and 1999b) and the OECD (2003), listed in annex V “References”.

## 2. Collection

97. While large industries may be responsible for the proper management of wastes consisting of, containing or contaminated with POPs that they generate or own, many smaller entities also possess such wastes. The wastes consisting of, containing or contaminated with POPs possessed by small entities may include household or commercial-size pesticide containers, PCB fluorescent light ballasts, small containers of pentachlorophenol-based wood preservatives with PCDD and PCDF contamination, small amounts of “pure” POPs in laboratories and research facilities, and pesticide-coated seeds used in agricultural and research settings. To deal with this scattered assortment of hazardous wastes, many Governments have established depots where small quantities of these wastes can be deposited by the owner at no charge or for a nominal fee. These depots may be permanent or temporary in nature, or may be located at an existing commercial hazardous waste transfer station. The waste collection depots and transfer stations may be set up on a regional basis by a group of countries, or may be provided by a developed country to a developing country.

98. Care should be taken in establishing and operating waste collection programmes, depots and transfer stations to:

- (a) Advertise the programme, depot locations and collection time periods to all potential holders of wastes consisting of, containing or contaminated with POPs;
- (b) Allow enough time of operation of collection programmes for the complete collection of all potential wastes consisting of, containing or contaminated with POPs;<sup>28</sup>
- (c) Include, to the extent practical, all wastes consisting of, containing or contaminated with POPs in the programme;
- (d) Make acceptable containers and safe-transport materials available to waste owners for those waste materials that may need to be re-packaged or made safe for transport;
- (e) Establish simple, low-cost mechanisms for collection;
- (f) Ensure the safety of both those delivering waste to depots and workers at the depots;
- (g) Ensure that the operators of depots are using an accepted method of disposal;
- (h) Ensure that the programme and facilities meet all applicable legislative requirements; and
- (i) Ensure separation of wastes consisting of, containing or contaminated with POPs from other waste streams.

## 3. Packaging

99. Wastes consisting of, containing or contaminated with POPs should be properly packaged for ease of transport and as a safety measure to reduce the risk of leaks and spills. Packaging of hazardous wastes falls into two categories: packaging for transport and packaging for storage.

100. Packaging for transport is often controlled by national dangerous goods transportation legislation. For packaging specifications for transport, the reader should consult reference material published by IATA, IMO, UNECE and national Governments.

101. Some general precepts for packaging of wastes consisting of, containing or contaminated with POPs for storage are as follows:

- (a) Packaging that is acceptable for transport is, in most cases, suitable for storage;
- (b) Such wastes in their original product containers are generally safe for storage if the packaging is in good condition;
- (c) Such wastes should never be stored in product containers that were not intended to contain such wastes or that have labels on them that incorrectly identify the contents;
- (d) Containers that are deteriorating or deemed to be unsafe should be emptied or placed inside a sound outer package (overpack). When unsafe containers are emptied, the contents should be placed in appropriate new or refurbished containers. All new or refurbished containers should be clearly labelled as to their contents;

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<sup>28</sup>

Complete collection may require the depots to operate either continuously or intermittently over several years.

- (e) Smaller containers can be packaged together in bulk by placing them in appropriate or approved larger containers containing absorbent material; and
- (f) Out-of-service equipment containing POPs may or may not constitute suitable packaging for storage. The determination of safety should be made on a case-by-case basis.

#### 4. Labelling<sup>29</sup>

102. Labelling of products and articles consisting of, containing or contaminated with POPs is critical for the success of inventories and is a basic safety feature of any waste management system. Each waste container should be labelled to identify the container (e.g., ID number), the POPs present and the hazard level. Each new package should bear identification labels as mentioned in FAO, 2001, *Training Manual on Inventory Taking of Obsolete Pesticides*, Series No 10 and ref No X9899.

#### 5. Transportation

103. Wastes consisting of, containing or contaminated with POPs should be transported in an environmentally sound manner to avoid accidental spills and to appropriately track their transport and ultimate destination. Prior to transport, contingency plans should be prepared in order to minimize environmental impacts associated with spills, fires and other emergencies that could occur during transport. During transportation, such wastes should be identified, packaged and transported in accordance with the “United Nations Recommendations on the Transport of Dangerous Goods: Model Regulations (Orange Book)”. Persons transporting such wastes should be qualified and/or certified as carriers of hazardous materials and wastes.

104. Guidance on the safe transportation of hazardous materials can be obtained from IATA, IMO, UNECE and the International Civil Aviation Organization (ICAO).

#### 6. Storage<sup>30</sup>

105. Wastes consisting of, containing or contaminated with POPs should be stored safely, preferably in dedicated areas away from other materials and wastes. Storage areas should be designed to prevent the release of POPs to the environment by all routes. Storage rooms, areas or buildings should be designed by professionals with expertise in the fields of structural design, waste management and occupational health and safety or can be purchased in prefabricated form from reputable suppliers.

106. Some basic principles of safe storage of wastes consisting of, containing or contaminated with POPs are as follows:

- (a) Storage sites inside multipurpose buildings should be in a locked dedicated room or partition that is not in an area of high use;
- (b) Outdoor dedicated storage buildings or containers<sup>31</sup> should be stored inside a lockable fenced enclosure;
- (c) Separate storage areas, rooms or buildings should be used for each type of such waste, unless specific approval has been given for joint storage;
- (d) Such wastes should not be stored on or near sensitive sites, such as hospitals or other medical care facilities, schools, residences, food processing facilities, animal feed storage or processing facilities, agricultural operations, or facilities located near or within sensitive environmental sites;
- (e) Storage rooms, buildings and containers should be located and maintained in conditions that will minimize volatilization, including cool temperatures, reflective roof and siding, shaded

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<sup>29</sup> International standards have been developed for the proper labelling and identification of wastes. Guidelines on the proper labelling and identification of hazardous materials have been produced by UNECE (2003b) and OECD (2001). See also “Training manual on inventory taking of obsolete pesticides”, Series No 10 and reference No X9899 (FAO, 2001) and UNEP (1995b) in annex V, References.

<sup>30</sup> Further information can be found in *Storage of Hazardous Materials: A Technical Guide for Safe Warehousing of Hazardous Materials* (UNEP, 1993 – see annex V, References). *Pesticide storage and stock control manual*, No 3 (FAO, 1996).

<sup>31</sup> Shipping containers are often used for storage.

location, etc. When possible, particularly in warmer climates, storage rooms and buildings should be maintained under negative pressure with exhaust gases vented through carbon filters bearing in mind the following conditions:

- (i) Ventilating a site with carbon filtration of exhaust gases may be appropriate when exposure to vapours for those who work in the site and those living and working in the vicinity of the site is a concern;
- (ii) Sealing and venting a site so that only well-filtered exhaust gases are released to outside air may be appropriate when environmental concerns are paramount;
- (f) Dedicated buildings or containers should be in good condition and made of hard plastic or metal, not wood, fibreboard, drywall, plaster or insulation;
- (g) The roofs of dedicated buildings or containers and the surrounding land should be sloped to provide drainage away from the site;
- (h) Dedicated buildings or containers should be set on asphalt, concrete or durable (e.g., 6 mm) plastic sheeting;
- (i) The floors of storage sites inside buildings should be concrete or durable (e.g., 6 mm) plastic sheeting. Concrete should be coated with a durable epoxy;
- (j) Storage sites should have fire alarm systems;
- (k) Storage sites inside buildings should have (preferably non-water) fire suppression systems. If the fire suppressant is water, then the floor of the storage room should be curbed and the floor drainage system should not lead to the sewer or storm-sewer or directly to surface water but should have its own collection system, such as a sump;
- (l) Liquid wastes should be placed in containment trays or a curbed, leak-proof area. The liquid containment volume should be at least 125 percent of the liquid waste volume, taking into account the space taken up by stored items in the containment area;
- (m) Contaminated solids should be stored in sealed containers such as barrels or pails, steel waste containers (lugger boxes) or in specially constructed trays or containers. Large volumes of material may be stored in bulk in dedicated shipping containers, buildings or vaults, so long as they meet the safety and security requirements as described herein;
- (n) A complete inventory of such wastes in the storage site should be created and kept up to date as waste is added or disposed;
- (o) The outside of the storage site should be labelled as a waste storage site; and
- (p) The site should be subjected to routine inspection for leaks, degradation of container materials, vandalism, integrity of fire alarms and fire suppression systems and general status of the site.

## **G. Environmentally sound disposal**

### **1. Pre-treatment**

107. This section presents some of the pre-treatment operations that may be required for the proper and safe operation of the disposal technologies described in the following subsections 2 and 3. There are also other pre-treatment operations, which may be applied. Pre-treatment operations prior to disposal according to subsections 2 and 3 should only be performed provided that POPs that are isolated from the waste during pre-treatment are subsequently disposed of in accordance with subsection 2. Where only part of a product or waste, such as waste equipment, contains or is contaminated with POPs, it should be separated and then disposed of as specified in subsections 1–4, as appropriate.

#### **(a) Adsorption and absorption**

108. “Sorption” is the general term for both absorption and adsorption processes. Sorption is a pre-treatment method that uses solids for removing substances from liquids or gases. Adsorption involves the separation of a substance (liquid, oil, gas) from one phase and its accumulation at the surface of another (activated carbon, zeolite, silica, etc.) Absorption is the process whereby a material transferred from one phase to another interpenetrates the second phase to form a solution (e.g., contaminant transferred from liquid phase onto activated carbon).

109. Adsorption and absorption processes can be used to concentrate contaminants and separate them from aqueous wastes and from gas streams. The concentrate and the adsorbent or absorbent may require treatment prior to disposal.

**(b) Dewatering**

110. Dewatering is a pre-treatment process that partially removes water from the wastes to be treated. Dewatering can be employed for disposal technologies that are not suitable for aqueous wastes. For example, over a certain temperature and pressure environment, water can react explosively with molten salts or sodium. Depending on the nature of the contaminant, resulting vapours may require condensation or scrubbing and further treatment.

**(c) Mechanical separation**

111. Mechanical separation can be used to remove larger-sized debris from the waste stream or for technologies that may not be suitable for both soils and solid wastes.

**(d) Mixing**

112. Mixing of materials prior to waste treatment may be appropriate in order to optimize treatment efficiencies. However, mixing of wastes with POP contents above a defined low POP content with other materials solely for the purpose of generating a mixture with a POP content below the defined low POP content is not environmentally sound.

**(e) Oil-water separation**

113. Some treatment technologies are not suitable for aqueous wastes; others are not suitable for oily wastes. Oil-water separation can be employed in these situations to separate the oily phase from the water. Both the water and the oily phase may be contaminated after the separation and both may require treatment.

**(f) pH adjustment**

114. Some treatment technologies are most effective in a defined pH range and in these situations, alkali, acid or CO<sub>2</sub> are often used to control pH levels. Some technologies may also require pH adjustment as a post-treatment step.

**(g) Size reduction**

115. Some technologies are only able to process wastes within a certain size limit. For example, some may handle POP-contaminated solid wastes only if they are less than 200 mms in diameter. Size reduction can be used in these situations to reduce the waste components to a defined diameter. Other disposal technologies require slurries to be prepared prior to waste injection into the main reactor. Note that facilities may become contaminated when reducing the size of wastes containing or contaminated with POPs. Precautions should therefore be taken to prevent subsequent contamination of POP-free waste streams.

**(h) Solvent washing**

116. Solvent washing can be used to remove POPs from electrical equipment such as capacitors and transformers. This technology has also been used for the treatment of contaminated soil and sorption materials used in adsorption or absorption pre-treatment.

**(i) Thermal desorption**

117. Low-temperature thermal desorption (LTTD), also known as low-temperature thermal volatilization, thermal stripping and soil roasting, is an ex-situ remedial technology that uses heat physically to separate volatile and semi-volatile compounds and elements (most commonly petroleum hydrocarbons) from contaminated media (most commonly excavated soils). Such processes have been used for the decontamination of the non-porous surfaces of electrical equipment such as transformer carcasses that formerly contained PCB-containing dielectric fluids. Thermal desorption of wastes containing or contaminated with POPs may result in the formation of unintentional POPs, which may require additional treatment.

## 2. Destruction and irreversible transformation methods

118. The following disposal operations, as provided for in Annexes IVA and IVB of the Basel Convention, should be permitted for the purpose of destruction and irreversible transformation of the POP content in wastes when applied in such a way as to ensure that the remaining wastes and releases do not exhibit the characteristics of POPs:

- D9 Physico-chemical treatment,
- D10 Incineration on land, and
- R1 Use as a fuel (other than in direct incineration) or other means to generate energy.

119. POPs that are isolated from the waste during a pre-treatment should subsequently be disposed of according to operation D9 and D10.

120. This subsection describes commercially available operations for the environmentally sound destruction and irreversible transformation of the POP content in wastes.<sup>32</sup> It is noted that pertinent national legislation applies for these operations.

121. While the information provided within these guidelines regarding vendors of technologies for destruction and irreversible transformation is believed to be accurate, UNEP disclaims any responsibility for possible inaccuracies or omissions and consequences, which may flow from them. Neither UNEP nor any individual involved in the preparation of this report shall be liable for any injury, loss, damage or prejudice of any kind that may be caused by any persons who have acted based on their understanding of the information contained within this publication.

122. Information on the economics of the following technologies can be found in annex IV.

### (a) Alkali metal reduction<sup>33</sup>

123. *Process description:* Alkali metal reduction involves the treatment of wastes with dispersed alkali metal. Alkali metals react with chlorine in halogenated waste to produce salt and non-halogenated waste. Typically, the process operates at atmospheric pressure and temperatures between 60 °C and 180 °C<sup>34</sup>. Treatment can take place either in situ (i.e., PCB-contaminated transformers) or ex situ in a reaction vessel. There are several variations of this process.<sup>35</sup> Although potassium or potassium sodium alloy has been used, metallic sodium is the most commonly used reducing agent. The remaining information is based on experiences with the metallic sodium variation.

124. *Efficiency:* Destruction efficiency (DE) values of greater than 99.999 percent and destruction removal efficiency (DRE) values of 99.9999 percent have been reported for aldrine, chlordane and PCBs (Ministry of Environment of Japan, 2004). The sodium reduction process has also been demonstrated to meet regulatory criteria in Australia, Canada, Japan, South Africa, United States of America, and the European Union for PCB transformer oil treatment, i.e., less than 2 ppm in solid and liquid residues.<sup>36</sup>

125. *Waste types:* Sodium reduction has been demonstrated with PCB-contaminated oils containing concentrations up to 10,000 ppm.<sup>37</sup> Some vendors have also claimed that this process is capable of treating whole capacitors and transformers<sup>38</sup>.

126. *Pre-treatment:* Ex-situ treatment of PCBs can be performed, however, following solvent extraction of PCBs. Treatment of whole capacitors and transformers could be carried out following size reduction

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<sup>32</sup> Further information regarding these technologies or others currently in the pilot or test phase can be found in Review of Emerging, Innovative Technologies for the Destruction and Decontamination of POPs and the Identification of Promising Technologies for Use in Developing Countries (UNEP, 2004b in annex V, References).

<sup>33</sup> Additional information is available from UNEP, 1998b; UNEP, 2000b; and UNEP, 2004b. See annex V, References.

<sup>34</sup> Ariizumi Otsuka, Kamiyama and Hosani, 1997, and Japan Industrial Waste Management Foundation, 1999, see annex 5 references

<sup>35</sup> See Piersol, 1989 in annex V, References.

<sup>36</sup> See Piersol, 1989 and UNEP, 2004b in annex V, References.

<sup>37</sup> See UNEP, 2004b in annex V, References.

<sup>38</sup> Ibid.



through shearing.<sup>39</sup> Pre-treatment should include de-watering to avoid explosive reactions with metallic sodium.

127. *Emissions and residues:* Air emissions include nitrogen and hydrogen gas. Emissions of organic compounds are expected to be relatively minor.<sup>40</sup> However, it has been noted that PCDDs/PCDFs can be formed from chlorophenols under alkaline conditions at temperature as low as 150 °C (Weber, 2004). Residues produced during the process include sodium chloride, sodium hydroxide, polyphenyls and water<sup>41</sup>. In some variations, a solidified polymer is also formed<sup>42</sup>.

128. *Release control and post-treatment:* After the reaction, the by-products can be separated out from the oil through a combination of filtration and centrifugation. The decontaminated oil can be reused, the sodium chloride can either be reused or disposed of in a landfill, and the solidified polymer can be disposed of in a landfill<sup>43</sup>.

129. *Energy requirements:* Immediate energy requirements are expected to be relatively low owing to low operating temperatures associated with the sodium reduction process.

130. *Material requirements:* Significant amounts of sodium are required to operate this process<sup>44</sup>.

131. *Portability:* This process is available in transportable and fixed configurations<sup>45</sup>.

132. *Health and safety:* Dispersed metallic sodium can react violently and explosively with water, presenting a major hazard to operators. Metallic sodium can also react with a variety of other substances to produce hydrogen – a flammable gas that is explosive in admixture with air. Great care must be taken in process design and operation to absolutely exclude water (and certain other substances, e.g. alcohols) from the waste and from any other contact with the sodium. A facility in Delfzijl, The Netherlands, has been severely damaged by a fire.

133. *Capacity:* Mobile facilities are capable of treating 15,000 litres per day of transformer oil<sup>46</sup>.

134. *Other practical issues:* Sodium reduction used for in-situ treatment of PCB contaminated transformer oils may not destroy all the PCBs contained in the porous internals of the transformer. Some authors have noted that there is a lack of information on the characterization of residues<sup>47</sup>.

135. *State of commercialization:* This process has been used commercially for approximately 20 years.

136. Vendors include:

- (a) Dr. Bilger Umweltconsulting GmbH – [www.bilgergmbh.de](http://www.bilgergmbh.de);
- (b) Decoman srl, Italy – [www.decoman.it](http://www.decoman.it);
- (c) Envio Germany GmbH & Co. KG – [www.envio-group.com](http://www.envio-group.com);
- (d) Kinectrics Inc. – [www.kinectrics.com](http://www.kinectrics.com);
- (e) Nippon Soda Co. Ltd. – [www.nippon-soda.co.jp](http://www.nippon-soda.co.jp);
- (f) Orion BV, Netherlands – [www.orionun2315.nl/en/index.php](http://www.orionun2315.nl/en/index.php).
- (g) Powertech Labs Inc. – [www.powertechlabs.com](http://www.powertechlabs.com);
- (h) Sanexen Environmental Services Inc. – [www.sanexen.com](http://www.sanexen.com).

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<sup>39</sup> Ibid

<sup>40</sup> See Piersol, 1980 in annex V, References.

<sup>41</sup> See UNEP, 2004b in annex V, References.

<sup>42</sup> See UNEP, 2000b, in annex V, References.

<sup>43</sup> Ibid.

<sup>44</sup> UNEP, 2004b, in annex V, References.

<sup>45</sup> Ibid.

<sup>46</sup> Ibid.

<sup>47</sup> See UNEP, 2000b, in annex V, References.

**(b) Base catalysed decomposition (BCD)<sup>48</sup>**

137. *Process description:* The BCD process involves treatment of wastes in the presence of a reagent mixture consisting of hydrogen donor oil, alkali metal hydroxide and a proprietary catalyst. When the mixture is heated to above 300°C, the reagent produces highly reactive atomic hydrogen. The atomic hydrogen reacts with the waste to remove constituents that confer the toxicity to compounds.

138. *Efficiency:* DEs of 99.99–99.9999 percent have been reported for DDT, PCBs, PCDDs and PCDFs<sup>49</sup>. DEs of greater than 99.999 percent and DREs of greater than 99.9999 percent have also been reported for chlordane (Ministry of the Environment of Japan, 2004). It has also been reported that reduction of chlorinated organics to less than 2 mg/kg is achievable<sup>50</sup>.

139. *Waste types:* BCD should be applicable to other POPs in addition to the waste types listed above<sup>51</sup>. BCD should be capable of treating wastes with a high POP concentration, with demonstrated applicability to wastes with a PCB content of above 30 percent<sup>52</sup>. It was believed that in practice, the formation of salt within the treated mixture could limit the concentration of halogenated material able to be treated<sup>53</sup>. However, the vendor has indicated that the build-up of salt within the reactor simply limits the amount of waste that can be fed to the reactor and that this problem does not appear insolvable. Applicable waste matrices include soil, sediment, sludge and liquids. The company BCD Group also claims that the process has been demonstrated to destroy PCBs in wood, paper and metal surfaces of transformers.

140. *Pre-treatment:* Soils may be treated directly. Different types of soil pre-treatment may be necessary:

- (a) Larger particles may need to be removed by sifting and crushed to reduce their size; or
- (b) pH and moisture content may need to be adjusted.

141. *Thermal desorption* has also been used in conjunction with BCD to remove POPs from soils prior to treatment. In these situations, the soil is premixed with sodium bicarbonate prior to being fed into the thermal desorption unit<sup>54</sup>. Water will need to be evaporated from aqueous media, including wet sludge, prior to treatment. Capacitors can be treated following size reduction through shredding<sup>55</sup>. If volatile solvents are present, such as occurs with pesticides, they should be removed by distillation prior to treatment<sup>56</sup>.

142. *Emissions and residues:* Air emissions are expected to be relatively minor. The potential to form PCDDs and PCDFs during the BCD process is relatively low. However, it has been noted that PCDDs can be formed from chlorophenols under alkaline conditions at temperature as low as 150°C (Weber, 2004). Other residues produced during the BCD reaction include sludge containing primarily water, salt, unused hydrogen donor oil and carbon residue. The vendor claims that the carbon residue is inert and non-toxic. For further details, users are referred to the literature produced by BCD Group, Inc.

143. *Release control and post-treatment:* Depending on the type of hydrogen donor oil used, the slurry residue may be treated in different ways. If No. 6 fuel oil has been used, the sludge may be disposed of as a fuel in a cement kiln. If more refined oils are used, these may be removed from the sludge by gravity or centrifuge separation. The oils can then be re-used and the remaining sludge can be further treated for usage as a neutralizing agent or disposed of in a landfill<sup>57</sup>. In addition, BCD plants are equipped with activated carbon traps to minimize releases of volatile organics in gaseous emissions.

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<sup>48</sup> Additional information is available from CMPS&F – Environment Australia, 1997; Costner, Luscombe and Simpson, 1998; Danish Environmental Protection Agency, 2004; Rahuman, Pistone, Trifirò and Miertu, 2000; UNEP, 1998b; UNEP, 2001; UNEP, 2004b and Vijgen, 2002. See annex V, References.

<sup>49</sup> See UNEP, 2004b in annex V, References.

<sup>50</sup> See UNEP, 2001 in annex V, References.

<sup>51</sup> See UNEP, 2004b and Vijgen, 2002 in annex V, References.

<sup>52</sup> See Vijgen, 2002 in annex V, References.

<sup>53</sup> See CMPS&F – Environment Australia, 1997; Rahuman et al., 2000 and UNEP 2001 in annex V, References.

<sup>54</sup> See CMPS&F – Environment Australia, 1997 in annex V, References.

<sup>55</sup> See CMPS&F – Environment Australia, 1997 and UNEP 2001, in annex V, References.

<sup>56</sup> See CMPS&F – Environment Australia, 1997 in annex V, References.

<sup>57</sup> See UNEP, 2004b, in Annex V, References.

144. *Energy requirements:* Energy requirements are expected to be relatively low owing to low operating temperatures associated with the BCD process.
145. *Material requirements:*
- (a) Hydrogen donor oil, such as No. 6 fuel oil or Sun Par oils No. LW-104, LW-106 and LW-110;
  - (b) Alkali or alkaline earth metal carbonate, bicarbonate or hydroxide, such as sodium bicarbonate. The amount of alkali required is dependent on the concentration of the halogenated contaminant contained in the medium<sup>58</sup>. Amounts range from 1 percent to about 20 percent by weight of the contaminated medium; and
  - (c) Proprietary catalyst amounting to 1 percent by volume of the hydrogen donor oil.
146. The *equipment* associated with this process is thought to be readily available<sup>59</sup>.
147. *Portability:* Modular, transportable and fixed plants have been built.
148. *Health and safety:* In general the health and safety risks associated with operation of this technology are thought to be low,<sup>60</sup> although a BCD plant in Melbourne, Australia, was rendered inoperable following a fire in 1995. The fire is thought to have resulted from the operation of a storage vessel without a nitrogen blanket.<sup>61</sup> Some associated pre-treatments such as alkaline pre-treatment of capacitors and solvent extraction have significant fire and explosion risks, although they can be minimized through the application of appropriate precautions.<sup>62</sup>
149. *Capacity:* BCD can process as much as 2,600 gallons per batch, with a capability of treating two–four batches per day.<sup>63</sup>
150. *Other practical issues:* Since the BCD process involves stripping chlorine from the waste compound, the treatment process may result in an increased concentration of lower chlorinated species. This can be of potential concern in the treatment of PCDDs and PCDFs, where the lower chlorinated congeners are more *toxic* than the higher chlorinated congeners. It is therefore important that the process be appropriately monitored to ensure that the reaction continues to completion. In the past, it has been reported that the BCD process was unable to treat high concentration wastes because of salt build-up<sup>64</sup>. More recently, however, it has been reported that this problem has been overcome<sup>65</sup>.
151. *State of commercialization:* BCD has been used at two commercial operations within Australia, with one still operating. Another commercial system has been operating in Mexico for the past two years. In addition BCD systems have been used for short-term projects in Australia, Spain and the United States of America. A BCD unit for the treatment of both soil and pesticide wastes contaminated with PCDD and PCDF is now under construction within the Czech Republic.
152. *Vendors:* The patent for this technology is held by BCD Group, Inc., USA (www.bcdinternational.com). BCD Group, Inc. sells licences to operate the technology. Currently, licences are held by companies based in Australia, Czech Republic, Japan, Mexico and the United States of America.

**(c) Catalytic hydro-dechlorination (CHD)**

153. *Process description.* CHD involves the treatment of wastes with hydrogen gas and palladium on carbon (Pd/C) catalyst dispersed in the paraffin oil. Hydrogen reacts with chlorine in halogenated waste to produce hydrogen chloride (HCl) and non-halogenated waste. In the case of PCBs, biphenyl is the main

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<sup>58</sup> See CMPS&F – Environment Australia, 1997 and UNEP 2001 in annex V, References.

<sup>59</sup> See Rahuman et al., 2000 in annex V, References.

<sup>60</sup> See CMPS&F – Environment Australia, 1997 and Rahuman et al., 2000 in annex V, References.

<sup>61</sup> See CMPS&F – Environment Australia, 1997 in annex V, References.

<sup>62</sup> Ibid.

<sup>63</sup> See Vijgen, 2002 and UNEP, 2004b in annex V, References.

<sup>64</sup> See CMPS&F – Environment Australia, 1997 in annex V, References.

<sup>65</sup> See Vijgen, 2002 in annex V, References.

product. Process operates at atmospheric pressure and temperatures between 180 °C and 260 °C (Sakai, Peter and Oono, 2001; Noma, Sakai and Oono, 2002; and Noma, Sakai and Oono, 2003a and 2003b).

154. *Efficiency.* DEs of 99.98–99.9999 percent have been reported for PCBs. It has also been reported that a reduction of the PCB content to less than 0.5 mg/kg is achievable.

155. *Waste types.* CHD has been demonstrated with PCBs removed from used capacitors. PCDDs/PCDFs contained in PCBs as impurities have also been dechlorinated. A vendor has also claimed that chlorinated wastes in liquid state or dissolved in solvents can be treated by CHD.

156. *Pretreatment.* PCBs and PCDDs/PCDFs need to be extracted using solvents or isolated by vaporizing. Substances with low boiling points such as water or alcohols should be removed by distillation prior to treatment.

157. *Emission and residues.* No emissions would occur during the dechlorination reaction because it takes place in the closed hydrogen circulation system. HCl is not discharged from the reaction because it is collected with water as hydrochloric acid within the circulation system. Biphenyl isolated after the reaction by distillation does not contain any toxic materials.

158. *Release control and post-treatment.* Biphenyl, the main product, is separated out from the reaction solvent by distillation after the reaction, and the catalyst and reaction solvent are reused for the next reaction.

159. *Energy requirements.* Energy requirements are expected to be relatively low due to low operating temperatures associated with the CHD process.

160. *Material requirements.* The CHD process requires the same amount of molecules of hydrogen as those of chlorine in PCBs, as well as 0.5 percent by weight of catalyst.

161. *Portability.* CHD is available in fixed and transportable configurations depending on the volume of PCBs to be treated.

162. *Health and safety.* The use of hydrogen gas requires adequate controls and safeguards to ensure that explosive air-hydrogen mixtures are not formed.

163. *Capacity.* In Japan, a plant which is capable of treating 2 Mg PCB per day using the CHD process is currently being designed and will be constructed in two years.

164. *Other practical issues.* There are many reports about PCB dechlorination by using CHD. Generally, Pd/C catalyst shows the largest degradation rate compared to the other supported metal catalyst. Reaction temperature can be increased to 260°C when paraffin oil is used as reaction solvent.

165. *State of commercialization.* A company in Japan started to treat capacitors containing or contaminated with PCBs using a CHD plant in 2004. A commercial-scale CHD plant will be operated in two years in Japan.

166. *Vendor(s).* The patent for this technology is held by Kansai Electric Power Co and Kanden-Engineering Co. ([www.kanden-eng.co.jp](http://www.kanden-eng.co.jp)).

167. *Additional information.* For further information, see the Technical Guideline for Treatment of PCBs in Japan (Japan Industrial Waste Management Foundation, 1999).

**(d) Cement kiln co-incineration<sup>66</sup>**

168. *Process description.* Cement kilns typically consist of a long cylinder of 50–150 metres, inclined slightly from the horizontal (3 percent to 4 percent gradient), which is rotated at about 1–4 revolutions per minute. Raw materials, such as limestone, silica, alumina and iron oxides are fed into the upper or so-called “cold” end of the rotary kiln. The slope and rotation cause the materials to move toward the lower or “hot” end of the kiln. The kiln is fired at the lower end of the kiln where temperatures reach 1400°C–1500°C. As the materials move through the kiln, they undergo drying and pyroprocessing reactions to form the clinker.

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<sup>66</sup> Additional information is available from CMPS&F – Environment Australia, 1997; Costner et al., 1998; Danish Environmental Protection Agency, 2004; Karstensen, 2001; Rahuman et al., 2000; Stobiecki, Cieszkowski, Silowiecki and Stobiecki, 2001 and UNEP, 1998b. In addition, information on BAT and BEP with respect to cement kilns firing hazardous waste is available from the European Commission, 2001 and UNEP 2004c. See annex V, References.

169. *Efficiency*: DREs of greater than 99.99998 percent have been reported for PCBs in several countries (Ahling, 1979; Benestad, 1989; Lauber, 1987; Mantus, 1992. US EPA, 1986; Lauber, 1982; von Krogbeumker, 1994; Black, 1983).

170. *Waste types*: As mentioned above cement kilns have been demonstrated with PCBs, but should be applicable to other POPs. Cement kilns are capable of treating both liquid and solid wastes.<sup>67</sup>

171. *Pre-treatment*: Pre-treatment can involve:

- (a) Thermal desorption of solid wastes prior; and
- (b) Homogenization of solid and liquid wastes through drying, shredding, mixing and grinding.

172. *Emissions and residues*: Emissions may include, inter alia, nitrogen oxides, carbon monoxide, sulphur oxides and dioxide, metals and their compounds, hydrogen chloride, hydrogen fluoride, NH<sub>3</sub>, PCDDs, PCDFs, benzene, toluene, xylene, polycyclic aromatic hydrocarbons, chlorobenzenes and PCBs.<sup>68</sup> It should be noted, however, that cement kilns can comply with PCDD and PCDF air emission levels below 0.1 ng TEQ/Nm<sup>3</sup><sup>69</sup>. Residues include cement kiln dust captured by the air pollution control system.

173. *Release control and post-treatment*: Process gases require treatment to remove cement kiln dust and organic compounds, sulphur dioxide, nitrogen oxide, as well as heat so that formation of PCDDs and PCDFs is minimized. Treatments include use of pre-heaters, electrostatic precipitators, fabric filters and activated carbon filters.<sup>70</sup> It has been reported that PCDD and PCDF concentrations within cement kiln dusts range between 0.4 and 2.6 ppb.<sup>71,72</sup> Accordingly, recovered cement kiln dusts should be put back into kilns to the maximum extent practicable, while the remainder may require disposal in a specially engineered landfill or permanent storage in an underground mine or formation.

174. *Energy requirements*: New kiln systems with 5 cyclone preheater stages and precalciner will require an average of 2,900–3,200 MJ to produce 1 Mg of clinker.<sup>73</sup>

175. *Material requirements*: Cement manufacturing requires large amounts of materials including limestone, silica, alumina, iron oxides and gypsum.<sup>74</sup>

176. *Portability*: Cement kilns are available only in fixed configurations.

177. *Health and safety*: Treatment of wastes within cement kilns can be regarded as relatively safe if properly designed and operated.<sup>75</sup>

178. *Capacity*: Cement kilns co-incinerating wastes as a fuel are normally limited up to a maximum of 40 percent of the heat requirement for hazardous waste.<sup>76</sup> It has been noted, however, that cement kilns with high throughput can potentially treat significant quantities of waste.<sup>77</sup>

179. *Other practical issues*: Cement kilns treating wastes may require modifications to the rotary kiln.<sup>78</sup> Potential feed points for supplying fuel to the kiln system are:

- the main burner at the rotary kiln outlet end;
- a feed chute at the transition chamber at the rotary kiln inlet end (for lump fuel);

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<sup>67</sup> See CMPS&F – Environment Australia, 1997; Rahuman et al., 2000 and UNEP, 2004c in annex V, References.

<sup>68</sup> See UNEP, 2004c in annex V, References.

<sup>69</sup> See UNEP, 2004c in annex V, References.

<sup>70</sup> See CMPS&F – Environment Australia, 1997; Karstensen, 2001 and UNEP, 2004c in annex V, References.

<sup>71</sup> TEQ were not indicated.

<sup>72</sup> See UNEP 2004c in annex V, References.

<sup>73</sup> Ibid.

<sup>74</sup> See CMPS&F – Environment Australia, 1997 in annex V, References.

<sup>75</sup> Ibid.

<sup>76</sup> See UNEP, 2004c in annex V, References.

<sup>77</sup> See UNEP, 1998b in annex V, References.

<sup>78</sup> See CMPS&F – Environment Australia, 1997 and UNEP, 2004c in annex V, References.

secondary burners to the riser duct;  
precalciner burners to the precalciner;  
a feed chute to the precalciner/preheater (for lump fuel);  
a mid kiln valve in the case of long wet and dry kilns (for lump fuel).(UNEP, 2004c)

180. Chlorides have an impact on the quality of the cement and so have to be limited. Chlorine can be found in all the raw materials used in cement manufacture, so the chlorine levels in the hazardous waste can be critical. However, if they are blended down sufficiently, cement kilns can treat highly chlorinated hazardous waste.

181. *State of commercialization:* Cement kilns in the United States of America and some European countries have been used to treat wastes contaminated with POPs. (World business council, 2004: Formation and Release of POPs in the Cement Industry.)

182. *Vendors:* A number of existing cement kiln co-incineration operations are identified in the inventory of worldwide PCB destruction capacity.<sup>79</sup>

(e) **Gas phase chemical reduction (GPCR)**<sup>80</sup>

183. *Process description:* The GPCR process involves the thermo-chemical reduction of organic compounds. At temperatures greater than 850°C and low pressures, hydrogen reacts with chlorinated organic compounds to yield primarily methane and hydrogen chloride.

184. *Efficiency:* DEs of 99.9999 percent have been reported for DDT, HCB, PCBs, PCDDs and PCDFs.<sup>81</sup>

185. *Waste types:* In addition to the substances listed above, GPCR should also be capable of treating wastes consisting of, containing or contaminated with all other POPs.<sup>82</sup> GPCR is capable of treating wastes with a high POP concentration.<sup>83</sup> This includes aqueous and oily liquids, soils, sediments, transformers and capacitors.<sup>84</sup>

186. *Pre-treatment:* Depending on the waste type, one of the following three pre-treatment units is used to volatilize wastes prior to treatment in the GPCR reactor:

- (a) Thermal reduction batch processor (TRBP) for bulk solids, including those in drums;
- (b) Torbed reactor for contaminated soils and sediments, but also adapted for liquids; and
- (c) Liquid waste pre-heater system (LWPS) for liquids.<sup>85</sup>

187. In addition, other pre-processing is required for large capacitors and building rubble. Large capacitors are punctured and drained, while rubble and concrete must be reduced in size to less than one square metre.<sup>86</sup>

188. *Emissions and residues:* In addition to hydrogen chloride and methane, low molecular weight hydrocarbons may be emitted. Residues from the GPCR process include used liquor and water. Solid

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<sup>79</sup> See UNEP, 1998b in annex V, References.

<sup>80</sup> Additional information is available from CMPS&F – Environment Australia, 1997; Costner et al., 1998; Danish Environmental Protection Agency, 2004; Kümmling, Gray, Power and Woodland, 2001; Rahuman et al., 2000; Ray, 2001; UNEP, 2001; UNEP, 2004b; and Vijgen, 2002. See annex V, References.

<sup>81</sup> See CMPS&F – Environment Australia, 1997; Kümmling, 2001; Rahuman et al., 2000; UNEP, 2004b and Vijgen, 2002 in annex V, References.

<sup>82</sup> See CMPS&F – Environment Australia, 1997; UNEP, 2004b and Vijgen, 2002 in annex V, References.

<sup>83</sup> See UNEP, 2004b and Vijgen, 2002 in annex V, References.

<sup>84</sup> See CMPS&F – Environment Australia, 1997; UNEP, 2004b and Vijgen, 2002 in annex V, References.

<sup>85</sup> See CMPS&F – Environment Australia, 1997; Kümmling et al., 2001; UNEP, 2001; UNEP, 2004b and Vijgen, 2004 in annex V, References.

<sup>86</sup> See CMPS&F – Environment Australia, 1997 in annex V, References.

residues will also be generated from solid waste inputs.<sup>87</sup> Since the GPCR process takes place in a reducing atmosphere the possibility of PCDD and PCDF formation is considered limited.<sup>88</sup>

189. *Release control and post-treatment:* Gases leaving the reactor are scrubbed to remove water, heat, acid and carbon dioxide.<sup>89</sup> Scrubber residue and particulate will require disposal off-site.<sup>90</sup> Solid residues generated from solid waste inputs should be suitable for disposal in a landfill.<sup>91</sup>

190. *Energy requirements:* Methane produced during the process can provide much of the fuel needs.<sup>92</sup> It has been reported that electricity requirements range from 96 kWh per ton of soil treated to around 900 kWh per ton of pure organic contaminants treated.<sup>93</sup>

191. *Material requirements:* There is a need for hydrogen supplies, at least during start-up. It has been reported that methane produced during the GPCR process can be used to form enough hydrogen to operate the process thereafter.<sup>94</sup> The hydrogen production unit has been plagued, however, by reliability problems in the past.<sup>95</sup> Other material requirements include caustic for the acid scrubber.<sup>96</sup>

192. *Portability:* GPCR is available in fixed and transportable configurations.<sup>97</sup>

193. *Health and safety:* Use of hydrogen gas under pressure requires suitable controls and safeguards to ensure that explosive air-hydrogen mixtures are not formed.<sup>98</sup> Operating experience gained to date has indicated that the GPCR process can be undertaken safely.<sup>99</sup>

194. *Capacity:* GPCR process capacity is dependent on the capacity of the three pre-treatment units, as specified below:

- (a) TRBP has a capacity of up to 100 tons of solids per month or up to 4 litres per minute of liquids. Two TRBPs can be used in parallel to double capacity;
- (b) TORBED reactor has a capacity of up to 5,000 tons of soils and sediments per month, although this pre-treatment unit is still in the development stage; and
- (c) LWPS has a capacity of three litres per minute.<sup>100</sup>

195. *Other practical issues:* Contaminants such as sulphur and arsenic were found to inhibit treatment in earlier development stages, although it is unclear whether this problem is still encountered.<sup>101</sup>

196. *State of commercialization:* Commercial scale GPCR plants have operated in Canada and Australia. The GPCR plant in Australia operated for more than five years. In addition, a GPCR plant has recently been authorized in Japan.<sup>102</sup>

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<sup>87</sup> See UNEP, 2004b and Vijgen, 2002 in annex V, References.

<sup>88</sup> See CMPS&F – Environment Australia, 1997 and Rahuman et al., 2000 in annex V, References.

<sup>89</sup> See Kümmling et al., 2001; CMPS&F – Environment Australia, 1997 and Rahuman et al., 2000 in annex V, References.

<sup>90</sup> See Rahuman et.al, 2000 and Vijgen, 2002 in annex V, References.

<sup>91</sup> See UNEP, 2004b in annex V, References.

<sup>92</sup> See CMPS&F – Environment Australia, 1997; Rahuman et al., 2000; UNEP, 2001; UNEP, 2004b and Vijgen, 2002 in annex V, References.

<sup>93</sup> CMPS&F – Environment Australia, 1997 in annex V, References.

<sup>94</sup> See CMPS&F – Environment Australia, 1997; Rahuman et al., 2000; UNEP, 2004b and Vijgen, 2002 in annex V, References.

<sup>95</sup> See CMPS&F – Environment Australia, 1997 in annex V, References.

<sup>96</sup> See UNEP, 2004b in annex V, References.

<sup>97</sup> See UNEP, 2001; UNEP, 2004b and Vijgen, 2002 in annex V, References.

<sup>98</sup> See CMPS&F – Environment Australia, 1997 in annex V, References.

<sup>99</sup> See CMPS&F – Environment Australia, 1997 and UNEP, 2004b in annex V, References.

<sup>100</sup> See UNEP, 2004b and Vijgen, 2002 in annex V, References.

<sup>101</sup> See CMPS&F – Environment Australia, 1997 in annex V, References.

<sup>102</sup> See CMPS&F – Environment Australia, 1997; Kümmling et al., 2001; Ray, 2001; UNEP, 2004b and Vijgen, 2002 in annex V, References.

197. *Vendors*: The patent for this technology is held by the sole supplier ELI Eco Logic International Inc. (www.ecologic.ca). ELI Eco Logic International Inc. sells licences to operate the technology.

(f) **Hazardous waste incineration**<sup>103</sup>

198. *Process description*: Hazardous waste incineration uses controlled flame combustion to treat organic contaminants mainly in rotary kilns. Typically a process for treatment involves heating to a temperature greater than 850 °C or, if the chlorine content is above 1 percent, greater than 1,100 °C, with a residence time greater than 2 seconds, under conditions that assure appropriate mixing. Dedicated hazardous waste incinerators are available in a number of configurations including rotary kiln incinerators, static ovens (for liquids only). High-efficiency boilers and lightweight aggregate kilns are also used for the co-incineration of hazardous wastes. (See Brunner, 2004, for additional information regarding the application of these technologies.)

199. *Efficiency*: DREs of greater than 99.9999 percent have been reported for treatment of wastes consisting of, containing or contaminated with POPs.<sup>104</sup> DEs of greater than 99.999 and DREs of greater than 99.9999 percent have been reported for aldrin, chlordane and DDT (Ministry of the Environment of Japan, 2004), while DEs between 83.15 and 99.88 percent have been reported for PCBs (United States Environmental Protection Agency, 1990).

200. *Waste types*: As noted above, hazardous waste incinerators are capable of treating wastes consisting of, containing or contaminated with any POP. Incinerators can be designed to accept wastes in any concentration or any physical form, i.e., gases, liquids, solids, sludges and slurries.<sup>105</sup>

201. *Pre-treatment*: Depending upon the configuration, pre-treatment requirements may include blending, dewatering, and size reduction of wastes.<sup>106</sup>

202. *Emissions and residues*: Emissions include carbon monoxide, carbon dioxide, HCB, hydrogen chloride, particulates, PCDDs, PCDFs and PCBs and water vapour.<sup>107</sup> Incinerators applying BAT, inter alia, designed for high temperature and equipped with prevention of reformation of PCDDs and PCDFs and dedicated PCDD and PCDF removal (e.g., activated carbon filters), have led to very low PCDD and PCDF emissions to air and discharges to water.<sup>108</sup> In the residues, PCDDs and PCDFs are mainly found in fly ash and salt, and to some extent in bottom ash and scrubber water sludge.

203. *Release control and post-treatment*: Process gases may require treatment to remove hydrogen chloride and particulate matter and to prevent the formation of and remove unintentionally produced POPs. This can be achieved through a combination of types of post-treatments, including cyclones and multi-cyclones, electrostatic filters, static bed filters, scrubbers, selective catalytic reduction, rapid quenching systems and carbon adsorption<sup>109</sup>. Depending upon their characteristics, bottom and fly ashes may require disposal within a specially engineered landfill<sup>110</sup>.

204. *Energy requirements*: The amount of combustion fuel required will depend upon the composition and calorific value of the waste.

205. *Material requirements*: Material requirements include cooling water and lime or another suitable material for removal of acid gases.

206. *Portability*: Hazardous waste incinerators are available in both portable and fixed units.

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<sup>103</sup> Additional information is available from Danish Environmental Protection Agency, 2004; Federal Remediation Technologies Roundtable (FRTR), 2002; Rahuman et al., 2000; UNEP, 1995c; UNEP, 1998b; UNEP, 2001 and United States Army Corps of Engineers, 2003. In addition, information on BAT and BEP with respect to hazardous waste incinerators is available from the European Commission 2004 and UNEP 2004c. See annex V, References.

<sup>104</sup> See FRTR, 2002; Rahuman et al., 2000; UNEP, 1998b and UNEP, 2001 in annex V, References.

<sup>105</sup> See UNEP, 1995c in annex V, References.

<sup>106</sup> See UNEP, 1995c; UNEP, 1998b and UNEP, 2004c in annex V, References.

<sup>107</sup> See UNEP, 1995c; UNEP, 1998b and UNEP, 2004c in annex V, References.

<sup>108</sup> UNEP, 2001 in annex V, References

<sup>109</sup> UNEP, 2004c

<sup>110</sup> See United States Army Corps of Engineers, 2003 in annex V, References.



207. *Health and safety*: Health and safety hazards include those associated with high operating temperatures<sup>111</sup>.
208. *Capacity*: Hazardous waste incinerators can treat between 30,000 and 100,000 tons per year<sup>112</sup>.
209. *Other practical issues*: None to report at this time.
210. *State of commercialization*: There is a long history of experience with hazardous waste incineration<sup>113</sup>.
211. *Vendors*: A number of existing hazardous waste incineration facilities are identified within the inventory of worldwide PCB destruction capacity.<sup>114</sup>

**(g) Photo-chemical dechlorination (PCD) and catalytic dechlorination (CD) reaction**

212. *Process description*: PCD and CD is a technology using the combined methods of both photo-chemical dechlorination (PCD) reaction and catalytic dechlorination (CD) reaction (Watanabe, Ohara and Tajima, 2002 and Watanabe, Ohara, Tarima, Yoneki and Hosya, 2003). In the destruction process, PCBs are mixed with NaOH and isopropyl alcohol (IPA) so that the PCB concentration in IPA should reach several percent by weight. Subsequently, PCBs are dechlorinated by two independent processes, i.e., PCD and CD processes. Each process is operated at moderate temperature (<75 °C) and atmospheric pressure. After the PCBs are dechlorinated, biphenyl, NaCl, acetone, and water are generated, but no gases such as hydrogen or hydrochloric gas are produced.
213. *Efficiency*: DEs of 99.99-99.9999 percent have been achieved for PCBs and 99.9999-99.999999 percent for PCDDs and PCDFs (Tajima et al., 2003; and Watanabe et al., 2003).
214. *Waste types*: PCD and CD has been demonstrated to treat oil from transformers and capacitors containing PCBs with a high concentration and contaminated with PCDDs and PCDFs, and should be applicable to other POPs as well. Soils and sludge are not treatable with this technology. PCB in clothing, packaging, wood and other multi-porous materials should be extracted by solvent.
215. *Pretreatment*: Electrical equipment contaminated with PCBs requires some pretreatment. After removing PCBs from the equipment, the contaminated material such as cases, coils and insulation papers are disassembled and separated. PCBs are extracted from those materials by hydrocarbon washing agent, such as decane. PCBs and the solvent are separated by the distiller. Distilled PCBs and solvent are respectively destroyed by the PCD and CD processes. The solvent is reused for washing. It is not necessary to pretreat soils, sludge and water.
216. *Potential emissions and residues*: Air emissions are expected to be relatively minor. The potential for PCDDs and PCDFs to be formed during the PCD and CD processes is not considered theoretically. Residues include solid NaCl and used catalyst. (Watanabe et al., 2002; Watanabe et al., 2003)
217. *Post-treatment*: A distiller separates IPA from the solution, and large parts of IPA can be recycled several times as solvent of PCBs. Wastes generated from the processes include biphenyl, NaCl, acetone, water and residual IPA. NaCl is filtrated from the solution and disposed to landfill. The used catalyst is washed with water in order to remove NaCl, and it can be reused several times for the CD process.
218. *Energy requirements*: The PCD process requires 3 kJ/g PCB for mercury lamp. The energy requirement is expected to be relatively low due to low operating temperatures (75 °C) associated with the PCD and CD process (Watanabe et al., 2002; Watanabe et al., 2003).
219. *Material requirements*:
- (a) Alkali: NaOH (NaOH/Cl = 1.3)
  - (b) Catalyst: 2 kg/m<sup>3</sup> by volume of the hydrogen donor
  - (c) Hydrogen donor: IPA
220. *Portability*: Modular, transportable plants should be available. A fixed plant has been established in Kawasaki, Japan.

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<sup>111</sup> Ibid.

<sup>112</sup> See UNEP, 2004c in annex V, References.

<sup>113</sup> See UNEP, 2001 in annex V, References.

<sup>114</sup> See UNEP, 1998 in annex V, References.

221. *Health and safety:* In general, the health and safety risks associated with operation of this technology are regarded to be low. (Watanabe et al., 2002; Watanabe et al., 2003; Sasaki, Masaaki, Watanabe, Nishida, Fujita, Harano, Nagata and Mimura et al., 2003).
222. *Capacity:* The PCD and CD technology is available with a capacity 50 kg oil per day by one unit. The capacity could be flexible due to the size of facility (e.g. either lower or as high as 2 ton/day)
223. *Other practical issues:* The PCD and CD method is especially suitable for pure PCB. This technology satisfies the stringent release standards in Japan (PCBs in the waste oil < 0.5 mg/kg).
224. *State of commercialization:* The PCD and CD technologies have been operated in Kawasaki, Japan, for the past two years (Watanabe et al., 2002; and Watanabe et al., 2003).
225. *Vendor(s):* The patent and all rights for this technology are held and reserved by Toshiba corporation ([www.toshiba.co.jp/efort/market/pcb/index\\_j.htm](http://www.toshiba.co.jp/efort/market/pcb/index_j.htm)). Toshiba Corporation sells licensees for operation of the technology.
226. *Additional information:* For further information, see the Technical Guideline for treatment of PCBs in Japan (Japan Industrial Waste Management Foundation, 1999; Watanabe et al., 2002; Watanabe et al., 2003; Sasaki et al., 2003; Noma et al., 2002; Noma et al., 2003).

**(h) Plasma arc<sup>115</sup>**

227. *Process description:* The Plascon™ process uses a plasma arc with temperatures in excess of 3000°C to pyrolyse wastes. Together with argon, wastes are injected directly into the plasma arc. The high temperature causes compounds to dissociate into their elemental ions and atoms. Recombination occurs in a cooler area of the reaction chamber, followed by a quench resulting in the formation of simple molecules.<sup>116</sup>
228. *Efficiency:* Bench scale tests with oils containing 60 percent PCBs have achieved DREs ranging from 99.9999 to 99.999999 percent<sup>117</sup>.
229. *Waste types:* In addition to PCB oils, a Plascon™ plant in Australia has recently been configured to treat pesticide wastes<sup>118</sup>. Waste types to be treated must be liquid, gas or solids if in the form of a fine slurry, which can be pumped. Very viscous liquids or sludges thicker than 30 to 40 weight motor oil cannot be processed without pre-treatment. Other solid wastes cannot be treated unless some form of pre-treatment is undertaken<sup>119</sup>.
230. *Pre-treatment:* Pre-treatment is not required for most liquids. Solids such as contaminated soils, capacitors and transformers can be pre-treated using thermal desorption or solvent extraction<sup>120</sup>.
231. *Emissions and residues:* Emissions include gases consisting of argon, carbon dioxide and water vapour. Residues include an aqueous solution of inorganic sodium salts, such as sodium chloride, sodium bicarbonate and sodium fluoride. Bench-scale tests with PCBs showed PCDD levels in scrubber water and stack gases in the part per trillion (ppt) range<sup>121</sup>. At a Plascon™ plant in Australia, used to treat a variety of wastes, the level of PCBs in the effluent discharged complies with a 2 ppb limit<sup>122</sup>. POP concentrations in solid residues are unknown<sup>123</sup>.
232. *Release control and post-treatment:* Currently, there is little information available regarding post-treatment requirements. Energy requirements: A 150 kW Plascon unit requires 1,000–3,000 kWh of electricity per tonne of waste<sup>124</sup>.

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<sup>115</sup> Additional information is available from CMPS&F – Environment Australia, 1997; Costner et al., 1998; Rahuman et al., 2000; Ray, 2001; UNEP, 1998b; UNEP, 2000b; UNEP, 2001 and UNEP, 2004b. See annex V, References.

<sup>116</sup> See CMPS&F – Environment Australia, 1997 in annex V, References.

<sup>117</sup> See Rahuman et al., 2000 and UNEP, 2004b in annex V, References.

<sup>118</sup> See UNEP, 2004b in annex V, References.

<sup>119</sup> See CMPS&F – Environment Australia, 1997 and UNEP, 2004b in annex V, References.

<sup>120</sup> Ibid.

<sup>121</sup> See CMPS&F – Environment Australia, 1997 and Rahuman et al., 2000 in annex V, References.

<sup>122</sup> See UNEP, 2004b in annex V, References.

<sup>123</sup> Ibid.

<sup>124</sup> See CMPS&F – Environment Australia, 1997 in annex V, References.

233. *Energy requirements:* A 150 kW Plascon unit requires 1,000–3,000 kWh of electricity per tonne of waste.<sup>125</sup>
234. *Material requirements:* Currently, there is little information available regarding material requirements. It has been noted, however, that this process does require argon gas, oxygen gas, caustic and cooling water<sup>126</sup>.
235. *Portability:* Plascon is available in transportable and fixed units<sup>127</sup>.
236. *Health and safety:* Since the Plascon process has a low through-put, there is a low risk associated with release of partially treated wastes following process failure<sup>128</sup>. Currently, there is little additional information available regarding health and safety.
237. *Capacity:* A 150 kW Plascon unit can process 1 to 3 tons per day of waste<sup>129</sup>.
238. *Other practical issues:* None to report at this time.
239. *State of commercialization:* BCD Technologies operates two plasma plants in Australia: one in Brisbane for PCBs and POPs; and another in Melbourne for treating CFCs and Halons. BCD Technologies also operates a BCD plant for low level PCBs and POPs and also has two thermal desorbers for treating contaminated solids. Mitsubishi Chemical Corporation has installed a Plascon plant in Japan to treat wastes consisting of, containing or contaminated with PCBs.
240. *Vendors:* The vendor for the Plascon process is SRL Plasma Pty Ltd Narangba Australia (www.srlplasma.com.au) and Commonwealth Scientific Industrial Research Organization (CSIRO). The three patents for Plascon are jointly owned by SRL Plasma PTY Ltd and CSIRO.

**(i) Potassium tert-Butoxide (t-BuOK) method**

241. *Process description:* PCBs in insulating oils are dechlorinated by the reaction with potassium tert-butoxide (t-BuOK). t-BuOK reacts with chlorine in PCBs to produce salt and non-chlorinated waste. Typically, the process operates at atmospheric pressure and temperatures between 200°C and 240°C (Oono, Kaneda and Kirata, 1997 and Oono and Kaneda, 1997).
242. *Efficiency:* DEs of 99.98-99.9999percent have been reported for PCBs. It has also been reported that a reduction of the PCB content to less than 0.5 mg/kg is achievable.
243. *Waste types:* The t-BuOK method has been demonstrated with low contaminated mineral oils. A vendor has also claimed that the chlorinated wastes in liquid state or dissolved in solvents can be treated by the t-BuOK method.
244. *Pretreatment:* t-BuOK reacts with water to produce potassium hydroxide and tert-butanol. If a high volume of water is contained in the mineral oils contaminated with PCBs, t-BuOK will react easier with the water than with the chlorine in PCBs. Therefore, water in the oils should be removed before the reaction.
245. *Emissions and residues:* No emission would occur during the reaction. There is little potential for PCDDs and PCDFs to be formed as by-products during the reaction due to very fast dechlorination rate, which causes chlorine to be released quickly (Takigami, Sakai and Oono, 2002a and 2002b).
246. *Release control and post-treatment:* By-products can be separated out from the oils by washing with water after the reaction. The decontaminated oils can be reused as fuel.
247. *Energy requirements:* Energy requirements are expected to be relatively low due to low operating temperatures associated with t-BuOK process.
248. *Material requirements:* When the PCB content in the mineral oils is below 200 ppm, the amount of t-BuOK required is about 0.5percent by weight of the contaminated oils.
249. *Portability:* This process is available in fixed and transportable configurations depending on the volume of the contaminated oil to be treated.

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<sup>125</sup> See CMPS&F – Environment Australia, 1997 in annex V, References.

<sup>126</sup> See CMPS&F – Environment Australia, 1997 and UNEP, 2004b in annex V, References.

<sup>127</sup> See UNEP, 2004b in annex V, References.

<sup>128</sup> See CMPS&F – Environment Australia, 1997 and UNEP, 2004b in annex V, References.

<sup>129</sup> Ibid.

250. *Health and safety*: In general, the health and safety risks associated with the operation of this technology are considered to be low.
251. *Capacity*: It has been reported that 36,000 litres per day of contaminated oil have been treated with this technology in Japan.
252. *Other practical issues*: It is possible to treat a large amount of contaminated oils in a short period of time with this technology, as it can be continuously operated.
253. *State of commercialization*: A company in Japan has been treating contaminated mineral oils with a continuously operated plant since 2004.
254. *Vendor(s)*: The patent for this technology is held by Kansai Electric Power Co and Kanden-Engineering Co. ([www.kanden-eng.co.jp](http://www.kanden-eng.co.jp)).
255. *Additional information*: For further information see the Technical Guideline for treatment of PCBs in Japan (Japan Industrial Waste Management Foundation, 1999).

**(j) Super-critical water oxidation (SCWO) and subcritical water oxidation<sup>130</sup>**

256. *Process description*: SCWO and subcritical water oxidation treat wastes in an enclosed system, using an oxidant (such as oxygen, hydrogen peroxide, nitrite, nitrate, etc.) in water at temperatures and pressures above the critical point of water (374°C and 218 atmospheres) and under subcritical conditions (370 °C and 262 atmospheres). Under these conditions, organic materials become highly soluble in water and are oxidized to produce carbon dioxide, water and inorganic acids or salts.
257. *Efficiency*: DEs of greater than 99.999 percent and DREs of greater than 99.9999 percent have been reported for aldrine, chlordane and PCBs for SCWO (Ministry of the Environment of Japan, 2004). DEs of greater than 99.999999 and DREs of greater than 99.9999999 percent have been reported for subcritical water oxidation (Ministry of the Environment of Japan, 2004). DREs as high as 99.9999 percent have also been demonstrated for PCDDs in bench-scale tests<sup>131</sup>.
258. *Waste types*: SCWO and subcritical water oxidation are thought to be applicable to all POPs<sup>132</sup>. (Japan Industrial Waste Management Foundation, 1999). Applicable waste types include aqueous wastes, oils, solvents and solids with a diameter less than 200 µm. The organic content of the waste is limited to less than 20 percent<sup>133</sup>.
259. *Pre-treatment*: Concentrated wastes may have to be diluted prior to treatment in order to reduce the organic content to less than 20 percent. In the case of subcritical water oxidation, dilution of wastes is not necessary. If solids are present, they will have to be reduced to less than 200 µm in diameter.
260. *Emissions and residues*: During laboratory scale PCB destruction, it was shown that the SCWO technology has the potential to form high concentrations of PCDF (in the percent range) during PCB degradation even at temperatures of practical operation (Weber, 2004). It has been reported that emissions contain no oxides of nitrogen or acid gases such as hydrogen chloride or sulphur oxide and that process residues consist of water and solids if the waste contains inorganic salts or organic compounds with halogens, sulphur or phosphorus<sup>134</sup>. Limited information has been reported regarding potential concentrations of undestroyed chemicals<sup>135</sup>. The process is designed such that emissions and residues can be captured for reprocessing if needed<sup>136</sup>.
261. *Release control and post-treatment*: Currently, there is no specific information available regarding post-treatment requirements.

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<sup>130</sup> Additional information is available from CMPS&F – Environment Australia, 1997; Costner et al., 1998; Rahuman et al., 2000; UNEP, 2001 and UNEP, 2004b. See annex V, References.

<sup>131</sup> See CMPS&F – Environment Australia, 1997; Rahuman et al., 2000 and Vijgen, 2002 in annex V, References.

<sup>132</sup> See UNEP, 2004b in annex V, References.

<sup>133</sup> See CMPS&F – Environment Australia, 1997; Rahuman et al., 2000 and Vijgen, 2002 in annex V, References.

<sup>134</sup> See CMPS&F – Environment Australia, 1997 in annex V, References.

<sup>135</sup> See CMPS&F – Environment Australia, 1997 and UNEP, 2004b in annex V, References.

<sup>136</sup> See UNEP, 2004b in annex V, References.

262. *Energy requirements*: Energy requirements are expected to be relatively high because of the combinations of high temperatures and pressures. It has been claimed, however, that as long as relatively high hydrocarbon content is present in the feed, no energy input is required to heat up the feed to supercritical temperatures<sup>137</sup>.

263. *Material requirements*: The SCWO and subcritical water oxidation reaction vessel must be constructed of materials capable of resisting corrosion caused by halogen ions<sup>138</sup>. Material corrosion can be severe at the temperatures and pressures used in the SCWO and subcritical water oxidation process. In the past, the use of titanium alloys has been proposed to tackle this problem. Current vendors claim to have overcome this problem through the use of advanced materials and engineering designs<sup>139</sup>.

264. *Portability*: The SCWO and subcritical water oxidation units are currently used in a fixed configuration, but are thought to be transportable<sup>140</sup>.

265. *Health and safety*: The high temperatures and pressures used in this process require special safety precautions<sup>141</sup>.

266. *Capacity*: Current SCWO demonstration units are capable of treating 500 kg/hr, while full-scale units will be designed to treat 2,700 kg/hr<sup>142</sup>.

267. *Other practical issues*: Earlier designs were plagued by reliability, corrosion and plugging problems. Current vendors claim to have addressed these problems through the use of special reactor designs and corrosion resistant materials<sup>143</sup>.

268. *State of commercialization*: A full-scale, commercial plant has recently begun to operate in Japan. In addition, the SCWO process has been approved for full-scale development and use in the chemical weapons programme of the United States of America.

269. *Vendors*: Firms providing this service include:

- (a) Foster Wheeler Development Corporation ([www.fosterwheeler.com](http://www.fosterwheeler.com));(b) General Atomics ([www.ga.com](http://www.ga.com));
- (b) Mitsubishi Heavy Industries, Ltd. ([www.mhi.co.jp](http://www.mhi.co.jp)).

### 3. **Other disposal methods when destruction or irreversible transformation does not represent the environmentally preferable option**

270. Where destruction or irreversible transformation does not represent the environmentally preferable option, for wastes with a POP content above the low POP content referred to in subsection A of section III above, a country may allow such wastes to be disposed of by other methods than the methods referred to in chapter IV, section G, subsection 2.

271. Wastes containing or contaminated with POPs where such other disposal methods may be considered include:

- (a) Waste from power stations and other combustion plants (except those listed in subparagraph (d) below), wastes from the iron and steel industry and from aluminium, lead, zinc, copper and other non-ferrous thermal metallurgy. These include bottom ash, slag, salt slags, fly ash, boiler dust, flue-gas dust, other particulates and dust, solid wastes from gas treatment, black drosses, wastes from treatment of salt slags and black drosses, dross and skimmings;
- (b) Carbon-based and other linings and refractories from metallurgical processes;

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<sup>137</sup> See Rahuman et al., 2000 in annex V, References.

<sup>138</sup> See Vijgen, 2002 in annex V, References.

<sup>139</sup> Ibid.

<sup>140</sup> See UNEP, 2004b and Vijgen, 2004 in annex V, References.

<sup>141</sup> See CMPS&F – Environment Australia, 1997 in annex V, References.

<sup>142</sup> See UNEP, 2004b and Vijgen, 2002 in annex V, References.

<sup>143</sup> Ibid.

- (c) The following construction and demolition wastes:
  - (i) Mixtures of, or separate fractions of, concrete, bricks, tiles and ceramics;
  - (ii) Inorganic fraction of soil and stones, including excavated soil from contaminated sites; and
  - (iii) Construction and demolition wastes containing PCBs, excluding equipment containing PCBs;
- (d) Wastes from incineration or pyrolysis of waste, including solid wastes from gas treatment, bottom ash, slag, fly ash and boiler dust; and
- (e) Vitrified wastes and waste from vitrification including fly ash and other flue-gas treatment wastes and non-vitrified solid phase.

272. The relevant authority of the country concerned should be satisfied that destruction or irreversible transformation of the POP content, performed according to best environmental practice or best available techniques, do not represent the environmentally preferable option.

273. Other disposal methods when destruction or irreversible transformation do not represent the environmentally preferable option include those described below.

**(a) Specially engineered landfill<sup>144</sup>**

274. Any landfilling should only be carried out in a way that minimizes the potential of the POPs content to enter the environment. This may be achieved by pre-treatment, e.g., a suitable solidification process. A specially engineered landfill generally should comply with requirements as regards location, conditioning, management, control, closure and preventive and protective measures to be taken against any threat to the environment in the short- as well as in the long-term perspective, in particular as regards measures against the pollution of groundwater by leachate infiltration into the soil. Protection of soil, groundwater and surface water should be achieved by the combination of a geological barrier and a bottom liner system during the operational phase and by the combination of a geological barrier and a top liner during the closure and post-closure phase. Measures should also be taken to reduce the production of methane gas and to introduce landfill gas control. In addition, a uniform waste acceptance procedure on the basis of a classification procedure for waste acceptable in the landfill, including in particular standardized limit values, should be introduced. Moreover, monitoring procedures during the operation and post-closure phases of a landfill should be established in order to identify any possible adverse environmental effects of the landfill and take the appropriate corrective measures. A specific permit procedure should be introduced for a landfill. Permits should include specifications regarding types and concentrations of wastes to be accepted, leachate and gas control systems, monitoring, on-site security, and closure and post-closure.

275. The following wastes containing or contaminated with POPs are not suitable for disposal in specially engineered landfills:

- (a) Liquids and materials containing free liquids;
- (b) Biodegradable organic wastes;
- (c) Empty containers unless they are crushed, shredded or similarly reduced in volume; and
- (d) Explosives, flammable solids, spontaneously combustible materials, water-reactive materials, oxidizers and organic peroxides.

**(b) Permanent storage in underground mines and formations**

276. Permanent storage in facilities located in geohydrologically isolated underground salt mines and hard rock formations is an option to separate hazardous wastes from the biosphere for geological periods of time. A site-specific security assessment according to pertinent national legislation such as the provisions contained in Appendix A to the Annex of the European Council decision 2003/33/EC of 19 December 2002 establishing criteria and procedures for the acceptance of waste at landfills pursuant to article 16 of and Annex II to Directive 1999/31/EC should be performed for every planned underground storage facility.

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<sup>144</sup> Further information is available within Technical Guidelines on Specially Engineered Landfill (D5), UNEP, 1995d, in annex V, References, and pertinent national legislation such as the European Directive 1999/31/EC.

277. Wastes should be disposed of in a manner that excludes any undesirable reaction between different wastes or between wastes and the storage lining, among other things by storing in chemically and mechanically secure containers. Wastes that are liquid, gaseous, causing toxic gases, explosive, flammable or infectious should not be stored in underground mines. Operational permits should define waste types that should be generally excluded.

278. The following should be considered in the selection of permanent storage for disposal of wastes consisting of, containing or contaminated with POPs:

- (a) Caverns or tunnels used for storage should be completely separated from active mining areas and areas that maybe re-opened for mining;
- (b) Caverns or tunnels should be located in geologic formations that are well below zones of available groundwater or in formations that are completely isolated by impermeable rock or clay layers from water-bearing zones; and
- (c) Caverns and tunnels should be located in geologic formations that are extremely stable and not in areas subject to earthquakes.

#### **4. Other disposal methods when the POP content is low**

279. In addition to the disposal methods described above, wastes containing or contaminated with POPs at concentrations beneath the low POP content may be disposed in accordance with pertinent national legislation and international rules, standards and guidelines, including the specific technical guidelines developed under the Basel Convention. Examples of pertinent national legislation are found in annex II below.

## **H. Remediation of contaminated sites**

### **1. Contaminated site identification<sup>145</sup>**

280. In particular, poor handling and storage practices may lead to releases of POPs at sites storing these chemicals, resulting in contamination of these sites with high levels of POPs that may pose serious health concerns. Identification of such sites is the first step in addressing potential concerns.

281. Identification of such sites can be undertaken using a phased approach, including:

- (a) Identification of suspect sites, such as sites involved in:
  - (i) Manufacturing of POPs;
  - (ii) Formulation of pesticides, filling and refilling of transformers;
  - (iii) Usage of POPs, inter alia, application of pesticides and location of transformers;
  - (iv) Disposal of wastes consisting of, containing or contaminated with POPs;
- (b) Review of current and historical information pertaining to the suspected site;
- (c) Initial testing programme to confirm the presence or absence of suspected contaminants and characterize the physical conditions at the suspected site; and
- (d) Detailed testing programme to further define the nature of the site contamination and to gather any additional information required.

### **2. Environmentally sound remediation<sup>146</sup>**

282. Contaminated site criteria developed by Governments using risk assessment techniques are used as general targets in the site remediation. Separate criteria can be developed or adopted for soil, sediment and

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<sup>145</sup> Further information on contaminated site identification is available within *Assessing Soil Contamination: A Reference Manual No. 8* (FAO, 2000) and *Guidance Document on the Management of Contaminated Sites in Canada* (Canadian Council of Ministers of the Environment, 1997). See annex V, References.

<sup>146</sup> Information on methods currently used for the remediation of sites contaminated with POPs is available from a variety of sources including: FRTR (2002), United States Environmental Protection Agency (1993 and 2000) and Vijgen (2002) See Annex V, References

groundwater. Often a distinction is made between industrial (least stringent criteria), commercial, residential and agricultural (most stringent criteria) soils. Examples of these criteria can be found in the German Federal Soil Protection and Contaminated Sites Ordinance, Swiss Soil Burden Ordinance and Canadian Environmental Quality Guidelines.<sup>147</sup>

## **I. Health and safety<sup>148</sup>**

283. Health and safety plans should be in place at all facilities that handle wastes consisting of, containing or contaminated with POPs to ensure the protection of everyone in and around the facility. The health and safety plan for a specific facility should be developed by a trained health and safety professional with experience managing health risks associated with the specific POPs at the facility.

284. In general there are three main ways to protect workers from chemical hazards (in order of preference):

- (a) Keep workers away from all possible sources of contamination;
- (b) Control the contaminants so that the possibility of exposure is minimized; and
- (c) Protect workers using personal protective equipment.

285. All health and safety plans should adhere to the above principles and recognize local or national labour standards. Most health and safety programmes recognize different levels of safety, with risk levels ranging from high to low depending on the site in question and the nature of the contaminated materials contained there. The level of protection provided to workers should correspond to the level of the risk to which they are exposed. Levels of risk can be established and each situation should be evaluated by health and safety professionals. Two risk situations are discussed below: first, high-volume, high-concentration or high-risk situations; and, second, low-volume, low-concentration or low-risk situations.

### **1. High-volume, high-concentration or high-risk situations**

286. Those who work with or near POPs, particularly in situations where high concentrations of POPs or high volumes of wastes consisting of, containing or contaminated with POPs are present or where there is a high risk of exposure, are particularly at risk. There is no international, quantitative definition of high volume or high concentration; each employer should be guided by the advice and input of health and safety professionals, labour representatives, the scientific literature, and government authorities. Many countries have worker health and safety regulatory or guideline exposure conditions and limits. Any situation where it is probable that these limits will be exceeded is high risk. A site-specific risk assessment may also indicate a high risk, whether or not government guideline levels of POPs are exceeded. Potential high-concentration, high-volume or high-risk situations may include the following:

- (a) Dedicated, large volume, storage sites;
- (b) Electrical rooms with large or multiple PCB transformers;
- (c) Areas where POPs are being intentionally produced;
- (d) So-called “open” chemical handling areas (where POPs are exposed to the air for sampling, mixing, transfer to containers, etc.);
- (e) Areas where pesticides are applied;
- (f) Sites where POPs are handled for transport;
- (g) Facilities used for treatment and disposal of wastes consisting of, containing or contaminated with POPs; and
- (h) Sites contaminated with a high concentration of POPs at or near the surface.

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<sup>147</sup> See Canadian Council of Ministers of the Environment, 2002 in annex V, References.

<sup>148</sup> Further information on health and safety is also available from the International Labour Organization (1999a and 1999b), the World Health Organization (1995 and 1999) and IPCS INCHEM (no date). See annex V, References.



## 2. Low-volume, low-concentration or low-risk situations

287. As discussed in section IV.I.1 above, there is no clear definition of low-volume, low-concentration or low-risk. These should be determined by comparing contaminant levels with government guidelines or by conducting site-specific risk assessments. Low-volume, low-risk or low-risk situations may include:

- (a) Properties that contain products or articles that contain or are contaminated with POPs in small quantities or low concentrations such as light ballasts containing PCBs or preservative treated utility poles, fence posts or lumber;
- (b) Electrical transformers or other equipment with low-level, PCB-contaminated mineral oil;
- (c) Commercial storage or inventory rooms that contain small quantities of products such as pesticides, pesticides, which are to be used in acceptable application situations;
- (d) Facilities that unintentionally produce POPs in very low concentrations compared with human exposure limits;
- (e) Transport of consumer products and articles containing or contaminated with POPs in approved containers; and
- (f) Sites contaminated with low concentrations of POPs or where the contamination cannot directly come into contact with workers (for example, where the contamination is underground or under water and is not being excavated).

## J. Emergency response<sup>149</sup>

288. Emergency response plans should be in place for all POPs in production, in use, in storage, in transport or at disposal sites. While the emergency response plans can vary for each situation and each type of POP, the principal elements of an emergency response include:

- (a) Identifying all potential hazards, risks and accident events;
- (b) Identifying of relevant local and national legislation governing emergency response plans;
- (c) Planning for anticipated emergency situations and possible responses;
- (d) Maintaining a complete up-to-date inventory of all POPs on site;
- (e) Training of personnel in response activities, including simulated response exercises and first-aid;
- (f) Maintaining mobile spill response capabilities or retaining the services of a specialized firm for spill response;
- (g) Notifying fire services, police and other government emergency response agencies of the location of POPs and the routes of transport;
- (h) Installing mitigation measures, such as fire suppression systems, spill containment equipment, fire-fighting water containment, spill and fire alarms and firewalls;
- (i) Installing emergency communication systems including signs indicating emergency exits, telephone numbers, alarm locations and response instructions;
- (j) Installing and maintaining emergency response kits containing sorbents, personal protective equipment, portable fire extinguishers and first aid supplies;
- (k) Integrating facility plans with local, regional, national and global emergency plans, if appropriate; and
- (l) Regular testing of emergency response equipment and review of emergency response plan.

289. Emergency response plans should be prepared jointly by interdisciplinary teams that include emergency response, medical, chemical and technical personnel as well as representatives of labour and

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<sup>149</sup> Further guidance on emergency response plans can be found in other guidelines developed by international organizations, such as the OECD Guiding Principles for Chemical Accident Prevention, Preparedness and Response, second edition (2003) and by national, regional or local governments or agencies (such as civil defence and emergency coordination agencies and fire departments).

management. When applicable, representatives of potentially impacted communities should also be included.

## **K. Public participation**

290. Public participation is a core principle of the Basel Declaration on Environmentally Sound Management and many other international agreements. It is essential that the public and all stakeholder groups have a chance to participate in the development of policy related to POPs, planning of programmes, development of legislation, review of documents and data, and decision-making on local issues related to POPs. Paragraphs 6 (g) and (h) of the Basel Declaration address the enhancement of information exchange, education and awareness-raising in all sectors of society and cooperation and partnership between countries, public authorities, international organizations, industry, non-governmental organizations and academic institutions.

291. The Stockholm Convention, in its article 10, paragraph 1 (d), calls on each Party, within its capabilities, to promote and facilitate public participation in addressing POPs and their health and environmental effects and in developing adequate responses, including opportunities for providing input at the national level regarding implementation of this Convention.

292. Articles 6, 7, 8, and 9 of the 1998 Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters require the conduct of fairly specific types of activities regarding public participation in specific government activities, the development of plans, policies and programmes, and the development of legislation, and call for access to justice for the public with regard to the environment.

293. The participation of the public in the establishment of standards and regulations for POPs is essential. Any Government planning new or changed regulations or policies should have an open process for soliciting comment from any and all person or groups. This means that a general invitation to comment is given through regular media outlets, the internet, or direct invitation. The individuals and groups who should be considered for direct invitation to comment are:

- (a) Individual citizens who have expressed interest;
- (b) Local citizens' groups, including local environmental groups, for local issues;
- (c) Groups of highly vulnerable people, such as women, children and the least-educated;
- (d) Regionally, nationally or globally organized environmental groups;
- (e) Individual industries and businesses with a stake in the process;
- (f) Business associations;
- (g) Trade unions and associations;
- (h) Professional associations; and
- (i) Other levels of government.

294. A public participation process may have several phases. Groups may be consulted before any changes or programmes are considered, during the policy development process and after each draft policy document is prepared. Comments may be invited in person, in writing or through an internet web site.

295. An example of public consultation regarding the development of POPs management plans can be found in the Australia Department of the Environment and Heritage document, "A case study of problem solving through effective community consultation"<sup>150</sup>.

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<sup>150</sup> See Australia Department of the Environment and Heritage, 2000 in annex V, References.

## **Annex I**

### **International instruments**

In addition to the Stockholm and Basel conventions, there are other international instruments that contain provisions pertaining to wastes containing, consisting of or contaminated with POPs , including:

- (a) 1998 Protocol on Persistent Organic Pollutants to the 1979 Convention on Long-range Transboundary Air Pollution;
- (b) 2003 Protocol on Pollutant Release and Transfer Registers to the 1998 Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environment Matters;
- (c) 1991 Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa;
- (d) Waigani Convention to Ban the Importation into Forum Island Countries of Hazardous and Radioactive Wastes and to Control the Transboundary Movement and Management of Hazardous Wastes within the South Pacific Region; and
- (e) OECD Council Decision C (2001) 107/FINAL Concerning the Control of Transboundary Movements of Wastes Destined for Recovery Operations.

## Annex II

### Examples of pertinent national legislation

Examples of national legislation containing provisions related to the management of wastes consisting of, containing or contaminated with POPs include those outlined below.

Country	Legislation	Brief description
Austria	Soil Protection Acts	<ul style="list-style-type: none"> <li>Contains stringent limit values on PCBs, PCDDs and PCDFs in sewage sludge used as fertilizer.</li> </ul>
Canada	Federal Mobile PCB Treatment and Destruction Regulations	<ul style="list-style-type: none"> <li>Contains emission standards for release of gases, liquids and solids contaminated with PCBs, PCDDs and PCDFs.</li> </ul>
European Community	Regulation (EC) No 850/2004 of the European Parliament and of the Council of 29 April 2004 on persistent organic pollutants and amending Directive 79/117/EEC	<ul style="list-style-type: none"> <li>Article 7 contains provisions regarding the management of wastes containing, consisting of or contaminated with POPs.</li> </ul>
European Community	Council Directive 96/59/EC of 16 September 1996 on the disposal of polychlorinated biphenyls and polychlorinated terphenyls (PCB/PCT)	<ul style="list-style-type: none"> <li>Contains regarding the disposal of PCBs and PCTs, inter alia on the decontamination and/or disposal of equipment and the PCBs therein.</li> </ul>
European Community	86/280/EEC Council Directive of June 12 1986 on limit values and quality objectives for discharges of certain dangerous substances included in List I of the Annex to Directive 76/464/EEC and 88/347/EEC Council Directive of June 16 1988 amending Annex II to Directive 86/280/EEC on limit values and quality objectives for discharges of certain dangerous substances included in List I of the Annex to Directive 76/464/EEC	<ul style="list-style-type: none"> <li>Annex II contains emission limit values for discharge of aldrin, dieldrin, endrin and HCB-contaminated waste water produced during production.</li> </ul>
European Community	Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste	<ul style="list-style-type: none"> <li>Annex IV contains emission limit values for discharges of PCDD and PCDF contaminated waste water from the cleaning of exhaust gases.</li> <li>Annex V contains air emission values for PCDDs and PCDFs</li> </ul>
European Community	Council Decision 2003/33/EC of 19 December 2002 establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC	<ul style="list-style-type: none"> <li>Paragraph 2.1.2.2 of the Annex contains criteria for landfill of inert waste of containing PCBs.</li> </ul>
Finland	Council of State decision (1071/1989) on the restriction of the use of PCBs and PCTs	<ul style="list-style-type: none"> <li>Contains limit values for PCBs and PCTs</li> </ul>
Finland	Council of State decision (101/1997) on oil waste management	<ul style="list-style-type: none"> <li>Contains limit values for PCBs in regenerated oil and in oil wastes destined for incineration</li> </ul>
Finland	Council of State decision (711/1998) on the disuse of PCB appliances and the treatment of PCB waste	<ul style="list-style-type: none"> <li>Contains limit values for PCBs</li> </ul>
Finland	Council of State decree (1129/2001) on a list of the most general wastes and hazardous wastes	<ul style="list-style-type: none"> <li>Contains limit values for PCBs</li> </ul>
Germany	Federal Soil Protection and Contaminated Sites Ordinance	<ul style="list-style-type: none"> <li>Contains action levels regarding sites contaminated with aldrin, DDT, HCB, PCBs, PCDDs and PCDFs.</li> </ul>
Germany	Ordinance on Landfills and Long-Term Storage Facilities	<ul style="list-style-type: none"> <li>Contains a limit for PCBs in soils used as reclamation layers of landfills.</li> <li>Prohibits the landfilling of waste, which may harm public welfare due to its content of long-lived or bio-accumulable toxic substances.</li> </ul>
Germany	Ordinance on Underground Waste Stowage	<ul style="list-style-type: none"> <li>Contains limits for use of waste contaminated with PCBs as stowing material.</li> </ul>

Country	Legislation	Brief description
Germany	Sewage Sludge Ordinance	<ul style="list-style-type: none"> <li>Contains limits for usage of sewage sludge contaminated with PCBs, PCDDs and PCDFs as fertilizer.</li> </ul>
Germany	Waste Wood Ordinance	<ul style="list-style-type: none"> <li>Contains limits for recycling of waste wood contaminated with PCBs.</li> </ul>
Germany	Waste Oil Ordinance	<ul style="list-style-type: none"> <li>Contains limits for recycling of PCB contaminated oils.</li> </ul>
Japan	Law Concerning Special Measures Against Dioxins	<ul style="list-style-type: none"> <li>Contains tolerable daily intake environmental standards for ambient air, water quality (including sediment) and soil, emission and residue standards for gas, effluent, ash and dust regarding PCDDs, PCDFs and co-planar PCBs.</li> </ul>
Japan	Law Concerning Special Measures Against PCB wastes	<ul style="list-style-type: none"> <li>Contains standards for the treatment of plastics and metals contaminated with PCBs.</li> </ul>
Japan	Law Concerning Special Measures Against Soil Contamination	<ul style="list-style-type: none"> <li>Contains standards for the treatment of soil contaminated with PCBs.</li> </ul>
Japan	Waste Management and Public Cleansing Law	<ul style="list-style-type: none"> <li>Contains criteria of hazardous wastes containing PCBs, PCDDs, PCDFs and co-planar PCBs.</li> </ul>
Japan	Water Pollution Control Law	<ul style="list-style-type: none"> <li>Contains emission standards for effluent containing PCBs.</li> </ul>
Mexico	Norm NOM-098 of 2004	<ul style="list-style-type: none"> <li>Contains emission and destruction efficiency standards for waste incinerators.</li> </ul>
Mexico	Norm NOM-133 of 2001	<ul style="list-style-type: none"> <li>Contains regulations regarding handling of PCBs and a programme for the preparation of inventories.</li> </ul>
Switzerland	Soil Burden Ordinance	<ul style="list-style-type: none"> <li>Contains actions levels regarding sites contaminated with PCBs, PCDDs and PCDFs.</li> </ul>
United States of America	US EPA 40 CFR 63 Subpart EEE National Emission Standards for Hazardous Air Pollutants from Hazardous Waste Combustors	<ul style="list-style-type: none"> <li>Contains standards for releases of PCDDs and PCDFs within air emissions.</li> </ul>
United States of America	40 CFR 268.48 Universal Treatment Standards for Hazardous Wastes	<ul style="list-style-type: none"> <li>Contains standards for the treatment of solid waste prior to land disposal and aqueous waste prior to release. Covers all POPs except mirex.</li> </ul>
United States of America	40 DFR 761.70 Incineration	<ul style="list-style-type: none"> <li>Contains standards for releases of PCBs within air emissions.</li> </ul>

## Annex III

### Selected analytical methods for POPs

#### 1. Aldrin

- (a) ISO 6468 (1996) Water quality -- Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzenes -- Gas chromatographic method after liquid-liquid extraction
- (b) ISO 10382 (2002): Soil quality -- Determination of organochlorine pesticides and polychlorinated biphenyls -- Gas-chromatographic method with electron capture detection

#### 2. DDT

- (a) ISO 6468 (1996) Water quality -- Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzenes -- Gas chromatographic method after liquid-liquid extraction
- (b) ISO 10382 (2002): Soil quality -- Determination of organochlorine pesticides and polychlorinated biphenyls -- Gas-chromatographic method with electron capture detection
- (c) United States Environmental Protection Agency (US EPA) Method 4042: Soil screening for DDT by immunoassay, US-EPA analytical chemistry guidance SW-846

#### 3. HCB

- (a) ISO 6468 (1996) Water quality -- Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzenes -- Gas chromatographic method after liquid-liquid extraction
- (b) ISO 10382 (2002): Soil quality -- Determination of organochlorine pesticides and polychlorinated biphenyls -- Gas-chromatographic method with electron capture detection

#### 4. PCBs

- (a) 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 (PCB) (P 20)
- (b) EN 1948 (draft 2004) 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
- (c) 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)
- (d) EN 12766-2 (2001): Petroleum products and used oils - Determination of PCBs and related products - Part 2: Calculation of polychlorinated biphenyl (PCB) content
- (e) EN 61619 (2004): Insulating liquids - Contamination by polychlorinated biphenyls (PCBs) - Method of determination by capillary column gas chromatography
- (f) ISO 6468 (1996) Water quality -- Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzenes -- Gas chromatographic method after liquid-liquid extraction
- (g) ISO 10382 (2002): Soil quality -- Determination of organochlorine pesticides and polychlorinated biphenyls -- Gas-chromatographic method with electron capture detection
- (h) JIS K 0093 (2002): Testing method for polychlorobiphenyl in industrial water and wastewater
- (i) 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 Labor, 3 July 1992

- (j) 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
- (k) 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
- (l) 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 diffusion test – Solid earthy and stony materials
- (m) United States Environmental Protection Agency (US 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
- (n) United States Environmental Protection Agency (US EPA) Method 4020: Screening for polychlorinated biphenyls by immunosassay ([www.epa.gov/epaoswer/hazwaste/test/pdfs/4020.pdf](http://www.epa.gov/epaoswer/hazwaste/test/pdfs/4020.pdf))
- (o) United States Environmental Protection Agency (US EPA) Method 8080: Organochlorine Pesticides and PCBs
- (p) United States Environmental Protection Agency (US EPA) Method 8082: Polychlorinated biphenyls (PCBs) by gas chromatography ([www.epa.gov/epaoswer/hazwaste/test/pdfs/8082.pdf](http://www.epa.gov/epaoswer/hazwaste/test/pdfs/8082.pdf))
- (q) United States Environmental Protection Agency (US 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), US-EPA analytical chemistry guidance SW-846
- (r) United States Environmental Protection Agency (US EPA) Method 9078: Screening test method for polychlorinated biphenyls in soil ([www.epa.gov/epaoswer/hazwaste/test/pdfs/9078.pdf](http://www.epa.gov/epaoswer/hazwaste/test/pdfs/9078.pdf))
- (s) United States Environmental Protection Agency (US EPA) Method 9079: Screening test method for polychlorinated biphenyls in transformer oil ([www.epa.gov/epaoswer/hazwaste/test/pdfs/9079.pdf](http://www.epa.gov/epaoswer/hazwaste/test/pdfs/9079.pdf))

#### 5. PCDDs and PCDFs

- (a) EN 1948 (draft 2004): 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
- (b) EN 1948 (1997): Stationary source emissions – determination of the mass concentration of PCDDs/PCDFs. Part 1 Sampling, Part 2: Extraction and clean-up, Part 3: Identification and quantification
- (c) ISO 18073 (2004): Water quality -- Determination of tetra- to octa-chlorinated dioxins and furans -- Method using isotope dilution HRGC/HRMS
- (d) JIS K 0311 (1999): Method for determination of tetra- through octa-chlorodibenzo-p-dioxins, tetra- through octa-chlorodibenzofurans and coplanar polychlorobiphenyls in stationary source emissions
- (e) JIS K 0312 (1999): Method for determination of tetra- through octa-chlorodibenzo-p-dioxins, tetra- through octa-chlorodibenzofurans and coplanar polychlorobiphenyls in industrial water and waste water
- (f) 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 Labor, July 3, 1992)
- (g) United States Environmental Protection Agency (US EPA) Method 1613: Tetra-through Octa-Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS, October 1994, ([www.epa.gov/waterscience/methods/1613.pdf](http://www.epa.gov/waterscience/methods/1613.pdf))

- (h) United States Environmental Protection Agency (US EPA) Method 0023A: Sampling Method for Polychlorinated Dibenzo-*p*-Dioxins and Polychlorinated Dibenzofuran Emissions from Stationary Sources. Revision 1 December 1996 ([www.epa.gov/SW-846/pdfs/0023a.pdf](http://www.epa.gov/SW-846/pdfs/0023a.pdf))
- (i) United States Environmental Protection Agency (US EPA) Method 8290A: Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by High-Resolution Gas Chromatography/High-Resolution Mass Spectrometry (HRGC/HRMS), revision 1 January 1998
- (j) United States Environmental Protection Agency (US EPA) Method T09: Determination of polychlorinated dibenzo-*p*-dioxins (PCDDs) in ambient air using high-resolution mass spectrometry (HRGC/HRMS)
- (k) United States Environmental Protection Agency (US EPA) Method 8280A: The analysis of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans by high resolution gas chromatography/low resolution mass spectrometry (HRGC/LRMS) (US-EPA analytical chemistry guidance SW-846)
- (l) United States Environmental Protection Agency (US EPA) Method 8290: Polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) by high-resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS) (US-EPA analytical chemistry guidance SW-846)

**6. Solid waste, particulate materials**

Nordtest: Method NT ENVIR 004; Solid Waste, Particulate Materials: Sampling, ISSN 1238-4445, 1996





	<ul style="list-style-type: none"> <li>i. Waste feed – molecular structure, weight and concentration;</li> <li>ii. Electricity costs;</li> <li>iii. Argon and oxygen costs;</li> <li>iv. Geographic location and site specific issues;</li> <li>v. Caustic costs; and</li> <li>vi. Required emission limits</li> </ul>	
<b>Potassium tert-Butoxide (t-BuOK) method</b>	No data available	
<b>Super-critical water oxidation (SCWO) and subcritical water oxidation</b>	Costs: US\$120 - US\$140/dry ton <sup>3</sup>	CMPS&F – Environment Australia, 1997

<sup>1</sup> It is not clear whether these estimates include potential costs associated with pretreatment and/or disposal of residues.

<sup>2</sup> It is not clear whether the above includes costs associated with the pre-treatment of solid wastes.

<sup>3</sup> Assuming some pre-treatment has been reported. It is not clear whether this estimate incorporates capital costs or costs associated with the disposal of any residues.

**Table 2 : Hazardous waste incineration (for an incinerator treating 70,000 tons per year)**

	Investment costs (million of euros)	
	2004 <sup>a</sup>	1999 <sup>b</sup>
Construction time	3	6.5
Electrical works	10	20
Infrastructure works	6	12.5
Machine parts	16	32.5
Other components	14	27.5
Planning/approval	3	6
<b>Total investment costs</b>	<b>52</b>	<b>105</b>
	Operational costs (million of euros)	
Administration	0.3	0.5
Capital financing costs	5	10.5
Maintenance	4	4
Operating resources/energy	1.3	2.5
Other	0.3	0.5
Personnel	3	5.5
Waste disposal	0.8	1.5
<b>Total operational costs</b>	<b>14.7</b>	<b>25</b>
<i>Per ton incineration costs (without revenues)</i>	<i>200–300</i>	<i>350</i>

Gate fees at hazardous waste incinerators within Europe have been reported to range between 50 and 1,500 euros (Source: European Commission 2004).

Notes:

<sup>a</sup> Source for figures in first column: European Commission 2004.

<sup>b</sup> Source for figures in second column: Mean values of the specific costs of incineration for municipal and hazardous wastes (1999), VDI 3460: Emission Control Thermal treatment of waste, Germany, March 2002

## Annex V

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## Annex III

### **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)**

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## **Abbreviations and acronyms**

ABS	acrylonitrile-butadiene-styrene copolymers (plastics)
ESM	environmentally sound management
HASP	health and safety plan
IPCS	International Programme on Chemical Safety
PBB	polybrominated biphenyl
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzofuran
PCN	polychlorinated naphthalene
PCT	polychlorinated terphenyl
POP	persistent organic pollutant
TEQ	toxic equivalent
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme

## **Units of measurement**

kg	kilogram
mg	milligram

## I. Introduction

### A. Scope

1. This document supersedes the Basel Convention's technical guidelines on wastes comprising or containing PCB, PCT and PBB (Y10) (February 1997).
2. These technical guidelines provide guidance for the environmentally sound management (ESM) of wastes consisting of, containing or contaminated with polychlorinated biphenyls (PCBs) in accordance with decisions V/8, VI/23 and VII/13 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 and OEWG-III/8 of the Open-ended Working Group of the Basel Convention, and taking into account resolution 5 of the Conference of Plenipotentiaries of the Stockholm Convention on Persistent Organic Pollutants and 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. The Conference of the Parties to the Stockholm Convention on Persistent Organic Pollutants will consider these guidelines in accordance with article 6.2 of that convention.
3. Along with PCBs, these technical guidelines address polychlorinated terphenyls (PCTs) and polybrominated biphenyls (PBBs) as a class or category of substances owing to similarities in the physico-chemical and toxicological properties of these substances. Topics addressed include waste management, treatment and disposal. It should be noted that neither PCTs nor PBBs are subject to the Stockholm Convention.
4. Unintentionally produced PCBs are not covered by these technical guidelines. They will be addressed in technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with polychlorinated dibenzo-dioxins (PCDDs) and polychlorinated dibenzo-furans (PCDFs), as well as unintentionally produced PCBs and hexachlorobenzene (HCB).
5. This document should be used in conjunction with the *General Technical Guidelines for Environmentally Sound Management of Wastes Consisting of, Containing or Contaminated with Persistent Organic Pollutants (General Technical Guidelines)*. This document provides more detailed information on the nature and occurrence of wastes consisting of, containing or contaminated with PCBs, PCTs or PBBs for purposes of their identification and management.

### B. Description, production, use and wastes

#### 1. Description

##### (a) PCBs

6. PCBs are 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 replaced by up to ten chlorine atoms. 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 ten possible substitution sites are occupied by a chlorine atom (Environment Canada 1988). The more highly chlorinated PCB congeners are virtually insoluble in water and highly resistant to degradation.
7. PCBs include 12 congeners for which the World Health Organization has assigned toxicity equivalency factors because they exhibit dioxin-like toxicity (coplanar PCBs).

##### (b) PCTs

8. PCTs also constitute a group of halogenated hydrocarbons. They are very similar in chemical structure to PCBs, except that they contain three phenyl rings instead of two. Therefore, they can have up to 14 chlorine atoms attached. The number of possible PCT congeners is very large; however, only a few occur in commercial chemical formulations. PCTs and PCBs have very 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.

**(c) PBBs**

9. PBBs are the bromine analogues of PCBs and thus have 209 possible congeners. Only a few, however, occur in commercial chemical formulations (International Programme on Chemical Safety (IPCS), 1994). They are solids or waxy substances at room temperature. They are virtually insoluble in water and highly resistant to degradation.

**2. Production****(a) PCBs**

10. 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.

11. The main period of manufacture occurred from 1930 to the late 1970s in the United States of America; up to 1974 in China (China State Environmental Protection Agency 2002); up to the early 1980s in Europe, up to 1993 in Russia (Arctic Monitoring and Assessment Programme 2000); and from 1954 to 1972 in Japan.

12. PCBs were manufactured as mixtures of congeners, for example as progressive chlorination of batches of biphenyl until a certain target percentage of chlorine by weight was achieved. The manufactured PCBs were rarely used at full strength. For example, they were added in small quantities to ink, plastics, paints and carbon paper or were used in formulations of up to 70% PCBs in hydraulic fluid, transformer fluid and heating fluids. At room temperature, the majority of them are oily liquids or waxy solids.

13. Prominent trade names of PCB products include those listed below. (See annex I for a more detailed list of PCB trade names and synonyms and section IV.D of the present report for considerations regarding precautions to take when using trade names in inventory exercises.)

Apirolio (Italy)  
 Aroclor (United States)  
 Clophen (Germany)  
 Delor (Czechoslovakia)  
 Elaol (Germany)  
 Fenclor (Italy)  
 Kanechlor (Japan)  
 Phenoclor (France)  
 Pyralene (France)  
 Pyranol (United States)  
 Pyroclor (United States)  
 Santotherm (Japan)  
 Sovol (USSR)  
 Sovtol (USSR)

14. 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% chlorine by weight.

15. 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. Those PCBs mixed with tri- and tetrachlorobenzenes were called askarel. Contaminants in commercial mixtures include PCDFs and chlorinated naphthalenes. Studies have found from 0.8 milligrams per kilogram (mg/kg) to 40 mg/kg of PCDFs in commercial mixtures (IPCS 1992). PCBs are also formed unintentionally in some thermal and chemical processes.

16. The cumulative worldwide production of PCBs has been estimated at 0.75–2 million tons.

**(b) PCTs**

17. 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 lubricants (Jensen and Jørgensen 1983). In the United States, Aroclor series PCTs are indicated by the digits 54 in the first two spaces of the four-digit code, e.g. Aroclor 5432, 5442 and 5460 (IPCS 1992). See annex I for examples of trade names and section IV.D for a discussion of trade names in inventory identification.

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

19. 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 tons between 1955 and 1980 (United Nations Economic Commission for Europe (UNECE), 2002).

**(c) PBBs**

20. Information on the production of PBBs is scarce. It is estimated that at least 11,000 tons of PBBs were produced worldwide, but production figures from some countries known to have produced PBBs are not available (IPCS 1994). PBBs were manufactured in the United States until 1979, in Germany until the mid-1980s, and in France until at least the mid-1990s. PBBs may still be in production in Asia (Lassen, Løkke and Andersen 1999).

21. The first PBB compound produced was hexabromobiphenyl, which was commercially known as FireMaster in the United States. FireMaster was produced from 1970 to 1974. Analysis has shown that FireMaster contained up to 80% hexa- and up to 25% heptabromobiphenyl. In France, a commercial mixture of PBBs was sold as Adine 0102. In Germany, highly brominated PBBs were produced and sold as Bromkal 80-9D. See annex I for examples of trade names and section IV.D for a discussion of trade names in inventory identification.

**3. Use****(a) PCBs**

22. PCBs were used in a very wide variety of industrial and consumer applications. The uses were categorized by the World Health Organization as completely closed, nominally closed and open ended (IPCS 1992). The uses included:

- (a) Completely closed systems:
  - (i) Electrical transformers;
  - (ii) Electrical capacitors (including lamp ballasts);
  - (iii) Electrical switches, relays and other;
  - (iv) Electrical cables;
  - (v) Electric motors and magnets (very small amounts);
- (b) Nominally closed systems:
  - (i) Hydraulic systems;
  - (ii) Heat transfer systems (heaters, heat exchangers);
- (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 lubricants, sealants and caulking material;

- (vii) Fire retardant in fabrics, carpets, polyurethane foam, etc.;
- (viii) Lubricants (microscope oils, brake linings, cutting oils, other lubricants).

23. While 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.

24. PCB oils were also added to or disposed of with non-PCB fluids such as heating or cooling fluid, hydraulic fluid, brake fluid, engine oil 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 in home heaters, hydraulic systems and motors (as a lubricant). Since most fluorescent lamp ballasts made before PCBs were banned contained PCBs, many homes and businesses that installed fluorescent lamps unknowingly acquired PCBs.

**(b) PCTs**

25. PCTs were used in almost exactly the same applications as PCBs but in much smaller amounts. Little is known, however, about remaining quantities because 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) PBBs**

26. The principal use of PBBs was as a fire retardant. PBBs were added to acrylonitrile-butadiene-styrene copolymers (plastics) (ABS) (10% PBBs), coatings, lacquers and polyurethane foam (IPCS, 1994).

**4. Wastes**

27. Wastes consisting of, containing or contaminated with PCBs, PCTs or PBBs are found in a number of physical forms, including:

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

28. Note that the categories above mainly apply to PCBs, which were produced in much larger quantities than PBBs or PCTs and have been stored as wastes awaiting disposal. PBBs and PCTs are rarely found in large bulk situations and therefore do not have the potential to form large amounts of waste.

## II. Relevant provisions of the Basel and Stockholm conventions

### A. Basel Convention

29. Article 1 (“Scope of Convention”) outlines the waste types subject to the Basel Convention. Article 1 paragraph 1(a) of the Basel Convention contains a two-step process for determining if 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”). Second, the waste must possess at least one of the characteristics listed in Annex III to the Convention (“List of Hazardous Characteristics”).

30. Annex I lists some of the wastes that may consist of, contain or be contaminated with PCBs, PCTs or PBBs. These include:

- Y6 Wastes from the production, formulation and use of organic solvents
- Y8 Waste mineral oils unfit for their originally intended use
- Y9 Waste oils/water, hydrocarbons/water mixtures, emulsions
- Y10 Waste substances and articles containing or contaminated with polychlorinated biphenyls (PCBs) and/or polychlorinated terphenyls (PCTs) and/or polybrominated biphenyls (PBBs)
- Y11 Waste tarry residues arising from refining, distillation and any pyrolytic treatment
- Y12 Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish
- Y13 Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives
- 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
- Y18 Residues arising from industrial waste disposal operations
- Y39 Phenols; phenol compounds including chlorophenol
- Y41 Halogenated organic solvents
- Y42 Organic solvents excluding halogenated solvents
- Y45 Organohalogen compounds other than substances referred to in this Annex (e.g. Y39, Y41, Y42, Y43, Y44)

31. Wastes contained in Annex I are presumed to exhibit an Annex III hazardous characteristic – for example H11 “Toxic (Delayed or Chronic)”; H12 “Ecotoxic”; or H6.1 “Poisonous (Acute)” – unless, through “national tests”, they can be shown to not exhibit the characteristics. National tests may be useful for a particular hazard characteristic in Annex III until such time as the hazardous characteristic is fully defined. Guidance papers for each Annex III hazardous characteristic are currently being developed under the Basel Convention.

32. List A of Annex VIII describes wastes that are “characterized as hazardous under article 1 paragraph 1(a)” although “Designation of a waste on Annex VIII does not preclude the use of Annex III (hazard characteristics) to demonstrate that a waste is not hazardous.” List B of Annex IX lists wastes that will not be wastes covered by article 1 paragraph 1(a), unless they contain Annex I material to an extent causing them to exhibit an Annex III characteristic. In particular, the following Annex VIII wastes are applicable to PCBs, PCTs or PBBs:

- A1180 Waste electrical and electronic assemblies or scrap<sup>1</sup> containing components such as accumulators and other batteries included on list A, mercury-switches, glass from cathode-ray tubes and other activated glass and PCB-capacitors, or contaminated with Annex I constituents (e.g. cadmium, mercury, lead, polychlorinated biphenyl) to an extent that they possess any of the characteristics contained in Annex III (note the related entry on list B B1110)<sup>2</sup>

<sup>1</sup> This entry does not include scrap assemblies from electric power generation.

<sup>2</sup> PCBs are at a concentration level of 50 mg/kg or more.

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 more<sup>3</sup>

33. 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 PBBs, including:

A1090 Ashes from the incineration of insulated copper wire  
 A1100 Dusts and residues from gas cleaning systems of copper smelters  
 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)  
 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)  
 A3020 Waste mineral oils unfit for their originally intended use  
 A3040 Waste thermal (heat transfer) fluids  
 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)  
 A3070 Waste phenols, phenol compounds including chlorophenol in the form of liquids or sludges  
 A3120 Fluff – light fraction from shredding  
 A3150 Waste halogenated organic solvents  
 A3160 Waste halogenated or unhalogenated non-aqueous distillation residues arising from organic solvent recovery operations  
 A4070 Wastes from the production, formulation and use of inks, dyes, pigments, paints, lacquers and varnish, excluding any such waste specified on list B (note the related entry on list B B4010)  
 A4100 Wastes from industrial pollution control devices for cleaning of industrial off-gases but excluding such wastes specified on list B  
 A4130 Waste packages and containers containing Annex I substances in concentrations sufficient to exhibit Annex III hazard characteristics  
 A4140 Wastes consisting of or containing off-specification or outdated<sup>4</sup> chemicals corresponding to Annex I categories and exhibiting Annex III hazard characteristics  
 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  
 A4160 Spent activated carbon not included on list B (note the related entry on list B B2060)

34. For further information please refer to section II.A of the General Technical Guidelines.

## B. Stockholm Convention<sup>5</sup>

35. The Stockholm Convention differentiates between two categories of PCBs:

- (a) Intentionally produced PCBs whose production and use are to be eliminated and, as wastes, are to be managed and disposed of in an environmentally sound manner in accordance with the provisions of articles 3 and 6 and Annex A;
- (b) Unintentionally produced PCBs, for which Parties are required to take specified measures to reduce total releases derived from anthropogenic sources “with the goal of their continuing minimization and, where feasible, ultimate elimination” in accordance with article 5 and Annex C. Unintentionally produced PCBs will be addressed in

<sup>3</sup> 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.

<sup>4</sup> “Outdated” means unused within the period recommended by the manufacturer.

<sup>5</sup> This section does not apply to PCTs and PBBs.

technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with PCDDs and PCDFs.

36. Annex A, Part II (“Polychlorinated biphenyls”) outlines specific requirements with respect to PCBs, as follows:

“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 percent 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”.

37. For further information, please refer to section II.B of the *General Technical Guidelines*.



### III. Issues under the Stockholm Convention to be addressed cooperatively with the Basel Convention<sup>6</sup>

#### A. Low POP content

38. The following provisional definition for low POP content should be applied for PCBs: 50 mg/kg<sup>7</sup> For further information, please refer to section III.A of the *General Technical Guidelines*.

#### B. Levels of destruction and irreversible transformation

39. Regarding the provisional definition for levels of destruction and irreversible transformation, please refer to section III.A of the *General Technical Guidelines*.

#### C. Methods that constitute environmentally sound disposal

40. Reference is made to section G of chapter IV below and section IV.G.3 of the “General technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants (POPs)”.

### IV. Guidance on environmentally sound management (ESM)

#### A. General considerations

##### 1. Basel Convention

41. One of the main vehicles for the promotion of ESM is the preparation and dissemination of technical guidelines such as the present document and the *General Technical Guidelines*. For further information please refer to section IV.A.1 of the *General Technical Guidelines*.

42. Parties planning or reviewing a national ESM programme should consult, inter alia, the Basel Convention 2003 guidance document *Preparation of a National Environmentally Sound Plan for PCB and PCB-Contaminated Equipment: Training Manual* (United Nations Environment Programme (UNEP), 2003a).

##### 2. Stockholm Convention

43. The term ESM is not defined in the Stockholm Convention. Environmentally sound methods for disposal of wastes consisting of, containing or contaminated with PCBs are, however, to be determined by the Conference of the Parties in cooperation with the appropriate bodies of the Basel Convention.

44. Parties should consult the document *Interim Guidance for Developing a National Implementation Plan for the Stockholm Convention* (UNEP 2003b).

##### 3. Organization for Economic Cooperation and Development

45. For information regarding the Organisation for Economic Cooperation and Development and ESM, refer to section IV.A.3 of the *General Technical Guidelines*.

#### B. Legislative and regulatory framework

46. Parties to the Basel and Stockholm Convention should examine national controls, standards and procedures to ensure that they are in line with of the respective conventions and their obligations under them, including those that pertain to ESM of wastes consisting of, containing or contaminated with PCBs.

<sup>6</sup> This section does not apply to PCTs and PBBs.

<sup>7</sup> Determined according to national or international methods and standards.

47. Elements of a regulatory framework applicable to PCBs, PCTs and PBBs could also include the following:

- (a) Enabling environmental protection legislation (sets release limits and environmental quality criteria);
- (b) Prohibitions on the manufacture, sale, import and export (for use) of PCBs, PCTs and PBBs;
- (c) Phase-out dates for PCBs that remain in service, inventory or storage;
- (d) Hazardous materials and waste transportation requirements;
- (e) Specifications for containers, equipment, bulk containers and storage sites;
- (f) Specification of acceptable analytical and sampling methods for PCBs, PCTs and PBBs;
- (g) Requirements for waste management and disposal facilities;
- (h) General requirement for public notification and review of proposed government regulations, policy, certificates of approval, licences, inventory information and national releases data;
- (i) Requirements for identification and remediation of contaminated sites;
- (j) Requirements for health and safety of workers;
- (k) Other potential legislative controls (waste prevention and minimization, inventory development, emergency response).

48. The timing of the phase-out of PCBs (and to a lesser extent PCTs and 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.

49. For further information please refer to section IV.B of the *General Technical Guidelines*.

### **C. Waste prevention and minimization**

50. Both the Basel and Stockholm Conventions advocate waste prevention and minimization, while PCB compounds are targeted in the Stockholm Convention for complete phase-out. PCBs, PCTs and PBBs should be taken out of service and disposed of in an environmentally sound manner.

51. Quantities of waste containing these compounds should be minimized through isolation and source separation in order to prevent mixing and contamination of other waste streams. For example, PCBs in electrical equipment, painted materials, resin-based floorings, sealants and sealed glazing units can contaminate large amounts of demolition waste if not separated prior to demolition.

52. Mixing of wastes with a PCB content above a defined low POP content with another material solely for the purpose of generating a mixture with a POP content below the defined low POP content is not environmentally sound. However, mixing of materials prior to waste treatment may be necessary in order to optimize treatment efficiencies.

53. For further information, please refer to paragraph 6 and section IV.C of the *General Technical Guidelines*.

### **D. Identification and inventories**

#### **1. Identification**

54. PCBs, PCTs and PBBs have historically been found in several locations, including:

- (a) Electrical utilities: transformers, capacitors, switches, voltage regulators, circuit breakers, light ballasts and cables;
- (b) Industrial facilities: transformers, capacitors, voltage regulators, circuit breakers, light ballasts, heat transfer fluids, hydraulic fluids and fire suppression systems;
- (c) Railroad systems: transformers, capacitors, voltage regulators and circuit breakers;
- (d) Underground mining operations: hydraulic fluids and earthing coils;

- (e) Military installations: transformers, capacitors, voltage regulators, hydraulic fluids and fire suppression systems;
- (f) Residential/commercial buildings: capacitors, circuit breakers, light ballasts and fire suppression systems; elastic joints and fillers, sealing glues; paints; concrete and plaster
- (g) Research laboratories: vacuum pumps, light ballasts, capacitors and circuit breakers;
- (h) Electronics manufacturing plants: vacuum pumps, light ballasts, capacitors and circuit breakers;
- (i) Waste-water discharge facilities: vacuum pumps and well motors;
- (j) Automotive service stations: reused oil.

55. It is important to note that even experienced technical persons may not be able to determine the nature of an effluent, substance, container or piece of equipment by its appearance or markings. PCB equipment, for example, was typically not labelled according to the type of dielectric fluid it contained. Experienced inspectors may be able to determine the original contents from other information on the nameplate by using guidance manuals such as *Guidelines for the Identification of PCB and Materials Containing PCB* (UNEP 1999) or by contacting the manufacturer.

56. When identifying PCBs, PCTs and PBBs, information on production, use and waste types outlined in section I.B of the present report may be useful.

57. For further information, please refer to section IV.D.1 of the *General Technical Guidelines*.

## 2. Inventories

58. Inventories are important tools for identifying, quantifying and characterizing wastes. A national inventory may be used to:

- (a) Establish a baseline quantity of products, articles and wastes consisting of, containing or contaminated with PCBs, PCTs or PBBs;
- (b) Assist with regulatory inspections;
- (c) Assist with the preparation of emergency response plans; and
- (d) Track progress to minimize and phase-out these chemicals.

When developing an inventory, priority should be placed on the identification of wastes with high POP concentrations.

59. The development of a national inventory requires a long-term commitment by the national government, the cooperation of owners and manufacturers of PCBs, PCTs and PBBs, a sound administrative process for collecting information on an ongoing basis and a computerized database system for storage of information. In some cases, government regulations may be required to ensure that owners report their holdings and cooperate with government inspectors.

60. A complete inventory of all PCBs, PCTs and PBBs is impossible to compile, mainly because of dispersive uses of these chemicals (e.g., use in inks, plasticizers, paint, flame retardants in small components, and lubricants).

61. For further information, please refer to section IV.D.2 of the *General Technical Guidelines*.

## E. Sampling, analysis and monitoring

### 1. Sampling

62. Sampling in this section refers to the taking of a sample of gas, liquid or solid for later analysis either in the field or in a laboratory.

63. The types of matrices that are sampled for analysis of PCBs, PCTs and PBBs are shown below.

- (a) Liquids:
  - (i) Water (surface water, rainwater, groundwater, soil pore water, drinking water, industrial process water, effluent water, condensate);

- (ii) Landfill leachate
  - (iii) Askarel (PCBs and PCTs) liquid from transformers or other equipment or in bulk storage;
  - (iv) Mineral oil from transformers contaminated with PCBs or in bulk storage;
  - (v) Waste motor oil and other waste oils, fuels and organic liquids;
  - (vi) Liquid fire suppressants and retardants (PBBs);
  - (vii) Biological liquids (blood, urine);
  - (viii) Liquids collected from spills or from free-product subsurface recovery systems at contaminated sites;
- (b) Solids:
- (i) Solid or semi-solid PCB, PCT or PBB products;
  - (ii) Containers or equipment (rinse or wipe sample);
  - (iii) Soil, sediment, rubble, compost;
  - (iv) Paint chips, pieces of caulking and sealant, plastic chips, pieces of wire and cable, automobile shredder fluff, ceramics, wood, mixed solid wastes;
  - (v) Tissues or fabric used in the collection of wipe samples;
  - (vi) Filter materials;
  - (vii) Solids extracted from a liquid or sludge (suspended solids, precipitates, coagulated solids, and filtered material);
  - (ix) Solids from industrial or disposal processes (fly ash, bottom ash, slag, still bottoms, other residues);
  - (x) Ice, snow and other frozen materials;
  - (xi) Plant materials and food;
  - (xii) Biological solids (whole animals, tissues, faeces);
- (c) Gases:
- (i) Product or waste gases in containers;
  - (ii) Stack gases from industry and treatment processes;
  - (iii) Volatile emissions from products, wastes, processes and contaminated sites;
  - (iv) Soil and groundwater gases;
  - (v) Air (ambient, personal breathing, confined space);
  - (vi) Biological gases (exhaled air, gases released by organisms).

64. For further information, please refer to section IV.E.1 of the *General Technical Guidelines*.

## 2. Analysis

65. Analysis refers to the determination of the physical, chemical or biological properties of a material using documented, peer-reviewed and accepted laboratory methods.

66. Each country should identify, through guidelines or legislation, standard methods that are required to be used for PCBs, PCTs and PBBs and the situations in which the methods should be used.

67. The methods specified should cover all aspects of the analytical process for each type of sample that could be collected, as per the list of sample materials in paragraph 63 above.

68. In very general terms, the methods available for chemical analysis for PCBs (UNEP 1999) are the following:

- (a) Test kits: In many cases, the use of chlorine-determining test kits is recommended for oils. If the result is negative, a PCB analysis is not necessary. If the result is positive, analysis as described below should be performed, or the waste may be regarded as waste containing or contaminated with PCBs;
- (b) High performance liquid chromatography coupled to adequate detectors;
- (c) Gas chromatography with either packed columns or capillary columns coupled to detectors like electron capture, or mass selective or high-resolution mass spectrometers.

69. Accreditation and certification of laboratories and interlaboratory calibration studies are important aspects of a national analytical programme. All laboratories should be able to meet quality standards as set and tested by government and by an independent body such as the International Organization for Standardization or by an association of laboratories.

70. For further information, please refer to section IV.E.2 of the *General Technical Guidelines*.

### 3. Monitoring

71. Monitoring programs should be implemented for operations managing wastes consisting of, containing or contaminated with PCBs, PCTs and PBBs. For further information please refer to section IV.E.3 of the *General Technical Guidelines*.

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

72. Handling, collection, packaging, labelling, transportation and storage are critically important steps as the risk of a spill, leak or fire (for example in preparation for storage or disposal) is equal to or greater than that during the normal operation of the equipment. The *Basel Convention: Manual for Implementation* (UNEP 1995), the *International Maritime Dangerous Goods Code* (International Maritime Organization (IMO), 2002), the *International Air Transport Association Dangerous Goods Code* and the *United Nations Recommendations on the Transport of Dangerous Goods: Model Regulations (Orange Book)* should be consulted to determine specific requirements for transport and transboundary movement of hazardous wastes.

### 1. Handling

73. The main concerns when handling wastes consisting of, containing or contaminated with PCBs, PCTs or PBBs are human exposure, accidental release to the environment and contamination of other waste streams with PCBs, PCTs or PCTs. Such wastes should be handled separately from other waste types in order to prevent contamination of these other waste streams. Recommended practices for this purpose include:

- (a) Inspecting containers for leaks, holes, rust, high temperature;
- (b) Handling wastes at temperatures below 25°C, if possible, due to the increased volatility at higher temperatures;
- (c) Ensuring that spill containment measures are adequate and would contain liquid wastes if spilled;
- (d) Placing plastic sheeting or absorbent mats under containers before opening containers if the surface of the containment area is not coated with a smooth surface material (paint, urethane, epoxy);
- (e) Removing the liquid wastes either by removing the drain plug or by pumping with a peristaltic pump and Teflon or silicon tubing;
- (f) Using dedicated pumps, tubing and drums, not used for any other purpose, to transfer liquid wastes;
- (g) Cleaning up any spills with cloths, paper towels or absorbent;
- (h) Triple rinsing of contaminated surfaces with a solvent such as kerosene to remove all of the residual PCBs, PCTs or PBBs;
- (i) Treating all absorbents and solvent from triple rinsing, disposable protective clothing and plastic sheeting as wastes consisting of, containing or contaminated with PCBs, PCTs or PBBs when appropriate.

74. Staff should be trained in the correct methods of handling hazardous wastes.

## 2. Collection

75. A significant part of the total national amount of PCBs, PCTs and PBBs may be held in small quantities by small business owners and homeowners (for example in PCB fluorescent light ballasts, other small electrical devices, heat exchangers and heaters containing PCB or PCT fluids, PBBs in fire suppression systems, small containers of pure products and small stockpiles). It is difficult for small-quantity owners to dispose of these materials. For example, the regulatory situation may require that they be a registered waste generator, logistical considerations may prevent or discourage pick-up (e.g. no industrial waste pick-up allowed or available in a residential neighbourhood), and costs may be prohibitive. National, regional or municipal governments should consider establishing collection stations for these small quantities so that each small-quantity owner does not have to make individual transport and disposal arrangements.

76. Collection and collection depots for wastes consisting of, containing or contaminated with PCBs, PCTs or PBBs should be separate from those for all other wastes.

77. It is imperative that collection depots do not become long-term storage facilities for wastes consisting of, containing or contaminated with PCBs, PCTs or PBBs. The risk of environmental and human health impairment is higher for a large amount of wastes, even if properly stored, than for small quantities scattered over a large area.

78. For further information, please refer to section IV.F.2 of the *General Technical Guidelines*.

## 3. Packaging

79. Wastes consisting of, containing or contaminated with PCBs, PCTs or PBBs should be packaged prior to storage or transport. Liquid wastes should be placed inter alia in double-bung steel drums. Regulations governing transport often specify containers of a certain quality (e.g. 16-gauge steel coated inside with epoxy). Therefore, containers used for storage should meet transport requirements in anticipation that they may be transported in the future.

80. Large, drained equipment may be stored as is, or may be placed inside a large container (overpack drum) or heavy plastic wrap if leakage is a concern. Small pieces of equipment, whether drained or not, should be placed in drums with an absorbent material. Numerous small pieces of equipment may be placed in one drum, as long as an adequate amount of absorbent material is present in the drum. Loose absorbents may be purchased from safety suppliers. Sawdust, vermiculite or peat moss may also be used.

81. Drums and equipment may be placed on pallets for movement by forklift truck and for storage. Equipment and drums should be strapped to the pallets prior to movement.

82. For further information, please refer to section IV.F.3 of the *General Technical Guidelines*.

## 4. Labelling

83. All drums, containers and equipment containing or contaminated with PCBs, PCTs or PBBs should be clearly labelled with both a hazard warning label and a label that gives the details of the equipment or drum. The details include the contents of the drum or equipment (exact counts of equipment or volume of liquid), the type of waste, and the name and telephone number of the responsible person.

## 5. Transportation

84. Transportation of dangerous goods and wastes is regulated in most countries, and the transboundary movement of wastes is controlled in particular by the Basel Convention.

85. Companies transporting wastes within their own country should be certified as shippers of hazardous materials and wastes and their personnel should be qualified.

## 6. Storage

86. While many countries have adopted storage regulations or developed storage guidelines related to PCBs, most do not have specific storage regulations or guidance related to PCTs and PBBs. However, it can be assumed that the storage procedures should be similar to PCBs since the properties and toxicity

of PCTs and PBBs are similar. While recommended practice varies somewhat from country to country, there are many common elements to safe storage of these wastes.

87. For further information, please refer to section IV.F.6 of the *General Technical Guidelines*.

## **G. Environmentally sound disposal**

### **1. Pretreatment**

88. Regarding pretreatment, please refer to section IV.G.1 of the *General Technical Guidelines*. In relation to size reduction, cutting and milling of capacitors should be performed immediately before destruction in a dedicated facility.

### **2. Destruction and irreversible transformation methods**

89. Regarding destruction and irreversible transformation methods, please refer to section IV.G.2 of the *General Technical Guidelines*.

### **3. Other disposal methods when destruction or irreversible transformation does not represent the environmentally preferable option**

90. Regarding other disposal methods when destruction or irreversible transformation does not represent the environmentally preferable option, please refer to section IV.G.3 of the *General Technical Guidelines*.

### **4. Other disposal methods when the POP content is low**

91. Regarding other disposal methods when the POP content is low, please refer to section IV.G.4 of the *General Technical Guidelines*.

## **H. Remediation of contaminated sites**

92. Poor handling and storage practices may lead to releases of PCBs at sites storing these chemicals, resulting in contamination of sites with high levels of PCBs, which may pose serious health concerns. For information on the identification and remediation of contaminated sites, please refer to section IV.H of the *General Technical Guidelines*.

## **I. Health and safety**

93. A health and safety plan for an individual facility should be developed by a trained health and safety professional with experience in PCB, PBB and/or PCT management. In general there are three main ways to protect workers from chemical hazards (in order of preference):

- (a) Keep the worker away from all possible sources of contamination;
- (b) Control the contaminants so that the possibility of exposure is minimized;
- (c) Protect the worker using personal protective equipment.

94. All health and safety plans should adhere to the above principles and recognize local or national labour standards. For further information please refer to section IV.I of the *General Technical Guidelines*.

### **1. High-volume, high-concentration or high-risk situations**

95. High-volume, high-concentration or high-risk PCB, PCT or PBB situations may include:

- (a) Electrical rooms with large or multiple PCB transformers;
- (b) Handling for transport;
- (c) Dedicated (large-volume) storage sites;
- (d) Treatment and disposal areas;
- (e) Sites contaminated with a high concentration of PCBs, PCTs or PBBs at or near the surface.

96. At a minimum, the following should be included in PCB, PCT or PBB health and safety plans for high-volume, high-concentration situations or high-risk situations:

- (a) The health and safety plan (HASP) should be in writing, with a copy posted at each site;
- (b) Workers, who are to have access to the site, should read the HASP and sign that they have read and understood it;
- (c) The HASP may be written to encompass all hazards at a site but should have a section or chapter specifically detailing procedures for PCBs, PCTs or PBBs;
- (d) Workers should only be present at a site when necessary for the servicing or inspection of equipment or stored materials;
- (e) Workers entering a site should have appropriate health and safety and operational training for chemical, physical and biological hazards;
- (f) Health and safety training should be performed annually;
- (g) PCBs, PCTs and PBBs should be routinely monitored for these contaminants in air;
- (h) When appropriate, workers entering a site should wear appropriate respiratory protection and impermeable fabric should cover the entire body (i.e coveralls with hood, face shield, gloves and boot covers or a full body suit);
- (i) Spill clean-up kits and personal decontamination materials should be present in all areas containing PCBs, PCTs or PBBs;
- (j) Workers who are, or are expected to be, routinely entering sites or working with these substances should be medically monitored, including a baseline medical examination;
- (k) Where PCBs, PCTs or PBBs are to be handled in an open system, or where it is reasonably expected that the protective clothing of a worker may contact PCBs, PCTs or PBBs, a contaminant reduction zone should be established where workers can be decontaminated and remove their protective equipment;
- (l) The HASP and general work procedures should be reviewed at least annually and revised if necessary to enhance safety and health at the site.

## 2. Low-volume, low-concentration sites or low-risk situations

97. The recommended health and safety practices outlined in the previous section do not apply to sites that contain or are contaminated with PCBs, PCTs and/or PBBs in amounts or concentrations that are seen as acute or chronically hazardous to human health and the environment. Low-volume, low-concentration or low-risk situations may include:

- (a) Those that involve only products or articles that contain or are contaminated with PCBs in small quantities or low concentrations (e.g. light ballasts containing PCBs in the fluorescent fixtures);
- (b) Electrical transformers or other equipment with low-level PCB-contaminated mineral oil;
- (c) Facilities that unintentionally produce PCBs, PCTs or PBBs in very low concentrations compared with human exposure limits;
- (d) Sites contaminated with a low concentration of PCBs, PCTs or PBBs or where the contamination cannot directly come into contact with workers (for example, contamination is underground or under water and is not being excavated).

98. Despite the low risk some health and safety measures should be taken to minimize exposure, including health and safety training of personnel who are likely to come into contact with PCBs, PCTs or PBBs.



**J. Emergency response**

99. Emergency response plans should be in place for PCBs, PBBs and PCTs that are in service, in storage, in transport and at a disposal site. Further information on emergency response plans can be found in section IV.J of the *General Technical Guidelines* or in *Preparation of a National Environmentally Sound Plan for PCB and PCB-Contaminated Equipment: Training Manual* (UNEP 2003a).

**K. Public participation**

100. Parties to the Basel or Stockholm Convention should have an open public participation process. For further information please refer to section IV.K of the *General Technical Guidelines*.

## Annex I

## Synonyms and trade names for PCBs, PCTs and PBBs

Chemical	Some synonyms and trade names <sup>8</sup>
PCBs	Abestol, Aceclor, Adkarel, ALC, Apirolio (Italy), Apirorio, 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 (Slovakia), Delor/Del (Slovakia), Delorene, Delorit, Delotherm DK/DH (Slovakia), 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), Fenchlor (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), Non-Flamol, Olex-sf-d, Orophene, Pheaoclor, 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), Santotherm, Santovac, Sat-T-America, Siclonyl, Solvol, Sorol, Soval, Sovol (USSR), Sovtol, Tarnol (Poland), Terphenychlore, Thermanal, Therminol, Turbinol
PCTs	Aroclor (US), Clophen Harz (W), Cloresil (A,B,100), Electrophenyl T-50 and T60, Kanechlor KC-C (Japan), Leromoll, Phenoclor, Pydraul
PBBs	Adine 0102, BB-9, Berkflam B <sub>10</sub> , Bromkal 80, Firemaster BP-6, Firemaster FF-1, Flammex B-10, hbb, hexabromobiphenyl, HFO 101, obb, BB-8

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The list of trade names is not intended to be exhaustive.

## Annex II

### Bibliography

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