UNITED
NATIONS

SC

UNEP/POPS/COP.3/INF/7

Distr.: General
2 April 2007

Original: English

United Nations
Environment
Programme

Conference of the Parties of the Stockholm Convention on Persistent Organic Pollutants
Third meeting
Dakar, 30 April–4 May 2007
Item 5 (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 wastes adopted by the Conference of the Parties to the Basel Convention

Note by the Secretariat

As referred to in document UNEP/POPS/COP.3/9, the Conference of the Parties of the Basel Convention at its eighth meeting, among other things, adopted the following:

(a) Decision VIII/16, technical guidelines on persistent organic pollutants, which is contained annex I to the present note;

(b) Updated general technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants, which are contained in annex II to the present note;

(c) Technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with 1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane (DDT), which are contained in annex III to the present note;

(d) Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with the pesticides aldrin, chlordane, dieldrin, endrin, heptachlor, hexachlorobenzene (HCB), mirex or toxaphene or with HCB as an industrial chemical, which are contained in annex IV to the present note;

---

* UNEP/POPS/COP.3/1.

(e) Technical guidelines on the environmentally sound management of wastes containing or contaminated with unintentionally produced polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), HCB or polychlorinated biphenyls (PCBs), which are contained in annex V to the present note;

(f) Updated technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with PCBs, polychlorinated terphenyls (PCTs) or polybrominated biphenyls (PBBs), which are contained in annex VI to the present note.

Annex I

Decision VIII/16, technical guidelines on persistent organic pollutants, of the Conference of the Parties of the Basel Convention

The Conference of the Parties,

Recalling its decision VII/13 on technical guidelines on persistent organic pollutants as wastes,

Noting with appreciation the roles played by Parties and others, especially the lead countries, in the preparation of the technical guidelines,

1. *Adopts* the technical guidelines for the environmentally sound management of:

(a) Wastes consisting of, containing or contaminated with the pesticides aldrin, chlordane, dieldrin, endrin, heptachlor, hexachlorobenzene (HCB), mirex or toxaphene or with HCB as an industrial chemical;[1]

(b) Wastes consisting of, containing or contaminated with 1,1,1-trichloro-2,2-bis (4-chlorophenyl)ethane (DDT);[2]

(c) Wastes containing or contaminated with unintentionally produced polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), hexachlorobenzene (HCB) or polychlorinated biphenyls (PCBs);[3]

2. *Adopts* the updated general technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants (POPs) and updated guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with polychlorinated biphenyls (PCBs), polychlorinated terphenyls (PCTs) or polybrominated biphenyls (PBBs);[4]

3. *Requests* the Secretariat to disseminate the technical guidelines referred to in paragraphs 1 and 2 of the present decision to Parties, signatories, intergovernmental organizations, environmental non-governmental organizations and industry in the six official languages of the United Nations;

4. *Also requests* the Secretariat to submit the present decision and the technical guidelines to the Conference of the Parties of the Stockholm Convention on Persistent Organic Pollutants at its third meeting through the Secretariat of the Stockholm Convention and invites the Conference of the Parties of the Stockholm Convention on Persistent Organic Pollutants to consider them;

5. *Invites* Parties and others to use the technical guidelines and to submit, not later than two months before the ninth meeting of the Conference of the Parties, reports to the Conference of the Parties, through the Secretariat, on their experience in the application of the guidelines, including on the definition of low persistent organic pollutant content and on levels of destruction and irreversible transformation and any difficulties or obstacles encountered, with a view to improving them as necessary;

6. *Notes* that having considered, among other things, comments compiled by the Secretariat,[5] it is not practical or feasible for the time being to consider further, at the level of the Basel Convention, a methodology for the further definition of low persistent organic pollutant content and of levels of destruction and irreversible transformation and that the concerns expressed in the discussion on this issue to date may better be addressed through the further work referred to in paragraph 7 of the present decision;

7. *Agrees* that the following should be included in the work programme of the Open-ended Working Group for 2007–2008:

---

[1] UNEP/CHW.8/5/Add.1*.

[2] UNEP/CHW.8/5/Add.2*; lead country: Mexico.

[3] UNEP/CHW.8/5/Add.3*; lead country: Australia.

[4] UNEP/CHW.8/5/Add.4, Add.4 /Corr.1 and Add.5.

[5] UNEP/CHW/OEWG/5/INF/21.

(a) Review and updating of the technical guidelines on persistent organic pollutants, including the definitions of low persistent organic pollutant content and of levels of destruction and irreversible transformation, if appropriate;

(b) Consideration of further guidance on other disposal methods when persistent organic pollutant content is less than low persistent organic pollutant content in areas where there may be a high risk for human health and the environment, inter alia, through the food chain and for the soil;

(c) Consideration of the amendment of entry A4110 in Annex VIII of the Basel Convention, relating to PCDDs and PCDFs, and other relevant entries relating to pesticide persistent organic pollutants and DDT, in order to include a concentration level for those persistent organic pollutants;

8. *Invites* Parties and others to submit comments to the secretariat by 31 March 2007 on the issues referred to in paragraphs78 (b) and 7 (c) above;

9. *Decides* to extend the mandate of the small intersessional working group established by decision OEWG I/14, paragraph 9, to continue to monitor and assist in the review and updating, as appropriate, of technical guidelines regarding persistent organic pollutants, working in particular by electronic means;

10. *Requests* the small intersessional working group to consider the comments referred to in paragraph 8 above and to report on the results of its work, through the Secretariat, to the Open-ended working Group for its consideration;

11. *Welcomes* the fact that the bodies of the Stockholm Convention are considering best available techniques and best environmental practices with respect to unintentionally produced persistent organic pollutants, including the more recent technologies for destruction and irreversible transformation listed in the general technical guidelines, and invites experts of the Basel Convention to contribute to that work.

Annex II

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

Contents

Abbreviations and acronyms

ASE	accelerated solvent extraction
ASTM	American Society for Testing and Materials
AOAC	Association of Official Agricultural Chemists
BAT	best available techniques
BCD	base-catalysed decomposition
BEP	best environmental practices
CD	catalytic dechlorination
CEN	European Committee for Standardization
CFCs	chlorofluorocarbons
CHD	catalytic hydrodechlorination
CSIRO	Commonwealth Scientific Industrial Research Organization (Australia)
DDT	1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane (dichlorodiphenyltrichloroethane)
DE	destruction efficiency
DRE	destruction removal efficiency
ECD	electron capture detector
EOX	acetone petroleum ether extractable organohalogen
EPA	Environmental Protection Agency (United States of America)
ESM	environmentally sound management
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FRTR	Federal Remediation Technologies Roundtable (United States of America)
GEMS	Global Environment Monitoring System
GEF	Global Environment Facility
GPCR	gas-phase chemical reduction
HASP	health and safety plan
HCB	hexachlorobenzene
HRGC	high-resolution gas chromatography
HRMS	high-resolution mass spectrometry
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IMO	International Maritime Organization
IPA	isopropyl alcohol
IPCS	International Programme on Chemical Safety
ISO	International Organization for Standardization
LRMS	low-resolution mass spectrometry
LTTD	low-temperature thermal desorption
LWPS	liquid waste pre-heater system
MSD	mass-selective detectors
NIP	national implementation plan
OCP	organochlorine pesticide
OECD	Organisation for Economic Co-operation and Development
OEWG	Open-ended Working Group of the Basel Convention
PAH	polycyclic aromatic hydrocarbon
PBB	polybrominated biphenyl
PCB	polychlorinated biphenyl
PCD	photochemical dechlorination
PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzo-furan
PCT	polychlorinated terphenyl
Pd/C	palladium on carbon
POP	persistent organic pollutant
QA	quality assurance
QC	quality control
SCWO	supercritical water oxidation
SOP	standard operational procedure
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
WHO	World Health Organization

Units of measurement

ng/kg	nanogram(s) per kilogram. Corresponds to parts per trillion (ppt) by mass.
µg/kg	microgram(s) per kilogram. Corresponds to parts per billion (ppb) by mass.
mg/kg	milligram(s) per kilogram. Corresponds to parts per million (ppm) by mass.
ng	nanogram
mg	milligram
kg	kilogram
Mg	megagram (1,000 kg or 1 tonne)
Nm^3	normal cubic metre; refers to dry gas, 101.3 kPa and 273.15 K
kW	kilowatt
kWh	kilowatt-hour
MJ	megajoule
million	10^6
billion	10^9
trillion	10^{12}
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), pursuant to decisions IV/17, V/26, VI/23, VII/13 and VIII/16 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, III/8, IV/11 and V/12 of the Open-ended Working Group of the Basel Convention, resolution 5 of the Conference of Plenipotentiaries to the Stockholm Convention on Persistent Organic Pollutants, decisions INC-6/5 and INC-7/6 of the Intergovernmental Negotiating Committee for an International Legally Binding Instrument for Implementing Action on Certain Persistent Organic Pollutants and decisions SC-1/21and SC-2/6 of the Conference of the Parties to the Stockholm Convention.

2. Specific technical guidelines on wastes consisting of, containing or contaminated with the following categories of POPs have been 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 are not POPs subject to the Stockholm Convention;

(b) The pesticide POPs aldrin, chlordane, dieldrin, endrin, heptachlor, hexachlorobenzene (HCB),[6] mirex and toxaphene, and HCB as an industrial chemical;

(c) 1,1,1-Trichloro-2,2-bis(4-chlorophenyl)ethane (DDT);

(d) Unintentionally produced polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), HCB and PCBs.

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, the 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 II.B.2 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 should be noted that guidance on best available techniques (BAT) and best environmental practices (BEP) as they apply to the prevention or minimization of the formation and release of unintentional POPs from the anthropogenic sources listed in Annex C of the Stockholm Convention is provided by the Stockholm Convention. It should also be noted that there are draft guidelines on best available techniques and provisional guidance on best environmental practices relevant to Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutants. Those guidelines were finalized by the Stockholm Convention Expert Group on Best Available Techniques and Best Environmental Practices in November 2006. A final version of the guidelines is expected to be adopted by the Conference of the Parties of the Stockholm Convention at its third meeting, in 2007.

---

[6] 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[7]

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 of that Article, it defines disposal as “any operation specified in Annex IV” to the Convention. In paragraph 8, it defines the environmentally sound management 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;

---

[7] 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 “Bibliography” below).

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

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. Annex I wastes 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 not to exhibit such characteristics. National tests may be useful for identifying a particular hazard characteristic listed in Annex III until such time as the hazardous characteristic is fully defined. Guidance papers for each Annex III hazard characteristic are currently 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) of this Convention” 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” (Annex I, paragraph (b)). List B of Annex IX lists wastes which “will not be wastes covered by Article 1, paragraph 1 (a), of this Convention unless they contain Annex I material to an extent causing them to exhibit an Annex III characteristic”. The following Annex VIII waste characteristics in particular are applicable to POPs:

(a) PCBs, PCTs and PBBs

A1180 Waste electrical and electronic assemblies or scrap[8] 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)[9]

---

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

[9] 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[10]

(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[11], 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

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)

---

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

[11] Outdated means unused within the period recommended by the manufacturer.

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[12]
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[13] 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 forth 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”.

23. The Stockholm Convention differentiates between two categories of POPs:

(a) Intentionally produced POPs, whose production and use are to be:

---

[12] This entry does not include wood treated with wood-preserving chemicals.

[13] “Outdated” means unused within the period recommended by the manufacturer.

(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 forth 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, inter alia:

(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;[14]

(b) PCDDs and PCDFs: 15 µg TEQ/kg;[15]

(c) Aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, HCB, mirex and toxaphene: 50 mg/kg for each.[16]

B. Levels of destruction and irreversible transformation

30. Recognizing the following considerations:

(a) Both destruction efficiency[17] (DE) and destruction removal efficiency[18] (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;

(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:

---

[14] Determined according to national or international methods and standards.

[15] TEQ as referred to in annex C, part IV, paragraph 2, of the Stockholm Convention, but only for PCDDs and PCDFs.

[16] Determined according to national or international methods and standards

[17] Calculated on the basis of the mass of the POP content within the waste, minus the mass of the remaining POP content 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.

[18] Calculated on the basis of mass of the POP content within the waste, minus the mass of the remaining POP content 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.

(a) Atmospheric emissions:
PCDDs and PCDFs: 0.1 ng TEQ/Nm^3;[19]
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;

(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.

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 Organisation for Economic Co-operation 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 various 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 each Party to 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.

---

[19] TEQ as referred to in annex C, Part IV, paragraph 2 of the Stockholm Convention, but only for PCDDs and PCDFs. Nm3 refers to dry gas, 101.3 kPa and 273.15 K. Standardization at 11 per cent O2.

36. Several key principles with respect to ESM of waste were articulated in the 1994 Framework Document on Preparation of Technical Guidelines for the Environmentally Sound Management of Wastes Subject to the Basel Convention.[20]

37. To achieve ESM of wastes, the Framework 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.

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 “environmentally sound management” 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.[21]

3. Organisation for Economic Co-operation and Development

41. OECD has adopted a recommendation on 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 and also elements subsequent to storage, transport, treatment and disposal of pertinent residues.[22]

42. The core performance elements are:

(a) That the facility should have an applicable environmental management system (EMS) in place;

---

[20] See Basel Convention 1994 in annex V, Bibliography.

[21] Parties should consult United Nations Environment Programme (UNEP) 2003 in annex V, Bibliography.

[22] See OECD 2004 in annex V, Bibliography.

(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 agreement with the conventions and with their obligations under them, including those which 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, countries' environmental legislation should include requirements for protection of both human health and the environment. Such enabling legislation can give governments the power to enact specific rules and regulations, inspect and enforce, and establish penalties for violations.

45. Such legislation on hazardous wastes should also define hazardous wastes. 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 POPs, including their environmentally sound disposal as described in the present guidelines and the Stockholm Convention. Specific components or features of a regulatory framework that would meet the requirements of the Basel and Stockholm conventions and other international agreements are discussed below.[23]

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[24] 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[25]

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 permitted only 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;

---

[23] 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 *Guidance for developing a NIP for the Stockholm Convention* (UNEP, 2005). See annex V, Bibliography.

[24] 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.

[25] This applies only to Basel Convention Parties.

(c) If the country of export does not have the technical capacity and the necessary facilities to dispose of 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.[26]

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.

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 particular POPs.[27] 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[28]

53. Neither the Basel nor the Stockholm convention specifically requires 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 either in 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.

---

[26] In this connection, the United Nations Recommendations on the Transport of Dangerous Goods (Model Regulations) (UNECE, 2003a – see annex V, Bibliography)) or later versions should be used.

[27] Parties should consult Food and Agriculture Organization (FAO) guidelines pertaining to the storage of pesticides and pesticide waste (FAO, 1996 – see annex V, Bibliography).

[28] See also section IV.I.

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 identifying 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 further 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 below 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 (article 6, paragraph 1 (e), of the Stockholm Convention) may be specified in legislation.

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 the 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;

  (iii) Post-decommissioning site requirements;

(c) Emergency contingency planning, spill and accident response, including:

  (i) Cleanup procedures and post-cleanup concentrations to be achieved;

  (ii) Worker training and safety requirements;

(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 … 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 Convention 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;

(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;

(d) Minimization of the volume of waste generated:

(i) By regular maintenance of equipment to increase efficiency and prevent spills and leaks;

(ii) By prompt containment of spills and leaks;

(iii) By decontamination of containers and equipment containing wastes consisting of, containing or contaminated with POPs;

(iv) By 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. Nevertheless, mixing of materials prior to waste treatment 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 the original use or are discarded;

(f) When products have been banned 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. The list of source categories provided in annex C to the Stockholm Convention should assist industrial managers and government regulators, and also the general public, in identifying wastes consisting of, containing or contaminated with unintentionally produced POPs.

2. Inventories

69. National implementation plans under the Stockholm Convention will include a national inventory. For the purpose of the environmentally sound management of wastes, a more specific and complete inventory may be needed. This will normally involve an iterative process. The following paragraphs provide more detailed guidance.

70. Inventories are an important tool for identifying, quantifying and characterizing wastes. National inventories may be used:

(a) To establish a baseline quantity of products, articles and wastes consisting of, containing or contaminated with POPs;

(b) To establish an information registry to assist with safety and regulatory inspections;

(c) To obtain the accurate information needed to draw up plans for site stabilization;

(d) To assist with the preparation of emergency response plans;

(e) To track progress towards minimizing and phasing out POPs.

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

72. An inventory should, as appropriate, include data on:

(a) Production of POPs within the country;

(b) Import/export of products and articles consisting of or containing POPs;

(c) Disposal of waste consisting of, containing or contaminated with POPs;

(d) Import/export of such waste.

73. The development of a national POPs inventory requires cooperation by the relevant authority with producers, users, transporters, customs offices, waste disposal facilities and the national focal points for the Basel Convention and for the Stockholm Convention. It requires also 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.

74. The first issue to consider in developing an inventory is the types of industries and locations which 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.

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

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.

Step 2: Train personnel: Government staff members 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.

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.

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) Weight of container or equipment (if applicable);

(d) Weight 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 (e.g., combustible, corrosive, flammable);

(h) Location;

(i) Owner information;

(j) Identifying labels, serial numbers, marks, etc.;

(k) Date entered inventory;

(l) Date removed from inventory and fate (if applicable).

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 ensure that the inventory information is correct.[29]

76. 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 Environmental Matters includes provisions pertaining to the inventories that may be applicable to POPs.

E. Sampling, analysis and monitoring

77. 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 in accordance with a well-designed plan and using internationally accepted or 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 standard operational procedures, can result in meaningless data or even programme-damaging data. Each Party, as appropriate, should therefore ensure that training, protocols and laboratory capability are in place for sampling, monitoring and analytical methods and that these standards are enforced.

78. 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, analysis and monitoring. 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.

79. For information on good laboratory practices the OECD series (OECD, various years) may be consulted; on general methodological considerations, the guidance document for the Global Monitoring Programme on POPs (UNEP 2004a) may be used; and further information on POPs analysis may be obtained from the UNEP/Global Environment Facility (GEF) project on capacity needs for analysing POPs at www.chem.unep.ch/pops/laboratory/default.htm.

1. Sampling[30]

80. The overall objective of any sampling activity is to obtain a sample which can be used for the targeted purpose, e.g., site characterization, compliance with regulatory standards or suitability for proposed treatment or disposal. This objective should be identified before sampling is started. It is indispensable for quality requirements in terms of equipment, transportation and traceability to be met.

81. Standard sampling procedures should be established and agreed upon before the start of the sampling campaign (both matrix- and POP-specific). Elements of these procedures include the following:

(a) The number of samples to be taken, the sampling frequency, the duration of the sampling project and a description of the sampling method (including quality assurance procedures put in place, e.g., field blanks and chain-of-custody);

(b) Selection of location or sites and time of sample-taking (including description and geographic localization);

(c) Identity of person who took the sample and conditions during sampling;

(d) Full description of sample characteristics – labelling;

---

[29] 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, Bibliography).

[30] 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, Bibliography).

(e) Preservation of the integrity of samples during transport and storage (before analysis);

(f) Close cooperation between the sampler and the analytical laboratory;

(g) Appropriately trained sampling personnel.

82. Sampling should comply with specific national legislation, where it exists, or with international regulations. In countries where regulations do not exist, qualified staff should be appointed. Sampling procedures include the following:

(a) Development of a standard operational procedure (SOP) for sampling each of the matrices for subsequent POPs analysis;

(b) Application of well-established sampling procedures such as those developed by the American Society for Testing and Materials (ASTM), the European Union, the United States Environmental Protection Agency (EPA) and the Global Environment Monitoring System (GEMS);

(c) Establishment of quality assurance and quality control (QA/QC) procedures.

83. All these steps should be followed for a sampling programme to be successful. Similarly, documentation should be thorough and rigorous.

84. Types of matrices typically sampled for POPs include solids, liquid and gases:

(a) Liquids:

  (i) Leachate from dumpsites and landfills;

  (ii) Liquid collected from spills;

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

  (iv) Biological fluids (blood, in the case of workers' health monitoring);

(b) Solids:

  (i) Stockpiles, products and formulations consisting of, containing or contaminated with POPs;

  (ii) Solids from industrial sources and treatment or disposal processes (fly ash, bottom ash, sludge, still bottoms, other residues, clothing, etc.);

  (iii) Containers, equipment or other packaging materials (rinse or wipe samples), including the tissues or fabric used in the collection of wipe samples;

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

(c) Gases:

  (i) Air (indoor).

85. In environmental and human monitoring programmes, both biotic and abiotic matrices may be included:

(a) Plant materials and food;

(b) Human breast milk or blood;

(c) Air (ambient, wet or dry deposition or, possibly, snow).

2. Analysis

86. Analysis refers to the extraction, purification, separation, identification, quantification and reporting of POPs concentrations in the matrix of interest. To obtain meaningful and acceptable results, the analytical laboratory should have the necessary infrastructure (housing) and proven experience with

the matrix and the POP (e.g., successful participation in international intercalibration studies). Accreditation of the laboratory according to ISO 17025 or other standards by an independent body is an important aspect. Indispensable criteria for obtaining high-quality results include:

(a) Specification of the analytical technique;

(b) Maintenance of analytical equipment;

(c) Validation of all methods used (including in-house methods);

(d) Training of laboratory staff.

87. Typically, POPs analysis is performed in a dedicated laboratory. For specific situations, test kits are available that can be used in the field for screening purposes.

88. For laboratory POPs analysis, there is no one analytical method available. Methods of analysing the various matrices for POPs have been developed by ISO, the European Committee for Standardization (CEN), EPA, AOAC and ASTM. Annex III lists some examples. Most in-house methods are variations of these, and after validation such in-house methods are also acceptable.

89. In addition, procedures and acceptance criteria for handling and preparation of the sample in the laboratory, e.g., homogenization, should be established.

90. The individual steps in the analytical determination include:

(a) Extraction, e.g., by Soxhlet, accelerated solvent extraction (ASE), liquid-liquid, etc.;

(b) Purification, e.g., by column chromatography or with Florisil. Purification should be efficient enough so that chromatographic retention is not influenced by the matrix;

(c) Separation by capillary gas chromatography (HRGC), which will provide sufficient separation of analytes;

(d) Identification by suitable detectors such as an electron capture detector (ECD) or a mass-selective detector (MSD), or by either low-resolution mass spectrometry or high-resolution mass spectrometry (LRMS or HRMS);

(e) Quantification according to internal standard methodology (for reference, see UNEP 2004a, UNEP, 2006);

(f) Reporting in accordance with regulation(s).

3. Monitoring

91. 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. Monitoring programmes 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 the monitoring programme should be used to ensure that the proper types of hazardous wastes are being managed by the waste management operation, to discover and repair any damage and to determine whether an alternative management approach might be appropriate. By implementing a monitoring programme, facility managers can identify problems and take appropriate measures to remedy them.[31]

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

92. 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 at least as great as at other times.

93. For transport and transboundary movement of hazardous wastes, the following documents should be consulted to determine specific requirements:

(a) Basel Convention: Manual for Implementation (UNEP, 1995);

---

[31] 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 “Bibliography”.

(b) International Maritime Dangerous Goods Code (IMO, 2002);

(c) International Civil Aviation Organization (ICAO) Technical Instructions for the Transport of Dangerous Goods;

(d) IATA Dangerous Goods Regulations and the United Nations Recommendations on the Transport of Dangerous Goods Model Regulations (Orange Book).

94. For the following sections 1–6, detailed information can be obtained from “Destruction and Decontamination Technologies for PCBs and other POPs wastes under the Basel Convention, a Training Manual for Hazardous Waste Project Managers, Volumes A and B” by the Secretariat of the Basel Convention (UNEP, 2002).

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[32]

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 be handled separately from other waste types in order to prevent contamination of other waste streams. Recommended practices for this purpose include:

(a) Inspecting containers for leaks, holes, rust or high temperature, and appropriate repackaging and relabelling as necessary;

(b) Handling wastes at temperatures below 25 °C, if possible, because of 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 them if the surface of the containment area is not coated with a smooth surface material (paint, urethane or epoxy);

(e) Removing liquid wastes either by removing the drain plug or by pumping with a peristaltic pump and suitable chemical-resistant 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;

(i) Treating all absorbents and solvent from triple rinsing, disposable protective clothing and plastic sheeting as wastes containing or contaminated with POPs when appropriate.

97. Staff should be trained in the correct methods of handling wastes consisting of, containing or contaminated with POPs.

2. Collection

98. Although 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-sized 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 existing commercial hazardous-waste transfer stations. Waste-collection depots and transfer stations may be set up on a regional basis by groups of countries or

---

[32] 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 OECD (2003), listed in annex V, “Bibliography”.

may be provided by a developed country to a developing country.

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

(a) To advertise the programme, depot locations and collection time periods to all potential holders of wastes consisting of, containing or contaminated with POPs;

(b) To allow enough time of operation of collection programmes for the complete collection of all potential wastes consisting of, containing or contaminated with POPs;[33]

(c) To include, to the extent practical, all wastes consisting of, containing or contaminated with POPs in the programme;

(d) To make acceptable containers and safe-transport materials available to waste owners for those waste materials that may need to be repackaged or made safe for transport;

(e) To establish simple, low-cost mechanisms for collection;

(f) To ensure the safety both of those delivering waste to depots and workers at the depots;

(g) To ensure that the operators of depots are using an accepted method of disposal;

(h) To ensure that the programme and facilities meet all applicable legislative requirements;

(i) To ensure separation of wastes consisting of, containing or contaminated with POPs from other waste streams.

3. Packaging

100. 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.

101. 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.

102. 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 are 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;

(e) Smaller containers can be packaged together in bulk by placing them in appropriate or approved larger containers containing absorbent material;

(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.

---

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

4. Labelling[34]

103. 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.

5. Transportation

104. Wastes consisting of, containing or contaminated with POPs should be transported in an environmentally sound manner to avoid accidental spills and to track their transport and ultimate destination appropriately. Before 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 certified as carriers of hazardous materials and wastes.

105. 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.

106. Companies transporting wastes within their own countries should be certified as carriers of hazardous materials and wastes, and their personnel should be qualified.

107. Guidance on the safe transportation of hazardous materials can be obtained from IATA, IMO, UNECE and ICAO.

6. Storage[35]

108. 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 any route. 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.

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

(a) Storage sites inside multi-purpose 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[36] should be stored inside a lockable fenced enclosure;

(c) Separate storage areas, rooms or buildings should be used for each type of POPs waste, unless specific approval has been given for joint storage;

(d) Such wastes should not be stored at 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 environmentally sensitive sites;

(e) Storage rooms, buildings and containers should be located and maintained in conditions that will minimize volatilization, including cool temperatures, reflective roofs and sidings, a shaded 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:

---

[34] 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, Bibliography.

[35] Further information can be found in Storage of Hazardous Materials: A Technical Guide for Safe Warehousing of Hazardous Materials (UNEP, 1993 – see annex V, Bibliography). Pesticide storage and stock control manual, No 3 (FAO, 1996).

[36] Shipping containers are often used for storage.

(i) Ventilating a site with carbon filtration of exhaust gases may be appropriate when exposure to vapours for those who work at 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 polymer;

(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 per cent 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 of;

(o) The outside of the storage site should be labelled as a waste storage site;

(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

110. 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 be performed only if the 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

111. “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 (e.g., contaminant transferred from liquid phase onto activated carbon).

112. 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

113. 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, water will react explosively with molten salts or sodium. Depending on the nature of the contaminant, the resulting vapours may require condensation or scrubbing, and further treatment.

(c) Mechanical separation

114. 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

115. 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

116. 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

117. Some treatment technologies are most effective over a defined pH range and in these situations alkali, acid or CO_2 are often used to control pH levels. Some technologies may also require pH adjustment as a post-treatment step.

(g) Size reduction

118. Some technologies are able to process wastes only within a certain size limit. For example, some may handle POP-contaminated solid wastes only if they are less than 200 mm 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 injection into the main reactor. It should be noted that facilities may become contaminated when reducing the size of wastes consisting of, containing or contaminated with POPs. Precautions should therefore be taken to prevent subsequent contamination of POP-free waste streams.

(h) Solvent washing

119. 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

120. 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

121. The following disposal operations, as provided for in Annexes IV A and IV B 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;

R1 Use as a fuel (other than in direct incineration) or other means to generate energy;

R3 Recycling/reclamation of organic substances which are not used as solvents, but restricted to waste-to-gas conversion;

R4 Recycling/reclamation of metals and metal compounds, but restricted to activities of primary and secondary metallurgy described in (k) below.

122. POPs that are isolated from the waste during pre-treatment should subsequently be disposed of in accordance with operations D9 and D10.

123. This subsection describes commercially available operations for the environmentally sound destruction and irreversible transformation of the POP content in wastes.[37] It should be noted that the pertinent national legislation applies for these operations.

124. 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.

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

(a) Alkali metal reduction[38]

126. *Process description*: Alkali metal reduction involves the treatment of wastes with dispersed alkali metal. Alkali metals react with chlorine in halogenated waste to produce salts and non-halogenated waste. Typically, the process operates at atmospheric pressure and temperatures between 60°C and 180°C.[39] Treatment can take place either in situ (e.g., PCB-contaminated transformers) or ex situ in a reaction vessel. There are several variations of this process.[40] Although potassium and potassium-sodium alloy have been used, metallic sodium is the most commonly used reducing agent. The remaining information is based on experiences with the metallic sodium variation.

127. *Efficiency*: Destruction efficiency (DE) values of greater than 99.999 per cent and destruction removal efficiency (DRE) values of 99.9999 per cent have been reported for aldrin, 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, the United States of America and the European Union for PCB transformer oil treatment, i.e., less than 2 ppm in solid and liquid residues.[41]

---

[37] 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, Bibliography).

[38] Additional information is available from UNEP, 1998b; UNEP, 2000b; and UNEP, 2004b. See annex V, Bibliography.

[39] Ariizumi Otsuka, Kamiyama and Hosani, 1997, and Japan Industrial Waste Management Foundation, 1999, see annex V, Bibliography

[40] See Piersol, 1989 in annex V, Bibliography.

[41] See Piersol, 1989 and UNEP, 2004b in annex V, Bibliography.

128. *Waste types*: Sodium reduction has been demonstrated with PCB-contaminated oils containing concentrations up to 10,000 ppm.[42] Some vendors have also claimed that this process is capable of treating whole capacitors and transformers.[43]

129. *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 through shearing.[44] Pre-treatment should include dewatering to avoid explosive reactions with metallic sodium.

130. *Emissions and residues*: Air emissions include nitrogen and hydrogen gas. Emissions of organic compounds are expected to be relatively minor.[45]It has been noted, however, that PCDDs and PCDFs can be formed from chlorophenols under alkaline conditions at temperatures as low as 150°C (Weber, 2004). Residues produced during the process include sodium chloride, sodium hydroxide, polyphenyls and water.[46] In some variations, a solidified polymer is also formed.[47]

131. *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.[48]

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

133. *Material requirements*: Significant amounts of sodium are required to operate this process.[49]

134. *Portability*: The process is available in transportable and fixed configurations.[50]

135. *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 absolutely to exclude water (and certain other substances, e.g., alcohols) from the waste and from any other contact with the sodium. In the past, a facility in Delfzijl, the Netherlands, was severely damaged by a fire.

136. *Capacity*: Mobile facilities are capable of treating 15,000 litres per day of transformer oil.[51]

137. *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.[52]

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

139. Vendors include:

(a) Dr. Bilger Umweltconsulting GmbH – www.bilgergmbh.de;

(b) Decoman srl, Italy – www.decoman.it;

(c) Envio Germany GmbH & Co. KG – www.envio-group.com;

(d) Kinectrics Inc. – www.kinectrics.com;

---

[42] See UNEP, 2004b in annex V, Bibliography.

[43] Ibid.

[44] Ibid..

[45] See Piersol, 1980 in annex V, Bibliography.

[46] See UNEP, 2004b in annex V, Bibliography.

[47] See UNEP, 2000b, in annex V, Bibliography.

[48] Ibid.

[49] UNEP, 2004b, in annex V, Bibliography.

[50] Ibid.

[51] Ibid.

[52] See UNEP, 2000b, in annex V, Bibliography.

(e) Nippon Soda Co. Ltd. – www.nippon-soda.co.jp;

(f) Orion BV, Netherlands – www.orionun2315.nl/en/index.php.

(g) Powertech Labs Inc. – www.powertechlabs.com;

(h) Sanexen Environmental Services Inc. – www.sanexen.com.

(b) Base-catalysed decomposition (BCD)[53]

140. *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.

141. *Efficiency*: DEs of 99.99–99.9999 per cent have been reported for DDT, PCBs, PCDDs and PCDFs.[54] DEs of greater than 99.999 per cent and DREs of greater than 99.9999 per cent 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.[55]

142. *Waste types*: BCD should be applicable to other POPs in addition to the waste types listed above.[56] BCD should be capable of treating wastes with a high POP concentration, with demonstrated applicability to wastes with a PCB content of above 30 per cent.[57] 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.[58] 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 unsolvable. Applicable waste matrices include soil, sediment, sludge and liquids. The company BCD Group also claims that the process has been shown to destroy PCBs in wood, paper and metal surfaces of transformers.

143. *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.

144. *Thermal desorption* has also been used in conjunction with BCD to remove POPs from soils prior to treatment. In these situations, the soil is pre-mixed with sodium bicarbonate prior to being fed into the thermal desorption unit.[59] Water will need to be evaporated from aqueous media, including wet sludge, prior to treatment. Capacitors can be treated following size reduction through shredding.[60] If volatile solvents are present, such as occurs with pesticides, they should be removed by distillation prior to treatment.[61]

145. *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 temperatures as low as 150°C (Weber, 2004). Other residues produced during the BCD reaction include sludge containing primarily

---

[53] 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, Bibliography.

[54] See UNEP, 2004b in annex V, Bibliography.

[55] See UNEP, 2001 in annex V, Bibliography.

[56] See UNEP, 2004b and Vijgen, 2002 in annex V, Bibliography.

[57] See Vijgen, 2002 in annex V, Bibliography.

[58] See CMPS&F – Environment Australia, 1997; Rahuman et al., 2000 and UNEP 2001 in annex V, Bibliography.

[59] See CMPS&F – Environment Australia, 1997 in annex V, Bibliography.

[60] See CMPS&F – Environment Australia, 1997 and UNEP 2001, in annex V, Bibliography.

[61] See CMPS&F – Environment Australia, 1997 in annex V, Bibliography.

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.

146. *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 reused and the remaining sludge can be further treated for use as a neutralizing agent or disposed of in a landfill.[62] In addition, BCD plants are equipped with activated carbon traps to minimize releases of volatile organics in gaseous emissions.

147. *Energy requirements*: Energy requirements are expected to be relatively low owing to the low operating temperatures associated with the BCD process.

148. 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.[63] Amounts range from 1 per cent to about 20 per cent by weight of the contaminated medium; and

(c) Proprietary catalyst amounting to 1 per cent by volume of the hydrogen donor oil.

149. The *equipment* associated with this process is thought to be readily available.[64]

150. *Portability*: Modular, transportable and fixed plants have been built.

151. *Health and safety*: In general, the health and safety risks associated with operation of this technology are thought to be low,[65] 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.[66] 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.[67]

152. *Capacity*: BCD can process as much as 2,600 gallons per batch, with a capability of treating two–four batches per day.[68]

153. *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.[69] More recently, however, it has been reported that this problem has been overcome.[70]

154. *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 PCDDs and PCDFs is now under construction within the Czech Republic.

---

[62] See UNEP, 2004b, in annex V, Bibliography.

[63] See CMPS&F – Environment Australia, 1997 and UNEP 2001 in annex V, Bibliography.

[64] See Rahuman et al., 2000 in annex V, Bibliography.

[65] See CMPS&F – Environment Australia, 1997 and Rahuman et al., 2000 in annex V, Bibliography.

[66] See CMPS&F – Environment Australia, 1997 in annex V, Bibliography.

[67] Ibid.

[68] See Vijgen, 2002 and UNEP, 2004b in annex V, Bibliography.

[69] See CMPS&F – Environment Australia, 1997 in annex V, Bibliography.

[70] See Vijgen, 2002 in annex V, Bibliography.

155. *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, the Czech Republic, Japan, Mexico and the United States of America.

(c) Catalytic hydrodechlorination (CHD)

156. *Process description*: CHD involves the treatment of wastes with hydrogen gas and palladium on carbon (Pd/C) catalyst dispersed in 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 product. The 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).

157. *Efficiency*: DEs of 99.98–99.9999 per cent 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.

158. *Waste types*: CHD has been demonstrated with PCBs removed from used capacitors. PCDDs and 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.

159. *Pre-treatment*: PCBs and PCDDs/PCDFs must be extracted using solvents or isolated by vaporization. Substances with low boiling points such as water or alcohols should be removed by distillation prior to treatment.

160. *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.

161. *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.

162. *Energy requirements*: Energy requirements are expected to be relatively low owing to the low operating temperatures associated with the CHD process.

163. *Material requirements*: The CHD process requires the same number of atoms of hydrogen as those of chlorine in the PCBs, and also 0.5 per cent by weight of catalyst.

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

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

166. *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.

167. *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 catalysts. Reaction temperature can be increased to 260°C when paraffin oil is used as reaction solvent.

168. *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 in operation in two years in Japan.

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

170. *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[71]

171. *Process description*: Cement kilns typically consist of a long cylinder of 50–150 metres, inclined slightly from the horizontal (3 per cent to 4 per cent 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 "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 1,400°C–1,500°C. As the materials move through the kiln, they undergo drying and pyroprocessing reactions to form clinker.

172. *Efficiency*: DREs of greater than 99.99998 per cent 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).

173. *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.[72]

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

(a) Thermal desorption of solid wastes;

(b) Homogenization of solid and liquid wastes through drying, shredding, mixing and grinding.

175. *Emissions and residues*: Emissions may include, inter alia, nitrogen oxides, carbon monoxide, sulphur dioxide and other oxides of sulphur, metals and their compounds, hydrogen chloride, hydrogen fluoride, ammonia, PCDDs, PCDFs, benzene, toluene, xylene, polycyclic aromatic hydrocarbons, chlorobenzenes and PCBs.[73] It should be noted, however, that cement kilns can comply with PCDD and PCDF air emission levels below 0.1 ng TEQ/Nm^3.[74] Residues include cement kiln dust captured by the air pollution control system.

176. *Release control and post-treatment*: Process gases require treatment to remove cement kiln dust and organic compounds, sulphur dioxide, nitrogen oxide and also heat so that formation of PCDDs and PCDFs is minimized. Treatments include use of preheaters, electrostatic precipitators, fabric filters and activated carbon filters.[75] It has been reported that PCDD and PCDF concentrations within cement kiln dusts range between 0.4 and 2.6 mg/kg.[76,77] 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.

177. *Energy requirements*: New kiln systems with five cyclone preheater stages and precalciner will require an average of 2,900–3,200 MJ to produce 1 Mg of clinker.[78]

178. *Material requirements*: Cement manufacturing requires large amounts of materials, including limestone, silica, alumina, iron oxides and gypsum.[79]

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

180. *Health and safety*: Treatment of wastes within cement kilns can be regarded as relatively safe if properly designed and operated.[80]

---

[71] 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 et al., 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 2004a. See annex V, Bibliography.

[72] See CMPS&F – Environment Australia, 1997; Rahuman et al., 2000 and UNEP, 2004c in annex V, Bibliography.

[73] See UNEP, 2004c in annex V, Bibliography.

[74] See UNEP, 2004c in annex V, Bibliography.

[75] See CMPS&F – Environment Australia, 1997; Karstensen, 2006 and UNEP, 2004c in annex V, Bibliography.

[76] TEQ were not given.

[77] See UNEP 2004a in annex V, Bibliography.

[78] Ibid.

[79] See CMPS&F – Environment Australia, 1997 in annex V, Bibliography.

[80] Ibid.

181. *Capacity*: Cement kilns co-incinerating wastes as a fuel are normally limited to a maximum of 40 per cent of the heat requirement in the form of hazardous waste.[81] It has been noted, however, that cement kilns with high throughput can potentially treat significant quantities of waste.[82]

182. *Other practical issues*: Cement kilns treating wastes may require modifications to the rotary kiln.[83] Potential feed points for supplying fuel to the kiln system are:

(a) The main burner at the rotary kiln outlet end;

(b) A feed chute at the transition chamber at the rotary kiln inlet end (for lump fuel);

(c) Secondary burners to the riser duct;

(d) Precalciner burners to the precalciner;

(e) A feed chute to the precalciner/preheater (for lump fuel);

(f) A mid-kiln valve in the case of long wet and dry kilns (for lump fuel) (UNEP, 2004c).

183. 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.

184. *State of commercialization*: Cement kilns in the United States of America, some European and a number of developing countries have been used to treat wastes contaminated with POPs (World Business Council, 2004: Formation and Release of POPs in the Cement Industry, Kartensen, 2006).

185. *Vendors*: A number of existing cement kiln co-incineration operations are identified in the inventory of worldwide PCB destruction capacity.[84]

(e) Gas-phase chemical reduction (GPCR)[85]

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

187. *Efficiency*: DEs of 99.9999 per cent have been reported for DDT, HCB, PCBs, PCDDs and PCDFs.[86]

188. *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.[87] GPCR is capable of treating wastes with a high POP concentration,[88] including aqueous and oily liquids, soils, sediments, transformers and capacitors.[89]

189. *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;

---

[81] See UNEP, 2004c in annex V, Bibliography.

[82] See UNEP, 1998b in annex V, Bibliography.

[83] See CMPS&F – Environment Australia, 1997 and UNEP, 2004c in annex V, Bibliography.

[84] See UNEP, 1998b in annex V, Bibliography.

[85] 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, Bibliography.

[86] See CMPS&F – Environment Australia, 1997; Kümmling, 2001; Rahuman et al., 2000; UNEP, 2004b and Vijgen, 2002 in annex V, Bibliography.

[87] See CMPS&F – Environment Australia, 1997; UNEP, 2004b and Vijgen, 2002 in annex V, Bibliography.

[88] See UNEP, 2004b and Vijgen, 2002 in annex V, Bibliography.

[89] See CMPS&F – Environment Australia, 1997; UNEP, 2004b and Vijgen, 2002 in annex V, Bibliography.

(b) Torbed reactor for contaminated soils and sediments, but also adapted for liquids;

(c) Liquid waste pre-heater system (LWPS) for liquids.[90]

190. 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.[91]

191. *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 residues will also be generated from solid waste inputs.[92] Since the GPCR process takes place in a reducing atmosphere, the possibility of PCDD and PCDF formation is considered limited.[93]

192. *Release control and post-treatment*: Gases leaving the reactor are scrubbed to remove water, heat, acid and carbon dioxide.[94] Scrubber residue and particulate will require disposal off site.[95] Solid residues generated from solid waste inputs should be suitable for disposal in a landfill.[96]

193. *Energy requirements*: Methane produced during the process can provide much of the fuel needs.[97] 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.[98]

194. *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.[99] The hydrogen production unit was plagued, however, by reliability problems in the past.[100] Other material requirements include caustic for the acid scrubber.[101]

195. *Portability*: GPCR is available in fixed and transportable configurations.[102]

196. *Health and safety*: Use of hydrogen gas under pressure requires suitable controls and safeguards to ensure that explosive air-hydrogen mixtures are not formed.[103] Operating experience gained to date has indicated that the GPCR process can be undertaken safely.[104]

197. *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 four 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

---

[90] See CMPS&F – Environment Australia, 1997; Kümmling et al., 2001; UNEP, 2001; UNEP, 2004b and Vijgen,, 2004 in annex V, Bibliography.

[91] See CMPS&F – Environment Australia, 1997 in annex V, Bibliography.

[92] See UNEP, 2004b and Vijgen, 2002 in annex V, Bibliography.

[93] See CMPS&F – Environment Australia, 1997 and Rahuman et al., 2000 in annex V, Bibliography.

[94] See Kümmling et al., 2001; CMPS&F – Environment Australia, 1997 and Rahuman et al., 2000 in annex V, Bibliography.

[95] See Rahuman et.al, 2000 and Vijgen, 2002 in annex V, Bibliography.

[96] See UNEP, 2004b in annex V, Bibliography.

[97] See CMPS&F – Environment Australia, 1997; Rahuman et al., 2000; UNEP, 2001; UNEP, 2004b and Vijgen, 2002 in annex V, Bibliography.

[98] CMPS&F – Environment Australia, 1997 in annex V, Bibliography.

[99] See CMPS&F – Environment Australia, 1997; Rahuman et al., 2000; UNEP, 2004b and Vijgen, 2002 in annex V, Bibliography.

[100] See CMPS&F – Environment Australia, 1997 in annex V, Bibliography.

[101] See UNEP, 2004b in annex V, Bibliography.

[102] See UNEP, 2001; UNEP, 2004b and Vijgen, 2002 in annex V, Bibliography.

[103] See CMPS&F – Environment Australia, 1997 in annex V, Bibliography.

[104] See CMPS&F – Environment Australia, 1997 and UNEP, 2004b in annex V, Bibliography.

(c) LWPS has a capacity of three litres per minute.[105]

198. *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.[106]

199. *State of commercialization*: Commercial-scale GPCR plants have operated in Canada and Australia. The GPCR plant in Australia has operated for more than five years. In addition, a GPCR plant has recently been authorized in Japan.[107]

200. *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[108]

201. *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 per cent, greater than 1,100°C, with a residence time greater than two seconds, under conditions that assure appropriate mixing. Dedicated hazardous-waste incinerators are available in a number of configurations, including rotary kiln incinerators, and 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.)

202. *Efficiency*: DREs of greater than 99.9999 per cent have been reported for treatment of wastes consisting of, containing or contaminated with POPs.[109] DEs of greater than 99.999 and DREs of greater than 99.9999 per cent have been reported for aldrin, chlordane and DDT (Ministry of the Environment of Japan, 2004), while DEs between 83.15 and 99.88 per cent have been reported for PCBs (EPA, 1990).

203. *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.[110]

204. *Pre-treatment*: Depending upon the configuration, pre-treatment requirements may include blending, dewatering and size reduction of wastes.[111]

205. *Emissions and residues*: Emissions include carbon monoxide, carbon dioxide, HCB, hydrogen chloride, particulates, PCDDs, PCDFs and PCBs and water vapour.[112] 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.[113] 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.

206. *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

---

[105] See UNEP, 2004b and Vijgen, 2002 in annex V, Bibliography.

[106] See CMPS&F – Environment Australia, 1997 in annex V, Bibliography.

[107] See CMPS&F – Environment Australia, 1997; Kümmling et al., 2001; Ray, 2001; UNEP, 2004b and Vijgen, 2002 in annex V, Bibliography.

[108] 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 2006. See annex V, Bibliography.

[109] See FRTR, 2002; Rahuman et al., 2000; UNEP, 1998b and UNEP, 2001 in annex V, Bibliography.

[110] See UNEP, 1995c in annex V, Bibliography.

[111] See UNEP, 1995c; UNEP, 1998b and UNEP, 2004c in annex V, Bibliography.

[112] See UNEP, 1995c; UNEP, 1998b and UNEP, 2004c in annex V, Bibliography.

[113] UNEP, 2001 in annex V, Bibliography.

quenching systems and carbon adsorption.[114] Depending upon their characteristics, bottom and fly ashes may require disposal within a specially engineered landfill.[115]

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

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

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

210. *Health and safety*: Health and safety hazards include those associated with high operating temperatures.[116]

211. *Capacity*: Hazardous-waste incinerators can treat between 30,000 and 100,000 tons per year.[117]

212. *Other practical issues*: None to report at this time.

213. *State of commercialization*: There is a long history of experience with hazardous waste incineration.[118]

214. *Vendors*: A number of existing hazardous-waste incineration facilities are identified within the inventory of worldwide PCB destruction capacity.[119]

(g) Photochemical dechlorination (PCD) and catalytic dechlorination (CD) reaction

215. *Process description*: PCD and CD is a technology using the combined methods of both photochemical 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 sodium hydroxide (NaOH) and isopropyl alcohol (IPA) so that the PCB concentration in the IPA should reach several per cent 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, sodium chloride, acetone and water are generated, but no gases such as hydrogen or hydrochloric acid gas are produced.

216. *Efficiency*: DEs of 99.99–99.9999 per cent have been achieved for PCBs and 99.9999–99.999999 per cent for PCDDs and PCDFs (Tajima et al., 2003; and Watanabe et al., 2003).

217. *Waste types*: The PCD and CD process has been demonstrated to treat oil from transformers and capacitors containing PCBs at high concentrations 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.

218. *Pretreatment*: Electrical equipment contaminated with PCBs requires some pre-treatment. 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 a hydrocarbon washing agent such as decane. PCBs and the solvent are separated by the distiller. Distilled PCBs and solvent are destroyed by the PCD and CD processes respectively. The solvent is reused for washing. It is not necessary to pre-treat soils, sludge and water.

219. *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 possible. Residues include solid sodium chloride and used catalyst (Watanabe et al., 2002; Watanabe et al., 2003).

220. *Post-treatment*: A distiller separates IPA from the solution, and large factions of the IPA can be recycled several times as a solvent of PCBs. Wastes generated from the processes include biphenyl, sodium chloride, acetone, water and residual IPA. Sodium chloride is removed from the solution by

---

[114] UNEP, 2004c.

[115] See United States Army Corps of Engineers, 2003 in annex V, Bibliography.

[116] Ibid.

[117] See UNEP, 2004c in annex V, Bibliography.

[118] See UNEP, 2001 in annex V, Bibliography.

[119] See UNEP, 1998 in annex V, Bibliography.

filtration and disposed of to landfill. The used catalyst is washed with water in order to remove sodium chloride, and can be reused several times for the CD process.

221. *Energy requirements*: The PCD process requires 3 MJ/kg PCB for mercury lamps. The energy requirement is expected to be relatively low owing to the low operating temperatures (75°C) associated with the PCD and CD process (Watanabe et al., 2002; Watanabe et al., 2003).

222. Material requirements:

(a) Alkali: NaOH (NaOH/Cl = 1:3);

(b) Catalyst: 2 kg/m^3 by volume of the hydrogen donor;

(c) Hydrogen donor: IPA.

223. *Portability*: Modular, transportable plants should be available. A fixed plant has been established in Kawasaki, Japan.

224. *Health and safety*: In general, the health and safety risks associated with operation of this technology are regarded as low (Watanabe et al., 2002; Watanabe et al., 2003; Sasaki et al., 2003).

225. *Capacity*: The PCD and CD technology is available with a capacity of 50 kg oil per day by one unit. The capacity could be flexible owing to the size of facility (e.g., either lower than or as high as 2 ton/day)

226. *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).

227. *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).

228. *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). Toshiba Corporation sells licenses for operation of the technology.

229. *Additional information*: For further information, see the Technical Guideline for treatment of PCBs in Japan (Japan Industrial Waste Management Foundation, 1999) and also Watanabe et al., 2002; Watanabe et al., 2003; Sasaki et al., 2003; Noma et al., 2002; and Noma et al., 2003.

(h) Plasma arc[120]

230. *Process description*: The Plascon™ process uses a plasma arc with temperatures in excess of 3,000°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.[121]

231. *Efficiency*: Bench-scale tests with oils containing 60 per cent PCBs have achieved DREs ranging from 99.9999 to 99.999999 per cent.[122]

232. *Waste types*: In addition to PCB oils, a Plascon™ plant in Australia has recently been configured to treat pesticide wastes.[123] Waste types to be treated must be liquid or gas, or solid if in the form of a fine slurry which can be pumped. Very viscous liquids or sludges thicker than 30–40 weight motor oil cannot be processed without pre-treatment. Other solid wastes cannot be treated unless some form of pre-treatment is undertaken.[124]

---

[120] 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, Bibliography.

[121] See CMPS&F – Environment Australia, 1997 in annex V, Bibliography.

[122] See Rahuman et al., 2000 and UNEP, 2004b in annex V, Bibliography.

[123] See UNEP, 2004b in annex V, Bibliography.

[124] See CMPS&F – Environment Australia, 1997 and UNEP, 2004b in annex V, Bibliography.

233. *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.[125]

234. *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.[126] 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.[127] POP concentrations in solid residues are unknown.[128]

235. *Release control and post-treatment*: Currently, there is little information available regarding post-treatment requirements.

236. *Energy requirements*: A 150 kW Plascon™ unit requires 1,000–3,000 kWh of electricity per tonne of waste.[129]

237. *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.[130]

238. *Portability*: Plascon™ is available in transportable and fixed units.[131]

239. *Health and safety*: Since the Plascon™ process has a low throughput, there is a low risk associated with release of partially treated wastes following process failure.[132] Currently, there is little additional information available regarding health and safety.

240. *Capacity*: A 150 kW Plascon™ unit can process 1–3 tons per day of waste.[133]

241. *Other practical issues*: It should be noted that metals or metal-like compounds (e.g., arsenic) may interfere with catalysts or cause problems in disposing of the residue. For example, arsenicals in pesticide waste exported from Pacific islands for disposal in Australia using the Plascon™ process have presented a particular problem for that project.

242. *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.

243. *Vendors*: The vendor for the Plascon™ process is SRL Plasma Pty Ltd., Narangba, Australia (www.srlplasma.com.au) and the 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

244. *Process description*: PCBs in insulating oils are dechlorinated by 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).

245. *Efficiency*: DEs of 99.98–99.9999 per cent 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.

246. *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.

---

[125] Ibid.

[126] See CMPS&F – Environment Australia, 1997 and Rahuman et al., 2000 in annex V, Bibliography.

[127] See UNEP, 2004b in annex V, Bibliography.

[128] Ibid.

[129] See CMPS&F – Environment Australia, 1997 in annex V, Bibliography.

[130] See CMPS&F – Environment Australia, 1997 and UNEP, 2004b in annex V, Bibliography.

[131] See UNEP, 2004b in annex V, Bibliography.

[132] See CMPS&F – Environment Australia, 1997 and UNEP, 2004b in annex V, Bibliography.

[133] Ibid.

247. *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 more easily with the water than with the chlorine in PCBs. Therefore, water in the oils should be removed before the reaction.

248. *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 owing to the very fast dechlorination rate, which causes chlorine to be released quickly (Takigami, Sakai and Oono, 2002a and 2002b).

249. *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.

250. *Energy requirements*: Energy requirements are expected to be relatively low owing to the low operating temperatures associated with t-BuOK process.

251. *Material requirements*: When the PCB content in the mineral oils is below 200 ppm, the amount of t-BuOK required is about 0.5 per cent by weight of the contaminated oils.

252. *Portability*: This process is available in fixed and transportable configurations depending on the volume of the contaminated oil to be treated.

253. *Health and safety*: In general, the health and safety risks associated with the operation of this technology are considered to be low.

254. *Capacity*: It has been reported that 36,000 litres per day of contaminated oil have been treated in Japan using this technology.

255. *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 operated continuously.

256. *State of commercialization*: A company in Japan has been treating contaminated mineral oils since 2004 in a continuously operated plant.

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

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

(j) Supercritical water oxidation (SCWO) and subcritical water oxidation[134]

259. *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 below 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.

260. *Efficiency*: DEs of greater than 99.999 per cent and DREs of greater than 99.9999 per cent have been reported for aldrin, 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 per cent have been reported for subcritical water oxidation (Ministry of the Environment of Japan, 2004). DREs as high as 99.9999 per cent have also been demonstrated for PCDDs in bench-scale tests.[135]

261. *Waste types*: SCWO and subcritical water oxidation are thought to be applicable to all POPs[136] (Japan Industrial Waste Management Foundation, 1999). Applicable waste types include aqueous wastes, oils, solvents and solids with a diameter of under 200 µm. The organic content of the waste is limited to below 20 per cent.[137]

---

[134] 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, Bibliography.

[135] See CMPS&F – Environment Australia, 1997; Rahuman et al., 2000 and Vijgen, 2002 in annex V, Bibliography.

[136] See UNEP, 2004b in annex V, Bibliography.

[137] See CMPS&F – Environment Australia, 1997; Rahuman et al., 2000 and Vijgen, 2002 in annex V, Bibliography.

262. *Pre-treatment*: Concentrated wastes may have to be diluted prior to treatment in order to reduce the organic content to below 20 per cent. In the case of subcritical water oxidation, dilution of wastes is not necessary. If solids are present, they must be reduced to under 200 µm in diameter.

263. *Emissions and residues*: During laboratory-scale PCB destruction, it was shown that the SCWO technology has the potential to form high concentrations of PCDFs (in the per cent 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 oxides of sulphur and that process residues consist of water and solids if the waste contains inorganic salts or organic compounds with halogens, sulphur or phosphorus.[138] Limited information has been reported regarding potential concentrations of undestroyed chemicals.[139] The process is designed so that emissions and residues can be captured for reprocessing if needed.[140]

264. *Release control and post-treatment*: Currently, there is no specific information available regarding post-treatment requirements.

265. *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 the feed to supercritical temperatures.[141]

266. *Material requirements*: The SCWO and subcritical water oxidation reaction vessel must be constructed of materials capable of resisting corrosion caused by halogen ions.[142] 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.[143]

267. *Portability*: The SCWO and subcritical water oxidation units are currently used in a fixed configuration, but are thought to be transportable.[144]

268. *Health and safety*: The high temperatures and pressures used in this process require special safety precautions.[145]

269. *Capacity*: Current SCWO demonstration units are capable of treating 500 kg/h, while full-scale units will be designed to treat 2,700 kg/h.[146]

270. *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.[147]

271. *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-weapon destruction programme of the United States of America.

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

(a) Foster Wheeler Development Corporation (www.fosterwheeler.com);

(b) General Atomics (www.ga.com);

(c) Mitsubishi Heavy Industries, Ltd. (www.mhi.co.jp).

---

[138] See CMPS&F – Environment Australia, 1997 in annex V, Bibliography.

[139] See CMPS&F – Environment Australia, 1997 and UNEP, 2004b in annex V, Bibliography.

[140] See UNEP, 2004b in annex V, Bibliography.

[141] See Rahuman et al., 2000 in annex V, Bibliography.

[142] See Vijgen, 2002 in annex V, Bibliography.

[143] Ibid.

[144] See UNEP, 2004b and Vijgen, 2004 in annex V, Bibliography.

[145] See CMPS&F – Environment Australia, 1997 in annex V, Bibliography.

[146] See UNEP, 2004b and Vijgen, 2002 in annex V, Bibliography.

[147] Ibid.

(k) Thermal and metallurgical production of metals

273. *Process description*: The processes described below are primarily designed for the recovery of iron and non-ferrous metals (NFM) e.g. aluminium, copper, zinc, lead and nickel from ore concentrates as well as from secondary raw materials (intermediates, wastes). However, due to the nature of the processes they are in some cases also used on a commercial basis for the destruction of the POP content of appropriate wastes (see paragraph 275). A general description of some of the following processes may also be found in the European BAT reference documents[148],[149]:

(a) Processes which are relevant for the destruction of the POP content in iron-containing wastes use certain types of blast furnace, shaft furnace or hearth furnace. All these processes operate under reducing atmospheres at high temperatures (1200°C–1450°C). The high temperature and the reducing atmosphere destroy PCDDs and PCDFs contained in the wastes and avoid de novo synthesis. The blast furnace and the shaft furnace processes use coke and small amounts of other reducing agents to reduce the iron-containing input to cast iron. There are no direct emissions of process gas as it is used as a secondary fuel. In the hearth furnace process, the iron-containing material is charged to a multi-hearth furnace together with coal. The iron oxide is directly reduced to solid direct reduced iron (DRI). In a second step the reduced iron is melted in an electric arc furnace to produce cast iron;

(b) Processes which are relevant for the destruction of the POP content in wastes containing NFMs are the Waelz rotary kiln process and bath melting processes using vertical or horizontal furnaces. These processes are reductive, reach temperatures of 1200°C and use rapid quenching thus PCDDs and PCDFs are destroyed and de novo synthesis is avoided. In the Waelz process zinc-containing steel mill dusts, sludges, filter cakes, etc. are pelletized and smelted together with a reductant. At temperatures of 1200°C, the zinc volatizes and is oxidized to “Waelz Oxide”, which is collected in a filter unit. In the vertical bath furnace process, copper-containing residues are smelted at temperatures of at least 1200°C. The filter dust is used for the production of zinc and zinc compounds. In the horizontal bath furnace process, lead-containing residues and ore concentrates are charged continuously into a smelting bath which has an oxidizing and a reducing zone with temperatures between 1000° and 1200°C. The process gas (SO2 concentration above 10 per cent) is used for sulphuric acid production after heat recovery and de-dusting. The dust from the process is recycled after cadmium leaching.

274. *Efficiency:* Data on DE or DRE are not available.

275. *Waste types:* The processes described in paragraph 273 above are specific to the treatment of the following wastes:

(a) Residues from iron- and steel-making processes such as dusts or sludges from gas treatment or mill scale that may be contaminated with PCDDs and PCDFs;

(b) Zinc-containing filter dusts from steelworks, dusts from gas cleaning systems of copper smelters etc. and lead-containing leaching residues of NMF production that may be contaminated with PCDDs and PCDFs.

276. *Pre-treatment:* Iron-containing materials recycled by the conventional blast furnace process require pre-treatment in an agglomeration plant. For the shaft furnace (“Oxycup” furnace) process the iron-containing waste is briquetted. This is a cold process in which a binder and water is added to the fines, which are then pressed to briquettes, dried and hardened. Generally no pre-treatment is necessary for the multi-hearth furnace process, although under in some special cases the fine solids may have to be pelletised. This involves only the addition of water and the formation of pellets in a drum. Special pre-treatment of materials contaminated with POPs is not usually necessary for NFMs.

277. *Emissions and residues:* In iron and NFM production PCDDs and PCDFs may be formed within the process or downstream in the flue gas treatment system. Application of BAT should, however, prevent or at least minimize such emissions. Where the processes described in paragraph 273 above are used for the destruction of POPs wastes appropriate release control and post-treatment techniques are required (see paragraph 279 below). When such techniques are employed, air emissions of PCDDs and PCDFs from these processes are below 0.1 ng TEQ/Nm3. Slags are in many cases used for construction

---

[148] European Commission, 2001a in annex V, Bibliography

[149] European Commission, 2001b in annex V, Bibliography

purposes. For iron metals, emissions can occur from pre-treatment in an agglomeration plant and also in the off-gas from the melting furnace. Residues from de-dusting systems are mainly used in the NFM industry. The off-gas of the multi-hearth furnace is de-dusted by a cyclone, underlies a post-combustion, is quenched and cleaned by addition of adsorbant and a bag filter. The off-gas of the melting furnace also underlies a post-combustion and is quenched before it is mixed up with the off-gas of the multi-hearth furnace for the joint adsorbance step. For NFMs, residues include filter dusts and sludges from waste water treatment.

278. *Release control and post-treatment:* Control of temperatures and rapid quenching are often suitable means of minimizing PCDD and PCDF formation. Process gases require treatment to remove dust which consists mainly of metals or metal oxides as well as sulfur dioxide when smelting sulfidic materials. In the ferrous metals industry waste gases from agglomeration plants are treated by an electrostatic precipitator followed by further flue gas treatment, e.g., adsorption techniques followed by an additional bag filter. The off-gases from multi-hearth furnaces are de-dusted by a cyclone and subjected to treatment by post-combustion, quenching and further cleaning by addition of adsorbant followed by a bag filter. The off-gases from the associated melting furnaces also require post-combustion and quenching and are then combined with the off-gas stream from the multi-hearth furnaces for further treatment by addition of absorbant followed by a bag filter. In NFM production suitable treatment techniques include, inter alia, the use of fabric filters, electrostatic precipitators or scrubbers, sulfuric acid plants or adsorption techniques with activated carbon.

279. *Energy requirements:* Production processes for iron and NFM are energy-intensive with significant differences between different metals. The treatment of the POP content in wastes within these processes requires little additional energy.

280. *Material requirements:* For production of metals, raw materials (ores, concentrates or secondary material) are used as well as additives (e.g., sand, limestone), reductants (coal and coke) and fuels (oil and gas). Temperature control to avoid de novo synthesis of PCDDs and PCDFs requires additional water for quenching.

281. *Portability:* Metal smelters are large and fixed installations.

282. *Health and safety:* The treatment of wastes within thermal processes can be regarded as safe if properly designed and operated.

283. *Capacity:* Metal smelters described above have feedstock capacities above 100,000 tonnes per year. Current experience with the addition of wastes contaminated with POPs to the feedstock involves much smaller quantities but the capability for treating larger quantities may well exist and is being explored.

284. Other practical issues: None

285. *State of commercialization:* Cast iron production from iron-containing materials of iron and steel production in a conventional blast furnace has been in operation for some years in Germany (www.dk-duisburg.de). A shaft furnace (“Oxycup furnace”) has been in operation since 2003 in Germany (www.thyssenkrupp.com). The hearth furnace process has been in operation on an industrial scale in Luxembourg since 2003 (www.paulwurth.com) and in Italy (www.lucchini.it). The Waelz rotary kiln process is well-established and is covered by BAT operating at different sites in Europe (www.bus-steel.com). The vertical bath melting process is operating in Germany (www.na-ag.com) as is the horizontal bath melting process (www.berzelius.de).

286. *Vendors:* As the primary use of plants operating these processes is not the destruction of the POP content in wastes there are no vendors of plants dedicated to this purpose.

(l) Waste-to-gas conversion

287. *Process description:* The process[150] is a gasification pre-treatment and treatment technology for the recovery of hydrocarbon-containing waste operating at high temperatures (1300°C–2000°C) and high pressure (about 25 bar) using steam and pure oxygen in a reducing atmosphere[151]. All hydrocarbon molecules in the waste are irreversibly cleft into small gaseous molecules such as hydrogen (H2) and carbon monoxide (CO), methane (CH4) and carbon dioxide (CO2). Short-chain hydrocarbons such as

---

[150] B. Buttker et al., 2005 in annex V, Bibliography

[151] Three types of gasifiers are operated by SVZ: pressurized bed gasifier, slagging gasifier BGL, entrained flow gasifier.

ethane (C2H6), propane (C3H8) and butane (C4H10) and other compounds are produced in small amounts (< 1 vol. %). Persistent organic pollutants including PCBs contained in the waste are effectively destroyed. The resulting raw gas is subsequently converted in a multistage process to pure synthesis gas for the production of highest-grade methanol.

288. *Efficiency:* DEs of 99.974 per cent have been reported for PCDDs and PCDFs[152].

289. *Waste types:* The process is suitable for a large variety of organic waste in different physical forms, i.e., solids, liquids, sludge and slurry containing or contaminated with POPs. Wastes containing or contaminated with PCBs (up to 500 mg/kg waste) and PCDDs/PCDFs (up to 50.000 ng TEQ/kg) may be treated. The chlorine levels in the hazardous waste can reach up to 6 wt. % (fluids) and 10 wt. % (solids).

290. *Pre-treatment:* Step (a): size reduction is required for solid waste with pieces extending 80 x 140 mm. Solid waste with pieces not extending 80 x 140 mm directly undergoes step (b). Ferrous and non ferrous metals are removed from solid wastes. After pelletizing, the waste undergoes step (b). In the case of liquid and pasty waste, sludge, solids and water are separated by sedimentation and density separation. The pre-purified oil is destilled in order to reach water content of < 1%. There is no water content restriction for slurry products to be fed into the entrained flow gasifier. Step (b): Gasification of waste (including drying and degassing) generates raw gas for further processing.

291. *Emissions and residues*: Sulphur and nitrogen compounds contained in the raw gas are removed in the gas processing facilities emission-free, in a sealed pressure system. Traces of POPs (0.0034 ng TEQ/Nm^3)[153] in the raw gas are finally destroyed in the entrained-flow gasifier at temperatures of 2000°C. PCBs, PCDDs and PCDFs have not been detected by analytic means in the methanol produced and in water, slag and gypsum. The vitrified slag may contain heavy metal compounds; that slag is capable of being recycled e.g., into insulating materials. Since the waste-to-gas conversion process takes place in a reducing atmosphere the possibility of the formation of PCDDs and PCDFs is limited. PCDDs and PCDFs emissions to air are reported as follows: Desulfurization plant 0.0006 ng TEQ/Nm^3; boiler plant 0.0029 ng TEQ/Nm^{3}[154].

292. *Release control and post-treatment*: CO_2 and other gases are removed already from the raw gas in separate fractions using an organic adsorbent (methanol) at subzero temperatures. Flammable gases are burned in a boiler plant; high quality steam is generated from this process.

293. *Energy requirements*: The waste is treated with a gasification mixture containing at least 15 wt. % coals in order to ensure stable process conditions. No additional energy in the form of electricity or steam is necessary.

294. *Material requirements*: There is a need for a gasification agent (steam and oxygen) for the gasification technologies used. Other material requirements include calcium carbonate (limestone) to influence viscosity of slag.

295. *Portability*: The gasification technology is available only in fixed configurations.

296. *Health and safety*: The process effectively destroys POPs in a closed loop system without endangering human health or the environment. Use of hydrogen gas under pressure requires suitable controls and safeguards to ensure that explosive air-hydrogen mixtures are not formed. Operating experience gained from 1992 to date has indicated that the process can be undertaken safely.

297. *Capacity*: Per year about 300,000 tonnes of solid and about 60,000 tonnes of liquid and pasty wastes can be treated.

298. *Other practical issues*: As large quantities are handled, appropriate and environmentally compatible storage capacities are required.

299. *State of commercialization:* Commercial scale waste gasification is operated in Germany since 1992 in the Sekundärrohstoff-Verwertungszentrum Schwarze Pumpe (SVZ). More than 2.5 million tonnes of waste have been treated within the last ten years.

---

[152] Reported DE mainly depends on low PCDD/F-concentration of 34.08 ng TEQ/kg in treated waste. DE is 99.99143 when PCDD/F-concentration in waste reachs 50.000 ng TEQ/kg. See B. Buttker et al., 2006.

[153] B. Buttker et. al., 2006 in annex V, Bibliography

[154] Ibid.

300. *Vendors*: Sustec Holding holds the patent for the entrained flow gasifier technology. Sustec sells licences to operate the technology. Licenses to operate the slagging gasifier technology are sold by Sustec Schwarze Pumpe Inc. together with Envirotherm Inc (www.svz-gmbh.de/).

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

301. Where neither destruction nor irreversible transformation is the environmentally preferable option, for wastes with a POP content above the low POP content referred to in subsection A of section III above countries may allow such wastes to be disposed of by other methods than the methods referred to in subsection IV.G.2.

302. 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 wastes 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;

(c) The following construction and demolition wastes:

  (i) Mixtures of, or separate fractions of, concrete, bricks, tiles and ceramics;

  (ii) The inorganic fraction of soil and stones, including excavated soil from contaminated sites;

  (iii) Construction and demolition wastes containing PCBs, excluding equipment containing PCBs;

(d) Wastes from the incineration or pyrolysis of waste, including solid wastes from gas treatment, bottom ash, slag, fly ash and boiler dust;

(e) Vitrified wastes and waste from vitrification, including fly ash and other flue-gas treatment wastes and non-vitrified solid phase wastes.

303. The relevant authority of the country concerned should be satisfied that neither destruction nor irreversible transformation of the POP content, performed according to best environmental practice or best available techniques, is the environmentally preferable option.

304. Other disposal methods when neither destruction nor irreversible transformation is the environmentally preferable option include those described below.

(a) Specially engineered landfill[155]

305. Any landfilling should 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 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

---

[155] Further information is available within Technical Guidelines on Specially Engineered Landfill (D5), UNEP, 1995d, in annex V, Bibliography, and pertinent national legislation such as the European Directive 1999/31/EC.

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 the 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.

306. 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;

(d) Explosives, flammable solids, spontaneously combustible materials, water-reactive materials, oxidizers and organic peroxides.

(b) Permanent storage in underground mines and formations

307. Permanent storage in facilities located underground in geohydrologically isolated 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 to 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.

308. 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, emit toxic gases or are explosive, flammable or infectious should not be stored underground in mines. Operational permits should define waste types that should be generally excluded.

309. 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 reopened for mining;

(b) Caverns or tunnels should be located in geological 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;

(c) Caverns and tunnels should be located in geological formations that are extremely stable and not in areas subject to earthquakes.

4. Other disposal methods when the POP content is low

310. If wastes containing or contaminated with POPs at concentrations under the low POP content are not disposed of with the methods described above, they should be disposed of 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 given in annex II to the present guidelines.

H. Remediation of contaminated sites

1. Contaminated site identification[156]

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

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

(a) Identification of suspect sites, such as sites involved in:

(i) Manufacture of POPs;

(ii) Formulation of pesticides and filling and retrofilling of transformers;

(iii) Usage of POPs, such as, application of pesticides and placement 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) An initial testing programme to confirm the presence or absence of suspected contaminants and characterize the physical conditions at the suspected site;

(d) A detailed testing programme to identify the nature of the site contamination and gather any additional information required.

2. Environmentally sound remediation[157]

313. Contaminated site criteria developed by governments using risk assessment techniques are used as general targets in site remediation. Separate criteria can be developed or adopted for soil, sediment and groundwater. Often, a distinction is made between industrial (least stringent criteria), commercial, residential and agricultural (most stringent criteria) soils. Examples of such criteria can be found in the German federal soil protection and contaminated sites ordinance, the Swiss soil burden ordinance and the Canadian environmental quality guidelines.[158]

I. Health and safety[159]

314. In general, there are three main ways to protect workers and members of the public from chemical hazards (in order of preference):

(a) Keep workers and members of the public away from all possible sources of contamination;

(b) Control the contaminants so that the possibility of exposure is minimized;

(c) Protect workers by ensuring that personal protective equipment is used.

315. Information on health and safety is also available from ILO (1999a and 1999b), WHO (1995 and 1999), IPCS INCHEM (various dates) and United Kingdom Health and Safety Executive guidance note HS(G)66 “Protection of workers and the general public during the development of contaminated land”. Examples of practical implementation can be found in UNEP 2001.

---

[156] 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, Bibliography.

[157] 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, Bibliography

[158] See Canadian Council of Ministers of the Environment, 2002 in annex V, Bibliography.

[159] 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, Bibliography.

316. 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 each specific facility should be developed by a trained health and safety professional with experience in managing the health risks associated with the specific POPs at the facility.

317. All health and safety plans should adhere to the above principles and recognize local or national labour standards. Most health and safety programmes recognize various levels of safety, with risk levels depending on the site in question and the nature of the contaminated materials found there. The level of protection provided to workers should correspond to the level of the risk to which they are exposed. Levels of risk should be established and each situation should be evaluated by health and safety professionals. Two situations are discussed below: higher-risk and lower-risk.

1. Higher-risk situations

318. Higher-risk situations occur where high concentrations of POPs or high volumes of wastes consisting of, containing or contaminated with POPs are found and a high potential for exposure is present. Such situations may potentially expose workers and the general population. Particular efforts should be made to minimize public exposure. In addition, guidance should be provided to ensure that the public is aware of the potential risk and of the measures to be taken in cases of exposure.

319. There is no international, quantitative definition of high volume or high concentration. Workers and employers can be guided by the advice and input of health and safety professionals, labour representatives, the scientific literature and government authorities. Potential higher-risk situations may occur:

(a) At sites producing, handling, and using POPs;

(b) At stockpiles of and large-volume storage sites for chemicals or wastes consisting of, containing or contaminated with POPs;

(c) At facilities for the treatment or disposal of wastes consisting of, containing or contaminated with POPs;

(d) At sites contaminated with high concentrations of POPs at or near the surface.

320. At a minimum, POPs health and safety planning for higher-risk situations should include the following elements:

(a) A written health and safety plan (HASP) should be developed and posted at each site;

(b) Workers who are to have access to the site should read the HASP and sign to confirm that they have read and understood it;

(c) The HASP may be written to encompass all hazards at the site but should have a section or chapter specifically detailing procedures for POPs;

(d) Workers should be present at the site only when necessary for servicing or inspecting equipment or stored materials;

(e) Workers entering the 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) Routine air monitoring should be carried out to detect the presence of POP contaminants;

(h) When appropriate, workers entering the 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 POPs;

(j) Workers who are or are expected to be routinely entering sites or working with POP substances should undergo medical monitoring, including a baseline medical examination;

(k) Where POPs are to be handled in an open system or where it is reasonably expected that the protective clothing of a worker may be contaminated with POPs, 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 health and safety at the site.

2. Lower-risk situations

321. There is also no definition of low volume or low concentration. These should be determined by comparing contaminant levels with government guidelines or by conducting site-specific risk assessments. Lower-risk situations may include:

(a) Sites that contain materials contaminated with POPs in small quantities or at low concentrations;

(b) Controlled storage rooms that contain small quantities of POPs;

(c) Sites contaminated with low concentrations of POPs or where the contamination cannot come directly into contact with people.

322. 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 POPs.

J. Emergency response[160]

323. 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 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 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;

---

[160] 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).

(l) Regular testing of emergency response equipment and review of emergency response plans.

324. Emergency response plans should be prepared jointly by interdisciplinary teams that include emergency response, medical, chemical and technical personnel and also representatives of labour and management. When applicable, representatives of potentially impacted communities should also be included.

K. Public participation

325. 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.

326. 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.

327. 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.

328. 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 persons or groups. This means that a general invitation to comment is given through regular media outlets, the internet, or by 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;

(i) Other levels of government.

329. 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 website.

330. 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”.[161]

---

[161] See Australia Department of the Environment and Heritage, 2000 in annex V, Bibliography.

Appendix 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 Environmental 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.

Appendix 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	• Contains stringent limit values on PCBs, PCDDs and PCDFs in sewage sludge used as fertilizer.
Brazil	Norm ABNT/NBR, N° 8371/1997	• Procedures for handling, transport and storage of materials containing PCBs
Brazil	Resolution CETESB (São Paulo state), N° 007/1997	• Determines limits for PCDDs and PCDFs on emissions from medical waste incinerators with capacity > 200 kg/day
Brazil	Resolution CONAMA, N° 264/1999	• Procedures for environmental licensing on waste co-processing in cement kilns
Brazil	Resolution CONAMA, N° 313/2002	• Provides for an inventory of PCB stocks and industrial wastes
Brazil	Resolution CONAMA, N° 316/2002	• Procedures and criteria for operating thermal wastes treatment systems, provides limits on emissions of PCDDs and PCDFs
Brazil	Resolution CONAMA, N° 334/2003	• Procedures for environmental licensing for those establishments responsible for receiving pesticides package
Brazil	Decision CETESB (São Paulo state), N° 26/2003	• Sets limits for air emissions of PCDDs and PCDFs of cement kilns treating also waste
Brazil	Resolution CONAMA, N° 357/2005	• Provides maximum permitted levels for POPs in effluents discharged to water
Canada	Federal Mobile PCB Treatment and Destruction Regulations	• Contains emission standards for release of gases, liquids and solids contaminated with PCBs, PCDDs and PCDFs.
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, amended by Council Regulation (EC) No. 1195/2006 of 18 July 2006 amending Annex IV to Regulation (EC) No. 850/2004	• Article 7 contains provisions regarding the management of wastes containing, consisting of or contaminated with POPs.
European Community	Council Directive 96/59/EC of 16 September 1996 on the disposal of polychlorinated biphenyls and polychlorinated terphenyls (PCB/PCT)	• Contains regarding the disposal of PCBs and PCTs, inter alia on the decontamination and/or disposal of equipment and the PCBs therein.
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	• Annex II contains emission limit values for discharge of aldrin, dieldrin, endrin and HCB-contaminated waste water produced during production.
European Community	Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste	• Annex IV contains emission limit values for discharges of PCDD and PCDF contaminated waste water from the cleaning of exhaust gases. • Annex V contains air emission values for PCDDs and PCDFs

Country	Legislation	Brief description
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	• Paragraph 2.1.2.2 of the Annex contains criteria for landfill of inert waste containing PCBs.
Finland	Council of State decision (1071/1989) on the restriction of the use of PCBs and PCTs	• Contains limit values for PCBs and PCTs
Finland	Council of State decision (101/1997) on oil waste management	• Contains limit values for PCBs in regenerated oil and in oil wastes destined for incineration
Finland	Council of State decision (711/1998) on the disuse of PCB appliances and the treatment of PCB waste	• Contains limit values for PCBs
Finland	Council of State decree (1129/2001) on a list of the most general wastes and hazardous wastes	• Contains limit values for PCBs
Germany	Federal Soil Protection and Contaminated Sites Ordinance	• Contains action levels regarding sites contaminated with aldrin, DDT, HCB, PCBs, PCDDs and PCDFs.
Germany	Ordinance on Landfills and Long-Term Storage Facilities	• Contains a limit for PCBs in soils used as recultivation layers of landfills. • Prohibits the landfilling of waste, which may harm public welfare due to its content of long-lived or bio-accumulable toxic substances.
Germany	Ordinance on Underground Waste Storage	• Contains limits for use of waste contaminated with PCBs as stowage material.
Germany	Sewage Sludge Ordinance	• Contains limits for usage of sewage sludge contaminated with PCBs, PCDDs and PCDFs as fertilizer.
Germany	Waste Wood Ordinance	• Contains limits for recycling of waste wood contaminated with PCBs.
Germany	Waste Oil Ordinance	• Contains limits for recycling of PCB contaminated oils.
Japan	Law Concerning Special Measures Against Dioxins	• 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.
Japan	Law Concerning Special Measures Against PCB Wastes	• Contains standards for the treatment of plastics and metals contaminated with PCBs.
Japan	Law Concerning Special Measures Against Soil Contamination	• Contains standards for the treatment of soil contaminated with PCBs.
Japan	Waste Management and Public Cleansing Law	• Contains criteria of hazardous wastes containing PCBs, PCDDs, PCDFs and co-planar PCBs.
Japan	Water Pollution Control Law	• Contains emission standards for effluent containing PCBs.
Mexico	Norm NOM-098 of 2004	• Contains emission and destruction efficiency standards for waste incinerators.
Mexico	Norm NOM-133 of 2001	• Contains regulations regarding handling of PCBs and a programme for the preparation of inventories.
Norway	Norwegian Product Regulation chapters 2 and 3 on regulated hazardous substances or a mix of substances and products containing hazardous substances	• Contains a ban on the production, use, import and export of PCBs, PCTs and products containing these substances, including PCB-containing capacitors.
Norway	Norwegian Waste Regulation chapter 14 on obsolete insulation windows that contain PCB	• Lays down requirements for the producers to collect and handle obsolete windows that contain PCBs.
Norway	Norwegian Pollution Regulation chapter 2 on clean-up of contaminated sites	• Contains limit values below which a soil is considered to be clean and suitable for use in

Country	Legislation	Brief description
		sensitive areas.
Switzerland	Soil Burden Ordinance	- Contains actions levels regarding sites contaminated with PCBs, PCDDs and PCDFs.
United States of America	EPA 40 CFR 63 Subpart EEE National Emission Standards for Hazardous Air Pollutants from Hazardous Waste Combustors	- Contains standards for releases of PCDDs and PCDFs within air emissions.
United States of America	40 CFR 268.48 Universal Treatment Standards for Hazardous Wastes	- Contains standards for the treatment of hazardous waste prior to land disposal and aqueous waste prior to release. Covers all POPs except mirex.
United States of America	40 CFR 761.70 Standards for incineration of PCBs	- Contains standards for air emissions, when incinerating PCBs

Appendix III

Selected analytical methods for POPs

1. Aldrin

(a) AOAC Official Method 970.52 Organochlorine and Organophosphorous Pesticide Residue Method. General Multiresidue Method. 2005 AOAC International

(b) AOAC Official Method 955.22 Organochlorine and Organophosphorous Pesticide Residue Method

(c) EPA Method 8081A: Organochlorine Pesticides by Gas Chromatography (and ECD)

(d) ISO 6468 (1996) Water quality – Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzenes – Gas chromatographic method after liquid-liquid extraction

(e) ISO 10382 (2002): Soil quality – Determination of organochlorine pesticides and polychlorinated biphenyls – Gas-chromatographic method with electron capture detection

2. DDT

(a) AOAC Official Method 970.52 Organochlorine and Organophosphorous Pesticide Residue Method. General Multiresidue Method. 2005 AOAC International

(b) AOAC Official Method 955.22 Organochlorine and Organophosphorous Pesticide Residue Method

(c) EPA Method 4042: Soil screening for DDT by immunoassay, EPA analytical chemistry guidance SW-846

(d) EPA Method 8081A: Organochlorine Pesticides by Gas Chromatography (and ECD)

(e) ISO 6468 (1996) Water quality – Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzenes – Gas chromatographic method after liquid-liquid extraction

(f) ISO 10382 (2002): Soil quality – Determination of organochlorine pesticides and polychlorinated biphenyls – Gas-chromatographic method with electron capture detection

3. HCB

(a) AOAC Official Method 970.52 Organochlorine and Organophosphorous Pesticide Residue Method. General Multiresidue Method. 2005 AOAC International

(b) AOAC Official Method 955.22 Organochlorine and Organophosphorous Pesticide Residue Method

(c) EPA Method 8081A: Organochlorine Pesticides by Gas Chromatography (and ECD)

(d) ISO 6468 (1996) Water quality – Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzenes – Gas chromatographic method after liquid-liquid extraction

(e) 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) 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

(g) EPA Method 4020: Screening for polychlorinated biphenyls by immunoassay (www.epa.gov/epaoswer/hazwaste/test/pdfs/4020.pdf)

(h) EPA Method 8080: Organochlorine Pesticides and PCBs

(i) EPA Method 8082: Polychlorinated biphenyls (PCBs) by gas chromatography (www.epa.gov/epaoswer/hazwaste/test/pdfs/8082.pdf)

(j) EPA Method 8275A: Semivolatile organic compounds (PAHs and PCBs) in soils/sludges and solid wastes using thermal extraction/gas chromatography/mass spectrometry (TE/GC/MS), EPA analytical chemistry guidance SW-846

(k) EPA Method 9078: Screening test method for polychlorinated biphenyls in soil (www.epa.gov/epaoswer/hazwaste/test/pdfs/9078.pdf)

(l) EPA Method 9079: Screening test method for polychlorinated biphenyls in transformer oil (www.epa.gov/epaoswer/hazwaste/test/pdfs/9079.pdf)

(m) ISO 6468 (1996) Water quality – Determination of certain organochlorine insecticides, polychlorinated biphenyls and chlorobenzenes – Gas chromatographic method after liquid-liquid extraction

(n) ISO 10382 (2002): Soil quality – Determination of organochlorine pesticides and polychlorinated biphenyls – Gas-chromatographic method with electron capture detection

(o) JIS K 0093 (2002): Testing method for polychlorobiphenyl in industrial water and wastewater

(p) Methods for Examining Standards of General Wastes under Special Control and Industrial Waste under Special Control, Notice 192 of the Japan Ministry of Welfare and Labour, 3 July 1992

(q) 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

(r) Norm NBR N° 13882:1997: Electrical Insulating Liquids - Determination of PCB contents

(s) Norwegian Institute for Water Research method no. H 3-2: Determination of organochlorine compounds in sediments, water and biological material by gas chromatography

(t) 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

(u) 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

5. PCDDs and PCDFs

(a) EN 1948 (draft 2006): Stationary source emissions – determination of the mass concentration of PCDDs/PCDFs and dioxin-like PCBs. Part 1 Sampling, Part 2: Extraction and clean-up of PCDDs/PCDFs, Part 3: Identification and quantification of PCDDs/PCDFs, Part 4: Sampling and analysis of dioxin-like PCBs

(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) EPA Method 1613: Tetra-through Octa-Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS, October 1994, (www.epa.gov/waterscience/methods/1613.pdf)

(d) 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)

(e) 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

(f) EPA Method T09: Determination of polychlorinated dibenzo-p-dioxins (PCDDs) in ambient air using high-resolution mass spectrometry (HRGC/HRMS)

(g) EPA Method 8280A: The analysis of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans by high resolution gas chromatography/low resolution mass spectrometry (HRGC/LRMS) (EPA analytical chemistry guidance SW-846)

(h) EPA Method 8290: Polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) by high-resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS) (EPA analytical chemistry guidance SW-846)

(i) EPS (1990): A Method for the Analysis of Polychlorinated Dibenzo-*para*-Dioxins (PCDDs), Polychlorinated Dibenzofurans (PCDFs) and Polychlorinated Biphenyls (PCBs) in Samples from the Incineration of PCB Waste. Reference Method 1/RM/2 and Reference Method 1/RM/3 (revised) May 1990

(j) ISO 18073 (2004): Water quality – Determination of tetra- to octa-chlorinated dioxins and furans – Method using isotope dilution HRGC/HRMS

(k) 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

(l) 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

(m) Methods for Examining Standards of General Wastes under Special Control and Industrial Waste under Special Control (Notice 192 of the Japan Ministry of Welfare and Labour, July 3, 1992)

6. Solid waste, particulate materials

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

Appendix IV

Economics of destruction and irreversible transformation methods

It should be noted that the information in table 1 and 2 below is intended only to provide a broad reference based on available cost estimates of the various destruction and irreversible transformation methods discussed in the present guidelines.

This information is not representative as several factors influence the data, such as the scarcity of data, the various points of time the data were estimated, the different currencies, the varying currency exchange rates, local costs of electricity, labour and materials, and also the quantity of waste involved and the use made of the technology (theoretically, the cost of technology should get cheaper over time).

Further information will be available in "Inventory of Worldwide PCB Destruction Capacity". The second issue is expected to be available in the near future.

Table 1: Cost estimates of destruction and irreversible transformation methods

Destruction and irreversible transformation methods	Cost estimates	Source
Alkali metal reduction[1]	i. Transformer oils: US$0.15/L, £500–1000/t, CAN$4/gallon, CAN$0.90/kg; and ii. Waste oils: CAN$0.60/kg.	Vendors UNEP 2004b
Base-catalysed decomposition (BCD)[1]	i. Licence fees vary; ii. Operating royalties: 5 per cent – 10 per cent of gross revenues/sales; iii. Capital costs (2,500-gallon BC liquid reactor): US$800,000–1.4M; iv. Operating costs: US$728–1,772 depending on the POP concentration.	Extracted in 2004 from BCD Group Inc.'s website
Catalytic hydrodechlorination (CHD)	No data available	
Cement kiln co-incineration	No data available	
Gas-phase chemical reduction (GPCR)[2]	i. AUS$4,000–6,000/ton for organochlorine pesticide solids; ii. AUS$4,000–$8,000/ton for PCBs and organochlorine pesticide liquids; iii. AUS$6,000–11,000/ton for PCB-contaminated capacitors	CMPS&F – Environment Australia 1997
Hazardous-waste incineration	See table 2 below	
Photochemical dechlorination (PCD) and catalytic dechlorination (CD) reaction	Available upon request: i. Licence fees ii. Operating royalties or costs	
Plasma arc	Capital cost[1] (150 kW Plascon™ unit): US$1 million, depending upon the configuration. Operating costs: below AUS$3,000 (including labour), typically range from AUS$1,500 to AUS$2,000 per ton. The costs depend upon factors such as: i. Waste feed – molecular structure, weight and concentration; ii. Electricity costs; iii. Argon and oxygen costs; iv. Geographic location and site specific issues; v. Caustic costs; and vi. Required emission limits.	CMPS&F – Environment Australia, 1997; Rahuman et al., 2000; UNEP, 2004b
Potassium tert-Butoxide (t-BuOK) method	No data available	

Destruction and irreversible transformation methods	**Cost estimates**	**Source**
Super-critical water oxidation (SCWO) and subcritical water oxidation	Costs: US$120–140/dry ton[3]	CMPS&F – Environment Australia, 1997

[1] It is not clear whether these estimates include potential costs associated with pre-treatment and/or disposal of residues.

[2] It is not clear whether the above includes costs associated with the pre-treatment of solid wastes.

[3] 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 (millions of euros)	
	2004[a]	**1999[b]**
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
Total investment costs	**52**	**105**
	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
Total operational costs	**14.7**	**25**
Per ton incineration costs (without revenues)	*200–300*	*350*

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

Notes:

[a] Source for figures in first column: European Commission 2004.

[b] 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

Appendix V

Bibliography

Agency for Toxic Substances and Disease Registry. Toxicological Profile Information Sheets. Available at www.atsdr.cdc.gov.

Ariizumi, A.; Otsuka, T.; Kamiyama, M.; Hosomi, M., 1997, *Dechlorination and decomposition behaviour of PCBs by the sodium dispersion process.* J. Environ. Chem., 7, pages 793–799.

Australia Department of the Environment and Heritage, 2000. A Case Study of Problem Solving Through Effective Community Consultation. Available at www.deh.gov.au/industry/chemicals/scheduled-waste/community-consultation.html.

Basel Convention, 1994. *Framework Document on Preparation of Technical Guidelines for the Environmentally Sound Management of Wastes Subject to the Basel Convention*. Document no. 94/005. Secretariat of the Basel Convention, Geneva.

Buttker, B., et al.: Full scale industrial recovery trials of shredder residue in a high temperature slagging-bed-gasifier in Germany. Sekundärrohstoff-Verwertungszentrum Schwarze Pumpe (SVZ), Technologie-Entwicklungs-GmbH für ökoeffiziente Polymerverwertung (Tecpol), Association of Plastics Manufacturers (PlasticsEurope), 2005 (www.tecpol.de/downloads/SVZ_TECPOL_REPORT_E.pdf).

Buttker, B., et. al.: Stoffliche Verwertung kunststoffreicher Abfälle im Sustec Verwertungszentrum Schwarze Pumpe (SVZ), Technical lecture given at the VDI/DECHEMA-meeting, Neumünster 2006.

Canadian Council of Ministers of the Environment, 1997. Guidance Document on the Management of Contaminated Sites in Canada. Available at www.ccme.ca.

Canadian Council of Ministers of the Environment, 2002. Canadian Environmental Quality Guidelines. Available at www.ccme.ca.

CMPS&F – Environment Australia, 1997. *Appropriate Technologies for the Treatment of Scheduled Wastes Review Report Number 4.* Available at www.deh.gov.au.

Costner, P., D. Luscombe and M. Simpson, 1998. Technical Criteria for the Destruction of Stockpiled Persistent Organic Pollutants. Greenpeace International Service Unit.

Danish Environmental Protection Agency, 2004. Detailed review of selected non-incineration and incineration POPs Elimination Technologies for the CEE Region. Available at www.mst.dk/publications/.

EPA, 1993. Technology Alternatives for the Remediation of PCB-Contaminated Soil and Sediment. Available at www.epa.gov.

EPA, 2000. The Bioremediation and Phytoremediation of Pesticide-contaminated Sites. Available at www.epa.gov.

EPA, 2002. RCRA Waste Sampling Draft Technical Guidance. Available at www.epa.gov.

European Commission, 2001. Reference Document on Best Available Techniques in the Cement and Lime Manufacturing Industries. Available at http://europa.eu.int/comm/environment/ippc/

European Commission, 2001a. Reference Document on Best Available Techniques in the Non Ferrous Metals Industry. Available at http://europa.eu.int/comm/environment/ippc/

European Commission, 2001b. Reference Document on Best Available Techniques on the Production of Irn and Steel. Available at http://europa.eu.int/comm/environment/ippc/

European Commission, 2003. *Reference Document on the General Principles of Monitoring, July 2003*. Available at http://europa.eu.int/comm/environment/ippc/.

European Commission, 2004. Draft Reference Document on Best Available Techniques for Waste Incineration, March, 2004. Available at http://europa.eu.int/comm/environment/ippc/.

FAO, 1996. *Pesticide Storage and Stock Control Manual. No.3.* Available at www.fao.org.

FAO, 2000. *Assessing Soil Contamination: a Reference Manual No.* 8. Available at www.fao.org.

FAO, 2001. Training manual on inventory taking of obsolete pesticides, Series No 10 and reference No X9899. Available at www.fao.org.

FRTR, 2002. *Remediation Technologies Screening Matrix and Reference Guide, Version 4.0*. Available at www.frtr.gov/matrix2/top_page.html.

Global Programme of Action for the Protection of the Marine Environment from Land-based Activities. GPA clearing-house mechanism. Available at http://pops.gpa.unep.org.

ILO, 1999a. Basics of Chemical Safety. Available at www.ilo.org.

ILO, 1999b. Safety in the use of chemicals at work: Code of Practice. Available at www.ilo.org.

IMO, 2002. International Maritime Dangerous Goods Code. Available at www.imo.org.

IPCS INCHEM, no date. Health and Safety Guide (HGSs). Available at www.inchem.org.

Japan Industrial Waste Management Foundation, 1999: Technical Guideline for Treatment of PCBs.

Karstensen, K.H. , 2001. Disposal of obsolete pesticides in cement kilns in developing countries. Lessons learned – How to proceed. 6th *International HCH & Pesticides Forum Book*, 20–22 March 2001, Poznań, Poland, November 2001.

Kümmling, K., D.J. Gray, J. P. Power and S. E. Woodland, 2001 Gas-phase chemical reduction of hexachlorobenzene and other chlorinated compounds: Waste treatment experience and applications. 6th *International HCH & Pesticides Forum Book*, 20-22 March 2001, Poznań, Poland, November 2001.

Ministry of the Environment of Japan, 2004. Report on study of the treatment standards for POPs waste in fiscal year 2003.

Noma Y., Sakai. S., Oono M., 2002, *Dechlorination pathways of PCBs by photochemical reaction and catalytic hydro-dechlorination*. Organohalogen Compd. 56, pages 413–416.

Noma Y., Sakai. S., Oono M., 2003, *Dechlorination pathways and kinetics in photochemical reaction and catalytic hydro-dechlorination*. Organohalogen Compd. 63, pages 276–279.

Noma Y., Sakai. S., Oono M., 2003, *Pathways for the degradation of PCBs by palladium-catalyzed dechlorination, Fresenius Environ. Bull,* 12, 3, pages 302–308.

OECD, various years. OECD Series on Principles of Good Laboratory Practice and Compliance Monitoring (various volumes). OECD Principles on Good Laboratory Practice (as revised 1997–1999), OECD. Available at www.oecd.org/ehs/.

OECD, 2001. Harmonised Integrated Classification System for Human Health and Environmental Hazards of Chemical Substances and Mixtures. Available at www.oecd.org.

OECD, 2003. *Guiding Principles for Chemical Accident Prevention, Preparedness and Response, Second Edition*. Available at www.oecd.org.

OECD, 2004. Recommendation of the Council on the Environmentally Sound Management (ESM) of Waste C(2004)100. Adopted June 9, 2004. Available at www.oecd.org.

Oono M. Kaneda M., and Hirata Y., 1997, *Destruction of PCBs by reaction with potassium tert-butoxide*, Organohalogen Compd. 31, pages 415–419.

Oono M. and Kaneda M., 1997, *Complete destruction of PCBs by a catalytic hydrogenation and t-BuOK method in a bench scale plant*, Organohalogen Compd. 31, pages 405–409.

Piersol, P. 1989. *The Evaluation of Mobile and Stationary Facilities for the Destruction of PCBs*. Environment Canada Report EPS 3/HA/5, May 1989..

Rahuman, M.S.M. Mujeebur; L.Pistone; F. Trifirò and S. Miertu, 2000. Destruction Technologies for Polychlorinated Biphenyls (PCBs). Available at www.unido.org.

Ray, I. D., 2001. Management of chlorinated wastes in Australia. 6th *International HCH & Pesticides Forum Book*, 20–22 March 2001, Poznań, Poland, November 2001.

Sakai S., Peter. A. B., Oono M. 2001. *PCB destruction by catalytic hydrodechlorination (CHD) and t-BuOK method: Combinatorial bio/chemical analysis*. Organohalogen Compd. 54, pages 293–296.

Sasaki Satoshi, A. Masaaki, A. Watanabe, O. Nishida, H. Fujita, W. Harano, S. Nagata, H. Mimura. 2003. *Dioxin formation and PCB Emissions in a Pool Combustion of a PCB Mixed oil – Simulation of Fires in PCB Degradation Facilities*. Organohalogen Compounds, 63, pages 171–175.

Stobiecki, S., J. Cieszkowski, A. Silowiecki and T. Stobiecki. Disposal of pesticides as an alternative fuel in cement kiln: project outline. 6th *International HCH & Pesticides Forum Book*, 20-22 March 2001, Poznań, Poland, November 2001.

Takigami H., Sakai S., and Oono M., 2002, *Validation study for practical bio-monitoring of waste PCB samples during their destruction treatment using DR-CALUX assay and PCB immunoassay*, Organohalogen Compd. 58, pages 397–400.

Takigami H., Sakai S., and Oono M., 2002, *Practical CALUX-monitoring of PCB wastes during their chemical treatments*, Organohalogen Compd. 58, pages 397–400.

UNECE, 2003a. Recommendations on the Transport of Dangerous Goods (Model Regulations). Available at www.unece.org.

UNECE, 2003b. Globally Harmonized System of Classification and Labelling of Chemicals (GHS). Available at www.unece.org

UNEP, 1993. Storage of Hazardous Materials: A Technical Guide for Safe Warehousing of Hazardous Materials. Available at www.uneptie.org.

UNEP, 1994. Guidance Document on the Preparation of Technical Guidelines for the Environmentally Sound Management of Wastes Subject to the Basel Convention. Available at www.basel.int.

UNEP, 1995a. 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. Available at www.basel.int.

UNEP, 1995b. Basel Convention: Manual for Implementation. Available at www.basel.int.

UNEP, 1995c. Technical Guidelines on Incineration on Land (D10). Available at www.basel.int.

UNEP, 1995d. Technical Guidelines on Specially Engineered Landfill (D5). Available at www.basel.int.

UNEP, 1998a. Basel Convention: Guide to the Control System. Available at www.basel.int.

UNEP, 1998b. Inventory of World-wide PCB Destruction Capacity. Available at www.chem.unep.ch.

UNEP, 2000a. Methodological Guide for the Undertaking of National Inventories of Hazardous Wastes Within the Framework of the Basel Convention. Available at www.basel.int.

UNEP, 2000b. Survey of Currently Available Non-Incineration PCB Destruction Technologies. Available at www.chem.unep.ch.

UNEP, 2001. Destruction and Decontamination Technologies for PCB and Other POPs Wastes Part III. Technology Selection Process. Available at www.basel.int.

UNEP, 2003. Interim guidance for developing a national implementation plan for the Stockholm Convention. Available at www.pops.int.

UNEP, 2004a. Guidance for a Global Monitoring Programme for Persistent Organic Pollutants. 1st edition, June 2004, UNEP Chemicals; Available at www.chem.unep.ch/gmn/GuidanceGPM.pdf.

UNEP, 2004b. Review of the Emerging, Innovative Technologies for the Destruction and Decontamination of POPs and the Identification of Promising Technologies for Use in Developing Countries. Available at www.unep.org/stapgef.

UNEP 2005: UNEP/GEF project on existing capacity and capacity building needs for analyzing pops in developing countries. Available at www.chem.unep.ch/pops/laboratory/default.htm.

UNEP, 2006a. Draft Guidelines on Best Available Techniques and Provisional Guidance on Best Environmental Practices. Available at www.pops.int.

UNEP, 2006b. Draft Guidance for Analysis of Persistent Organic Pollutants (POPS). Available at www.chem.unep.ch/pops/laboratory/default.htm.

United States Army Corps of Engineers, 2003. Safety and Health Aspects of HTRW Remediation Technologies. Available at www.usace.army.mil.

Vijgen, J., 2002. NATO/CCMS Pilot Study: Evaluation of Demonstrated and Emerging Technologies for the Treatment of Contaminated Land and Groundwater. Available at www.unep.org/stapgef.

Watanabe Atsuo, A. Ohara, and N. Tajima 2002. *Basic Analysis on Severe Accident for Chemical PCB Detoxification Plant using the UV/Catalyst Method*. Journay of Chemical Engineering of Japan, 35, pages 729–736.

Watanabe Atsuo, A. Ohara, N. Tarima, S. Yoneki, and Y. Hosoya, 2003. *PSA application for PCBs detoxification plant.* Journal of Material Cycle and Waste Management, 5, No. 1 pages 39–48

Weber, Roland, 2004. Relevance of PCDD/PCDF Formation for the Evaluation of POPs Destruction Technologies – Necessity and Current Status. Organohalogen Compd. 66: 1282–1288.

WHO, 1995. Global Strategy on Occupational Health for All. The Way to Health at Work. Available at www.who.int.

WHO International Programme on Chemical Safety, 1995. A Review of the Persistent Organic Pollutants – An Assessment Report on: DDT, Aldrin, Dieldrin, Endrin, Chlordane, Heptachlor, Hexachlorobenzene, Mirex, Toxaphene, Polychlorinated Biphenyls, Dioxins and Furans. Available at www.pops.int.

WHO, 1999. Teacher's guide on basic environmental health. Available at www.who.int.

Annex III

Technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with 1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane (DDT)

Contents

Annexes

Abbreviations and acronyms

DDD	1,1-dichloro-2,2-bis(4-chlorophenyl)ethane
DDE	1,1-dichloro-2,2-bis(4-chlorophenyl)ethene
DDT	1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane (dichlorodiphenyltrichloroethane)
EPA	Environmental Protection Agency (United States of America)
ESM	environmentally sound management
FAO	Food and Agriculture Organization of the United Nations
GC	gas chromatography
ILO	International Labour Organization
IMO	International Maritime Organization
IOMC	Inter-Organization Programme for the Sound Management of Chemicals
IPCS	International Programme on Chemical Safety
MS	mass spectrometry
NFPA	National Fire Protection Association (United States of America)
OECD	Organisation for Economic Co-operation and Development
PCB	polychlorinated biphenyl
POP	persistent organic pollutant
UNEP	United Nations Environment Programme
WHO	World Health Organization

Units of measurement

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

I. Introduction

A. Scope

1. The present technical guidelines provide guidance for the environmentally sound management (ESM) of wastes consisting of, containing or contaminated with dichlorodiphenyltrichloroethane (DDT) pursuant to decisions IV/17, V/26, VI/23, VII/13 and VIII/16 of the Conference of the Parties to the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal; decisions OEWG-I/4, OEWG-II/10, OEWG-III/8, OEWG-IV/11 and OEWG-V/12 of the Open-ended Working Group of the Basel Convention; resolution 5 of the Conference of Plenipotentiaries to the Stockholm Convention on Persistent Organic Pollutants; decisions INC-6/5 and INC-7/6 of the Stockholm Convention Intergovernmental Negotiating Committee for a Legally Binding Instrument for Implementing International Action on Certain Persistent Organic Pollutants and decisions SC-1/21 and SC-2/6 of the Conference of the Parties of the Stockholm Convention.

2. DDT is covered by Annex B of the Stockholm Convention on Persistent Organic Pollutants and is the subject of the present technical guidelines because of its importance for malaria vector control in many tropical countries; all other pesticides listed as POPs in Annex A of the Stockholm Convention are covered separately in the document entitled “Technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with the pesticides aldrin, chlordane, dieldrin, endrin, heptachlor, hexachlorobenzene (HCB), mirex or toxaphene or with HCB as an industrial chemical” (UNEP, 2006a).

3. The breakdown of DDT typically gives rise to two other substances, 1,1-dichloro-2,2-bis(4-chlorophenyl)ethane (DDD) and 1,1-dichloro-2,2-bis(4-chlorophenyl)ethene (DDE). Those substances are also usually present as impurities in commercial DDT. Their physical and chemical properties are similar to those of DDT and they are even more persistent in the environment than DDT itself. Consequently, most wastes containing or contaminated with DDT are likely also to contain or be contaminated with DDD and DDE. From the point of view of their environmentally sound management and disposal, such wastes should be treated as though the amounts of DDD and DDE were the equivalent amount of DDT.

4. The present document should be used in conjunction with the document entitled “General technical guidelines for environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants” (“the general technical guidelines”) (UNEP, 2006b). That document provides more detailed information on the nature and occurrence of wastes consisting of, containing or contaminated with DDT for purposes of their identification and management.

B. Description, production, use and wastes

1. Description

5. The substance DDT (CAS no. 50-29-3) was synthesized by Zeidler in Switzerland for first time in 1874. It does not occur naturally in the environment. Its pesticidal properties were recognized in 1939 by Paul Muller.

6. Pure p,p’-DDT (or 4,4’-DDT) is a colourless crystalline or powder-like substance with a melting point of 108°C and a boiling point of 260°C. It is nearly insoluble in water but soluble in many organic solvents. Because of its lipophilicity (log Kow = 6.36), it concentrates in sediments and shows bioaccumulation (in adipose tissues) and biomagnification. Furthermore, it is a flammable substance (flash point 72–75°C). Technical DDT consists of various isomers with similar properties. If released to the terrestrial compartment, DDT will adsorb very strongly to soil and be subject to evaporation and photooxidation near the surface. It will not hydrolyse and will not significantly biodegrade in most waters. If released to the air it will be subject to direct photodegradation and reaction with photochemically produced hydroxyl radicals. DDT was regarded as an ideal pesticide because it was toxic to a wide range of insects but was relatively harmless to mammals, fish, and plants, particularly when compared to other pesticides in common use at the time, such as lead arsenate. The basic structure of DDT is shown in Figure 1 below.

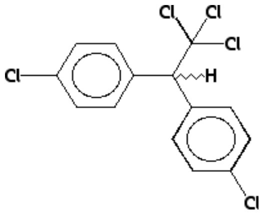

Figure 1. The structure of DDT

2. Production

7. The early popularity of DDT was due to its reasonable cost, effectiveness, persistence and versatility. In the United States of America during the 30 years before its use was banned, a total of approximately 613,000 Mg of DDT was used domestically. After 1959, DDT usage declined greatly, dropping from a peak of approximately 36,000 Mg in that year to just under 5,500 Mg in the early 1970s. The decline in DDT usage was attributable to increased insect resistance; the development of more effective alternative pesticides; growing public concern over adverse environmental side effects; and increasing government restrictions on its use. In addition to domestic consumption, large quantities of DDT were purchased by the United States Agency for International Development and by the United Nations and exported for malaria control. DDT exports increased from 12 per cent of the total production in 1950 to 67 per cent in 1969. However, exports showed a marked decline, from approximately 32,000 Mg in 1970 to 16,000 Mg in 1972 (EPA, 1975).

8. DDT is also produced for use as a chemical intermediate in the production of the pesticide dicofol (2,2,2-trichloro-1,1-bis(4-chlorophenyl)ethanol, CAS no. 115-32-2). Information on production processes and volumes is given in the provisional table for listing notifications of production and use of closed-system site-limited intermediates pursuant to note (iii) of Annex A and note (iii) of Annex B of the Stockholm Convention posted at www.pops.int/documents/registers/closedsys.htm.

9. Information on current use of DDT is provided in the DDT register posted on the Stockholm Convention website at www.pops.int/documents/registers/ddt.htm. Further information on past production of DDT can be found in the national implementation plans posted at www.pops.int/documents/implementation/nips/submissions/default.htm.

10. Common trade names of DDT products include those listed below (see annex I for a more detailed list of DDT trade names and synonyms and section D of chapter IV below for considerations regarding precautions to take when using trade names in inventory exercises):

Agritan
Anofex
Arkotine
Azotox
Bosan supra
Bovidermol
Chlorophenothane
Dedelo
Deoval

3. Use

11. DDT was the first of the chlorinated organic insecticides to come into wide commercial use, during the Second World War, as a pesticide against mosquitoes for the prevention of malaria and yellow fever and also for the control of tsetse flies (TOMES Plus® System from Thomson MICROMEDEX). It was also used as an insecticide on crops, including tobacco and cotton.

12. DDT was banned by most developed countries during the 1970s because of its damaging effects on the environment and human health. DDT is still used today, however, under restrictions, for vector control to prevent malaria transmission and for controlling epidemics in some countries.

4. Wastes

13. Obsolete pesticide stocks consisting of or containing DDT are present in most developing countries and countries with economies in transition (FAO, 2001). Quantities range from a few tonnes to several thousands of tonnes. In addition, there are large quantities of heavily contaminated soil and sediments, together with contaminated production facilities and many contaminated empty containers and other used packing materials which must be regarded as hazardous waste. In many cases, the contaminated soil, sediments, production facilities, empty containers and other used packing materials must be treated in the same manner as the obsolete pesticides. Countries in the migratory locust zone, agricultural countries and countries where DDT is or was manufactured often still have large quantities of DDT-containing compounds left over from old strategic stocks for locust control, from former agricultural uses and from previous production. New data on obsolete pesticide stocks containing DDT can be obtained from the national implementation plans prepared under the Stockholm Convention and their associated POPs inventories (see www.pops.int/documents/implementation/nips/submissions/default.htm). Additional information on obsolete pesticide stocks containing DDT will be provided through the African Stockpile Project for pesticide disposal.

14. Wastes consisting of, containing or contaminated with DDT are found in a number of physical forms, including:

(a) Obsolete stocks of DDT in original packages which are no longer usable because their shelf life has been exceeded or the packaging has deteriorated;

(b) Liquid technical-grade DDT diluted with solvents such as gas oil;

(c) Solid technical-grade DDT diluted with inert materials;

(d) Demolition wastes such as storage walls and slabs, foundations, beams and so forth;

(e) Equipment such as shelves, spray pumps, hoses, personal protective materials, vehicles and storage tanks;

(f) Packaging materials such as drums, bags, bottles and gas cylinders;

(g) Soil, sediment, sewage sludge and water;

(h) Spent treatment media such as activated carbon;

(i) Foodstuffs and animal feeds.

II. Relevant provisions of the Basel and Stockholm Conventions

A. Basel Convention

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

16. Annex I lists some of the wastes which may consist of, contain or be contaminated with DDT. These include:

Y4 Wastes from the production, formulation and use of biocides and phytopharmaceuticals

Y18 Residues arising from industrial waste disposal operations

17. Y45 Organohalogen compounds other than substances referred to in this Annex (e.g., Y39, Y41, Y42, Y43, Y44)

18. Annex I wastes are presumed to exhibit an Annex III hazardous characteristic such as H11 “Toxic (Delayed or Chronic)”, H12 “Ecotoxic”, H3 “Flammable liquids” or H 4.1 “Flammable solids” unless, through “national tests”, they can be shown to not exhibit such characteristics. National tests may be useful for identifying a particular hazardous characteristic listed in Annex III until such time as the hazardous characteristic is fully defined. Guidance papers for each Annex III hazardous characteristic are currently 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) of this Convention” 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” (Annex I, paragraph (b)). List B of Annex IX lists wastes which “will not be wastes covered by Article 1, paragraph 1 (a), of this Convention unless they contain Annex I material to an extent causing them to exhibit an Annex III characteristic”. The following Annex VIII waste categories in particular are applicable to DDT:

A4030	Wastes from the production, formulation and use of biocides and phytopharmaceuticals, including waste pesticides and herbicides which are off-specification, outdated,[162] or unfit for their originally intended use
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[163] chemicals corresponding to Annex I categories and exhibiting Annex III hazard characteristics
A4160	Spent activated carbon not included on list B (note the related entry on list B B2060)

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

B. Stockholm Convention

21. The Stockholm Convention addresses DDT in its Article 3 (“Measures to reduce or eliminate releases from intentional production and use”), Article 4 (“Register of specific exemptions”) and Annex B (“Restriction”).

22. With respect to the production and use of DDT, the Stockholm Convention differentiates between the acceptable purpose of production and use, which is for disease vector control in accordance with Part II of Annex B of the Convention, and the specific exemption for production and use, which is production of dicofol and intermediate.

23. Part I of Annex B sets forth specific requirements with respect to DDT, as follows:

Chemical	**Activity**	**Acceptable purpose or specific exemption**
DDT (1,1,1-trichlor-2,2-bis(4-chlorophenyl)ethane) (CAS No.: 50-29-3)	Production	Acceptable purpose: Disease vector control use in accordance with Part II of this Annex Specific exemption: Intermediate in production of dicofol Intermediate
	Use	Acceptable purpose: Disease vector control in accordance with Part II of this Annex. Specific exemption: Production of dicofol Intermediate

---

[162] “Outdated” means unused within the period recommended by the manufacturer.

[163] Ibid.

Notes:

(i) Except as otherwise specified in this Convention, quantities of a chemical occurring as unintentional trace contaminants in products and articles shall not be considered to be listed in this Annex;

(ii) This note shall not be considered as a production and use acceptable purpose or specific exemption for purposes of paragraph 2 of Article 3. Quantities of a chemical occurring as constituents of articles manufactured or already in use before or on the date of entry into force of the relevant obligation with respect to that chemical, shall not be considered as listed in this Annex, provided that a Party has notified the Secretariat that a particular type of article remains in use within that Party. The Secretariat shall make such notifications publicly available;

(iii) This note shall not be considered as a production and use specific exemption for purposes of paragraph 2 of Article 3. Given that no significant quantities of the chemical are expected to reach humans and the environment during the production and use of a closed-system site-limited intermediate, a Party, upon notification to the Secretariat, may allow the production and use of quantities of a chemical listed in this Annex as a closed-system site-limited intermediate that is chemically transformed in the manufacture of other chemicals that, taking into consideration the criteria in paragraph 1 of Annex D, do not exhibit the characteristics of persistent organic pollutants. This notification shall include information on total production and use of such chemical or a reasonable estimate of such information and information regarding the nature of the closed-system site-limited process including the amount of any non-transformed and unintentional trace contamination of the persistent organic pollutant-starting material in the final product. This procedure applies except as otherwise specified in this Annex. The Secretariat shall make such notifications available to the Conference of the Parties and to the public. Such production or use shall not be considered a production or use specific exemption. Such production and use shall cease after a ten year period, unless the Party concerned submits a new notification to the Secretariat, in which case the period will be extended for an additional ten years unless the Conference of the Parties, after a review of the production and use decides otherwise. The notification procedure can be repeated;

(iv) All the specific exemptions in this Annex may be exercised by Parties that have registered in respect of them in accordance with Article 4.

24. Part II of Annex B ("DDT (1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane)"), sets forth specific restrictions with respect to DDT, as follows:

> "1. The production and use of DDT shall be eliminated except for Parties that have notified the Secretariat of their intention to produce and/or use it. A DDT Register is hereby established and shall be available to the public. The Secretariat shall maintain the DDT Register.
>
> 2. Each Party that produces and/or uses DDT shall restrict such production and/or use for disease vector control in accordance with the World Health Organization recommendations and guidelines on the use of DDT and when locally safe, effective and affordable alternatives are not available to the Party in question.
>
> 3. In the event that a Party not listed in the DDT Register determines that it requires DDT for disease vector control, it shall notify the Secretariat as soon as possible in order to have its name added forthwith to the DDT Register. It shall at the same time notify the World Health Organization.
>
> 4. Every three years, each Party that uses DDT shall provide to the Secretariat and the World Health Organization information on the amount used, the conditions of such use and its relevance to that Party's disease management strategy, in a format to be decided by the Conference of the Parties in consultation with the World Health Organization.
>
> 5. With the goal of reducing and ultimately eliminating the use of DDT, the Conference of the Parties shall encourage:
>
> (a) Each Party using DDT to develop and implement an action plan as part of the implementation plan specified in Article 7. That action plan shall include:

(i) Development of regulatory and other mechanisms to ensure that DDT use is restricted to disease vector control;

(ii) Implementation of suitable alternative products, methods and strategies, including resistance management strategies to ensure the continuing effectiveness of these alternatives;

(iii) Measures to strengthen health care and to reduce the incidence of the disease.

(b) The Parties, within their capabilities, to promote research and development of safe alternative chemical and non-chemical products, methods and strategies for Parties using DDT, relevant to the conditions of those countries and with the goal of decreasing the human and economic burden of disease. Factors to be promoted when considering alternatives or combinations of alternatives shall include the human health risks and environmental implications of such alternatives. Viable alternatives to DDT shall pose less risk to human health and the environment, be suitable for disease control based on conditions in the Parties in question and be supported with monitoring data.

6. Commencing at its first meeting, and at least every three years thereafter, the Conference of the Parties shall, in consultation with the World Health Organization, evaluate the continued need for DDT for disease vector control on the basis of available scientific, technical, environmental and economic information, including:

(a) The production and use of DDT and the conditions set out in paragraph 2;

(b) The availability, suitability and implementation of the alternatives to DDT;

(c) Progress in strengthening the capacity of countries to transfer safely to reliance on such alternatives.

7. A Party may, at any time, withdraw its name from the DDT Registry upon written notification to the Secretariat. The withdrawal shall take effect on the date specified in the notification.”

25. Further information on the DDT register is available at www.pops.int/documents/registers/ddt.htm.

26. For further general information, see section II.B of the general technical guidelines.

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

A. Low POP content

27. The provisional definition of low POP content for DDT is 50 mg/kg. For further information, see section III.A of the general technical guidelines.

B. Levels of destruction and irreversible transformation

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

C. Methods which constitute environmentally sound disposal

29. See section IV.G of the general technical guidelines.

IV. Guidance on environmentally sound management (ESM)

A. General considerations: Basel and Stockholm conventions and Organisation for Economic Co-operation and Development

1. Basel Convention

30. One of the principal 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 see subsection IV.A.1 of the general technical guidelines.

2. Stockholm Convention

31. The term “environmentally sound management” is not defined in the Stockholm Convention. Environmentally sound methods for disposal of wastes consisting of, containing or contaminated with DDT are, however, to be determined by the Conference of the Parties in cooperation with the appropriate bodies of the Basel Convention.

32. Parties should consult Interim guidance for developing a national implementation plan for the Stockholm Convention (UNEP, 2003).

3. Organisation for Economic Co-operation and Development

33. For information regarding the Organisation for Economic Co-operation and Development and ESM, see subsection IV.A.3 of the general technical guidelines.

B. Legislative and regulatory framework

34. Parties to the Basel and Stockholm conventions should examine national controls, standards and procedures to ensure that they are in keeping with the conventions and with their obligations under them, including those which pertain to ESM of wastes consisting of, containing or contaminated with DDT.

35. Elements of a regulatory framework applicable to DDT could also include the following:

(a) Environmental protection legislation establishing a regulatory regime and setting release limits;

(b) Restrictions on the production and use of DDT for disease vector control and use only in accordance with World Health Organization (WHO) recommendations and guidelines;

(c) Prohibitions or restrictions on the manufacture, sale, import and export (for use) of DDT;

(d) Phase-out dates for DDT in inventory or storage;

(e) Transportation requirements for hazardous materials and waste;

(f) Specifications for containers, equipment, bulk containers and storage sites;

(g) Specification of acceptable analytical methods for DDT;

(h) Requirements for waste management and disposal facilities;

(i) A general requirement for public notification and review of proposed government regulations, policy, certificates of approval, licences, inventory information and national emissions data;

(j) Requirements for identification and remediation of contaminated sites;

(k) Requirements for health and safety of workers;

(l) Other potential legislative controls, as for waste prevention and minimization, inventory development and emergency response.

36. The restriction on production and use and, eventually, the timing of the DDT phase-out will probably be the most critical legislative concern for most countries, although most already have some form of legislative framework covering DDT.

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

C. Waste prevention and minimization

38. Both the Basel and Stockholm Conventions advocate waste prevention and minimization, while DDT is targeted in the Stockholm Convention for restriction in production and use or complete phase-out. The issue of waste prevention and minimization is being considered by the Stockholm Convention Expert Group on Best Available Techniques and Best Environmental Practices; in that connection, see also the draft Guidelines on best available techniques and provisional guidance on best environmental practices relevant to Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutants (UNEP, 2004). A final text of the guidelines is expected to be adopted by the Conference of the Parties of the Stockholm Convention in mid-2007.

39. Quantities of waste containing DDT should be minimized through isolation and source separation to prevent mixing with and contamination of other waste streams. It should be borne in mind that obsolete DDT poorly packaged in warehouses can contaminate large amounts of soil and water.

40. Mixing of wastes with DDT 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. Nevertheless, mixing of materials before waste treatment may be necessary in order to optimize treatment efficiencies.

41. In particular, Parties with ongoing production or use of DDT should consider the following actions, as appropriate:

(a) Process modifications in the synthesis or formulation of dicofol pesticides with a view to reducing DDT impurities;

(b) Maintenance of equipment so as to prevent spills and leaks;

(c) Training in the correct use of DDT and in ways to minimize waste production during use, handling, transport and storage;

(d) Development of waste management plans which could include decontamination of containers and equipment containing DDT. Logically, such plans should cover all toxic and hazardous wastes, with POPs wastes, including DDT, taken into consideration as one component;

(e) Raising awareness amongst workers in particular and the public in general concerning DDT and how they and the environment can be harmed by it.

42. For further information, see paragraph 6 and section IV.C of the general technical guidelines.

D. Identification and inventories

1. Identification

43. DDT and its wastes typically occur in the following forms and places:

(a) In residues from DDT production and at sites where it was produced and formulated;

(b) In government storage under health and agriculture ministries;

(c) In storage facilities at farms, stables and other livestock facilities;

(d) In homes (domestic storage), outlets for drugs and pesticides, shopping centres, schools, hospitals, industrial facilities, office and apartment buildings and so on;

(e) In contaminated materials including protective clothing, application equipment and accessories, empty packaging materials, containers, floors, walls, windows and mosquito nets;

(f) At dumpsites and in landfills;

(g) In soils, sediment and sewage sludge and in water which has been contaminated by spills;

(h) In commercial products containing DDT such as paints, household insect sprays and mosquito coils;

(i) In residues from dicofol production and at sites where it is or was produced and formulated.

44. It should be noted 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. It is very probable that obsolete DDT containers were not properly labelled. Experienced inspectors may be able to determine the original contents from other information using guidance manuals issued by various organizations or by contacting the manufacturer. Critical aspects of waste identification require knowledge of products or articles consisting of, containing or contaminated with DDT, including their manufacturers, trade names and synonyms, dates of manufacture, the applications to which they were put, the manner in which they were used and the sector which used them.

45. The information on production, use and waste types provided in section I.B of the present document may be found useful in identifying DDT.

46. For further information, see subsection IV.D.1 of the general technical guidelines.

2. Inventories

47. A complete inventory of DDT may be very difficult to compile, mainly because of the dispersed nature of the uses and storage of the chemical over broad rural and urban areas. In that connection, national and local governments responsible for pesticides and pesticide wastes may be able to provide valuable assistance. In developing a complete inventory, it should be borne in mind that the security of the inventoried site should match the effort put into carrying out the inventory itself. If the inventory is detailed, then the inventoried stock should be secured so that only known additions to or removals from the stock occur and so that contamination of or mixing with other materials is prevented. Consequently, an inventory should also provide a summary of categories of possible destination for the inventoried DDT (see UNEP, 2001).

48. In the case of DDT, an additional use of an inventory may be to determine which products, articles and wastes consisting of, containing or contaminated with DDT are obsolete and which may still be usable.

49. For further information, see subsection IV.D.2 of the general technical guidelines. It is advisable also to refer to the FAO pesticide storage and stock control manual (FAO, 1996) and the FAO provisional guidelines on prevention of accumulation of obsolete pesticide stocks (FAO, 1995).

E. Sampling, analysis and monitoring

50. For general information, see section IV.E. of the general technical guidelines.

1. Sampling

51. The types of matrix which are of special interest for sampling and analysis of DDT include consumer goods impregnated with DDT such as mosquito coils, bed nets and so on, and indoor air in homes to determine the exposure of the general population, in contrast to workplace monitoring.

52. For further information on sampling, see subsection IV.E.1 of the general technical guidelines.

2. Analysis

53. For information on analysis, see subsection IV.E.2 of the general technical guidelines.

3. Monitoring

54. Monitoring programmes should be implemented for facilities managing wastes consisting of, containing or contaminated with DDT. For further information see subsection IV.E.3 of the general technical guidelines.

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

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

1. Handling

56. The main concerns when handling wastes consisting of, containing or contaminated with DDT are human exposure, accidental release to the environment, unwanted release during DDT production and contamination of other waste streams with DDT. Such wastes should be handled separately from other waste types to prevent contamination of other waste streams. Recommended practices towards that end include:

(a) Inspecting containers and other packing materials for leaks, holes, rust, high temperature (resulting from chemical reactions), and appropriate repackaging and relabelling as necessary;

(b) Handling wastes at temperatures below 25°C, if possible, because of the increased volatility at higher temperatures, and also the flammability;

(c) Ensuring that spill containment measures are in good condition and adequate to contain liquid wastes if spilled, i.e., the total volume plus 10 per cent;

(d) Placing plastic sheeting or absorbent mats under containers before opening them if the surface of the containment area is not coated with a smooth surface material (paint, urethane or epoxy);

(e) Removing liquid wastes either by removing the drain plug or by pumping with a peristaltic pump and suitable chemical-resistant 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 residual DDT;

(i) Treating all absorbents and solvents from triple rinsing, disposable protective clothing and plastic sheeting as wastes consisting of, containing or contaminated with DDT when appropriate.

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

2. Collection

57. A significant fraction of total national inventories of DDT may be held in small quantities by small farms, business owners and homeowners (e.g., commercial-sized DDT containers, small containers of pure products and small stockpiles). It is difficult for small-quantity owners to dispose of those materials. For example, the regulatory situation may require that they must 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 rural location or residential neighbourhood), and costs may be prohibitive. National, regional and municipal governments should consider establishing collection stations in rural and urban areas for those small quantities so that each small-quantity owner does not have to make individual transport and disposal arrangements.

58. Collection and collection depots for wastes consisting of, containing or contaminated with DDT should ensure that such wastes are handled and stored separately from all other wastes.

59. It is imperative that collection depots do not become long-term storage facilities for wastes consisting of, containing or contaminated with DDT.

60. For further information, see subsection IV.F.2 of the general technical guidelines.

3. Packaging

61. Wastes consisting of, containing or contaminated with DDT should be properly packaged before storage or transport:

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

Regulations governing transport often specify containers of a certain quality (e.g., 16-gauge steel coated on the inside with epoxy); consequently, containers used for storage should meet transport requirements given that they may be transported in the future;

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

62. Bulk quantities of pesticides are commonly supplied in 200-litre metal drums. For countries without good repackaging facilities this may create problems if the DDT is intended for use by plant protection staff, extension staff or small-scale farmers. To transfer the contents of large drums into smaller packages, large numbers of small empty containers, a pump, labels and so on are needed. These are often not available at the repackaging location or are not available in sufficient quantities. Consequently, DDT may remain unused or improvised measures may be taken which are dangerous to handlers or users.

63. DDT may sometimes be delivered in containers of poor durability which soon start leaking. Once drums have corroded or leak, they can no longer be transported, which makes it considerably more difficult to use their contents. The same applies to torn bags and other damaged packaging. If the container quality is not specified in tender documents, bidders may be tempted to reduce their price by compromising on the quality of containers.

64. Adequate precautions should be taken to ensure that pesticide containers cannot be used for other purposes, particularly the storage of food or water for human or animal consumption.

65. For further information, see subsection IV.F.3 of the general technical guidelines.

4. Labelling

66. All containers containing DDT should be clearly labelled with both a hazard warning label and a label which gives the details of the container and a serial number. The details should include the contents of the container (exact counts of volume and weight), the type of waste, the trade name, the name of the active ingredient (including percentage), the name of the original manufacturer, the name of the site from which it originated so as to allow traceability, the date of repackaging and the name and telephone number of the responsible person during the repackaging operation. Each new package should bear identification labels as specified in the FAO training manual for inventory taking of obsolete pesticides (FAO, 2001). Additional and separate labels are required for materials classified as marine pollutants.

67. For further information, see subsection IV.F.4 of the general technical guidelines.

5. Transportation

68. For information, see subsection IV.F.5 of the general technical guidelines.

6. Storage

69. Whereas many countries have adopted storage regulations or developed storage guidelines concerning hazardous materials and waste, most do not have specific storage regulations or guidance concerning DDT. Nevertheless, it can be assumed that storage procedures should be similar. Although the recommended practice varies somewhat from country to country, there are many common elements to safe storage of these wastes.

70. For further information, see subsection IV.F.6 of the general technical guidelines.

G. Environmentally sound disposal

1. Pre-treatment

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

2. Destruction and irreversible transformation methods

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

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

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

4. Other disposal methods when the POP content is low

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

H. Remediation of contaminated sites

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

I. Health and safety

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

1. Higher-risk situations

77. For information on higher-risk situations, see subsection IV.I.1 of the general technical guidelines. Potential higher-risk situations specific to DDT may include the health sectors and approved use for vector control.

2. Lower-risk situations

78. For information on lower-risk situations, see subsection IV.I.2 of the general technical guidelines. Lower-risk situations specific to DDT may include:

(a) Exposure to consumer goods containing DDT such as mosquito coils and impregnated bed nets;

(b) Sites producing, handling or using DDT, including dicofol sites.

J. Emergency response

79. Emergency response plans should be in place for DDT, in storage, in transport and at disposal sites. Further information on emergency response plans is given in section IV.J of the general technical guidelines.

K. Public participation

80. Parties to the Basel and Stockholm Conventions should have an open public participation process. For further information see section IV.K of the general technical guidelines.

Appendix I

Synonyms and trade names for DDT

Chemical	Some synonyms and trade names[164]
DDT CAS-No: 50-29-3	Aerosol DDT, Aerosol DL, Agritan, Anofex, Antrix, Arkotine, Azotox, benzene,1,1'-(2,2,2-trichloroethylidene)bis(4-chloro-alpha, alpha-bis(p-chlorophenyl)-beta,beta,beta-trichlorethane, Bercema-Aero-Super, Bercema-Spritz-Aktiv, Bercema-Bekusal, Bosan Supra, Bovidermol, chlorophenothan, chlorophenothanes, chloro phenothan, chlorophenothane, chlorophenotoxum, Citox, Clofenotane, Cyklodyn, p,p'-DDT, Dedelo, Deoval, Detox, Detoxan, Dibovan, Dibovin, dichlorodiphenyltrichloroethane, p,p'- dichlorodiphenyltrichloroethane, 4,4'-dichlorodiphenyltrichloroethane, Dicophane, Didigam, Didimac, Diphenyltrichloroethane, Dodat, Duaryl, Dykol, Dynocid, Dynol, Estonate, Gamadyn, Genitox, Gesafid, Gesapon, Gesarex, Gesarol, Guesapon, Guesarol, Gyron, Havero-extra, Hildit, Holus, Hylotox 59, Ipsotox, Ipsotox Special, Ivoran, Ixodex, Kopsol, Lidykol, Meryl N, Micro DDT 75, Mutoxin, Nera-emulze, Nerafum, Neracaine (Nerakain), Neratidine (Neratidin), Neocid, OMS 16, Parachlorocidum, Pararyl, Pentachlorin, Pentalidol, Pentech, Pilusan, Ppzeidan, p,p´-dichlordiphenyltrichlormethylmethane, R50, Rukseam, Santobane, Solomitol, Tech DDT, Trichlorobis(4-chlorophenyl)ethane, 1,1,1-Trichloro-2,2-bis(p-chlorophenyl)ethane, 1,1,1-trichloro-2,2-di(4-chlorophenyl) ethane, 1,1'-(2,2,2-trichloroethylidene)bis(4-chlorobenzene), 1,1-bis-(p-chlorophenyl)-2,2,2-trichloroethane, 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane, 4,4'-dicholorodiphenyltrichloroethane, Tridynol Zeidane, Zerdane

---

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

Appendix II

Bibliography

About DDT

Agency for Toxic Substances and Disease Registry. Toxicological Profile Information Sheets. Available at www.atsdr.cdc.gov.

EPA, 1975. *DDT Regulatory History: A Brief Survey (to 1975)*. Available at www.epa.gov.

EPA, 2002. *The Foundation for Global Action on Persistent Organic Pollutants: A United States Perspective.* Available at www.epa.gov.

FAO, 1999. *Guidelines for the management of small quantities of unwanted and obsolete pesticides.* Series no. 7 and ref. no. X1531. Available at www.fao.org.

FAO, 2001. *Baseline study on the problem of obsolete pesticide stocks*. Series no. 9, ref. no. X8639. Available at www.fao.org.

Global Programme of Action (GPA) for the Protection of the Marine Environment from Land-based Activities. GPA clearing-house mechanism. Available at http://pops.gpa.unep.org.

IPCS INCHEM datasheets. Available at www.inchem.org.

UNEP, 2006c. *General technical guidelines for environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants.* Available at www.basel.int.

WHO IPCS, 1995. *Persistent Organic Pollutants: An Assessment Report on: DDT, Aldrin, Dieldrin, Endrin, Chlordane, Heptachlor, Hexachlorobenzene, Mirex, Toxaphene, Polychlorinated Biphenyls, Dioxins and Furans*. Available at www.pops.int.

Basel Convention

UNEP, 1994. *Guidance Document on the Preparation of Technical Guidelines for the Environmentally Sound Management of Wastes Subject to the Basel Convention*. Available at www.basel.int.

OECD

OECD, 2003. *Core Performance Elements of the Guidelines for Environmentally Sound Management of Wastes.* Available at www.oecd.org.

Legislative and regulatory framework

UNEP, 1995. *Manual for Implementation of the Basel Convention*. Available at www.basel.int.

UNEP, 1995. *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*. Available at www.basel.int.

UNEP, 1998. *Basel Convention: Guide to the Control System (Instruction Manual)*. Available at www.basel.int.

Waste prevention and minimization

FAO, 1995. *Prevention of accumulation of obsolete pesticide stocks. Provisional guidelines.* Available at www.fao.org.

CropLife, 2004. *Managing obsolete stocks of crop protection products*. Available at www.croplife.org.

IOMC, 2002. *Reducing and Eliminating the use of Persistent Organic Pesticides: Guidance on alternative strategies for sustainable pest and vector management*. Available at www.chem.unep.ch/pops/.

UNEP, 2004. Draft *Guidelines on best available techniques and provisional guidance on best environmental practices relevant to Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutants*. (A final text of the guidelines is expected to be adopted by the Conference of the Parties of the Stockholm Convention in mid-2007.) Available at www.pops.int.

WHO, 2004. *A Generic Risk Assessment Model for Insecticide Treatment and Subsequent Use of Mosquito Nets*. Available at www.who.org.

Identification and inventories

FAO, 1995. *Prevention and Disposal of Unwanted Pesticide Stocks in Africa and the Near East.* Available at www.fao.org.

UNEP, 2000. *Methodological Guide for the Undertaking of National Inventories of Hazardous Wastes Within the Framework of the Basel Convention*. Available at www.basel.int.

UNEP, 2001. *Destruction and Decontamination Technologies for PCBs and Other POPs Wastes under the Basel Convention, Volumes A, B and C.* Available at www.basel.int.

WHO, 2002. *The WHO Recommended Classification of Pesticides by Hazard*. Available at www.who.org.

UNEP, 2006a. *Technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with the pesticides aldrin, chlordane, dieldrin, endrin, heptachlor, hexachlorobenzene (HCB), mirex or toxaphene or with HCB as an industrial chemical*. Available at www.basel.int.

UNEP, 2006b. *General technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants (POPs).* Available at www.basel.int.

Sampling, analysis and monitoring

ASTM International, 1996. *Sampling Environmental Media*. Available at www.astm.org.

EPA, 1996. *Method 4042: Soil screening for DDT by immunoassay*. www.epa.gov/epaoswer/hazwaste/test/main.htm.

EPA, 1996. *Method 8081B: Organochlorine pesticides by gas chromatography*. www.epa.gov/epaoswer/hazwaste/test/main.htm.

EPA, 1996. *Method 8270C: Semivolatile organic compounds by gas chromatography/ mass spectrometry (GC/MS).* www.epa.gov/epaoswer/hazwaste/test/main.htm.

Handling, collection, packaging, labelling, transportation and storage

FAO, 1996. *Pesticide storage and stock control manual*. Available at www.fao.org.

FAO, 1995. *Guidelines for packaging and storage of pesticides (revised version).* Available at www.fao.org.

FAO, 1995. *Prevention and Disposal of Unwanted Pesticide Stocks in Africa and the Near East.* Available at www.fao.org.

FAO, 2001. *FAO training manual for inventory taking of obsolete pesticides*. Available at www.fao.org.

IMO, 2002. *International Maritime Dangerous Goods Code*. Available at www.imo.org.

UNEP, 1990. *Storage of Hazardous Materials: A Technical Guide for Safe Warehousing of Hazardous Materials*. Available at www.uneptie.org.

Environmentally sound disposal

FAO, 1996. *Disposal of bulk quantities of obsolete pesticide in developing countries. Provisional technical guidelines.* Available at www.fao.org.

FAO, 1999a. *Guidelines for the management of small quantities of unwanted and obsolete pesticides.* Available at www.fao.org.

FAO, 1999b. *Obsolete pesticides: problems, prevention and disposal.* CD-ROM. Available through www.fao.org.

Ministry of the Environment, Canada. Environmental Partnerships Branch. *A gas-phase chemical reduction process.* Available at www.ene.gov.on.ca/programs/3354e26.pdf.

National Pesticide Stewardship Alliance Conference, 2001. *Gas-Phase Chemical Reduction: A Proven and Accepted Technology for Pesticide and Dioxin Treatment.* Available at www.tpsalliance.org.

Santoleri, Reynolds and Theodore, 2000. *Introduction to Hazardous Waste Incineration. 2nd ed.*

UNEP, 1999. *Technical Guidelines on Hazardous Waste Physico-Chemical Treatment (D9) / Biological Treatment (D8).* Available at www.basel.int.

UNEP, 2001. *Destruction and Decontamination Technologies for PCB and Other POPs Wastes: A Training Manual for Hazardous Waste Project Managers, parts I, I and III*. Available at www.basel.int.

UNEP, 2003. *Interim guidance for developing a national implementation plan for the Stockholm Convention*. Available at www.pops.int.

UNEP, 2006b. *General technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants (POPs).* Available at www.basel.int.

University of Connecticut. *Handling and Disposal of Chemicals. Best Management Practice Environmental Fact Sheet.*

World Bank Technical Paper No. 93. *The safe disposal of hazardous wastes – the special needs and problems of developing countries. Vol. III*. Available at www-wds.worldbank.org.

Health and safety

ILO, 1999. *Safety in the use of chemicals at work: Code of Practice*. Available at www.ilo.org.

ILO, no date. International Chemical Safety Cards. Available at www.ilo.org.

Emergency response

NFPA 472. *Standard for Professional Competence of Responders to Hazardous Materials Incidents.* Available at www.nfpa.org.

OECD, 2003. *Guiding Principles for Chemical Accident Prevention, Preparedness and Response, 2nd ed.* Available at www.oecd.org.

Public participation

Australian Government, Department of the Environment and Heritage, 2000. *A Case Study of Problem Solving Through Effective Community Consultation*. Available at www.deh.gov.au/settlements/publications/chemicals/scheduled-waste/community-consultation.html.

Annex IV

Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with the pesticides aldrin, chlordane, dieldrin, endrin, heptachlor, hexachlorobenzene (HCB), mirex or toxaphene or with HCB as an industrial chemical

Contents

Annexes

Abbreviations and acronyms

ADR	European Agreement Concerning the International Carriage of Dangerous Goods by Road
ATSDR	Agency for Toxic Substances and Disease Registry
BAT	best available techniques
BEP	best environmental practices
DDT	1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane (dichlorodiphenyltrichloroethane)
EPA	Environmental Protection Agency (United States of America)
ESM	environmentally sound management
EXTOXNET	Extension Toxicology Network
FAO	Food and Agriculture Organization of the United Nations
GC	gas chromatography
HCB	hexachlorobenzene
HEOD	1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo-1,4-exo-5,8,-dimethanonaphthalene
HHDN	1,2,3,4,10,10-hexachloro1,4,4a,5,8,8a-hexahydro-endo-1,4-exo-5,8-dimethanonaphthalene
HSDB	Hazardous Substances Data Bank
IARC	International Agency for Research on Cancer
ICAO	International Civil Aviation Organization
IMO	International Maritime Organization
INCHEM	International Programme on Chemical Safety Information on Chemicals
IPCS	International Programme on Chemical Safety
NTP	National Toxicology Program (United States of America)
OECD	Organisation for Economic Co-operation and Development
PCBs	polychlorinated biphenyls
PCCs	polychlorinated camphenes
PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzofuran
Pesticide POPs	Group of pesticides listed in Annex A of the Stockholm Convention (aldrin, chlordane, dieldrin, endrin, heptachlor, hexachlorobenzene (HCB), mirex and toxaphene) and HCB as an industrial chemical
POP	persistent organic pollutant
RID	International Regulations Concerning the Carriage of Dangerous Goods by Rail
STARS	Stoffdatenbank für Altlasten- /umweltrelevante Stoffe (Substance database for contaminated sites: environmentally relevant substances)
TOXNET	Toxicology Data Network
UNEP	United Nations Environment Programme
WHO	World Health Organization

Units of measurement

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

I. Introduction

A. Scope

1. The present technical guidelines provide guidance for the environmentally sound management (ESM) of wastes consisting of, containing or contaminated with the pesticides aldrin, chlordane, dieldrin, endrin, heptachlor, hexachlorobenzene (HCB), mirex or toxaphene or with HCB as an industrial chemical (abbreviated as “pesticide POPs”) pursuant to decisions IV/17, V/26, VI/23, VII/13 and VIII/16 of the Conference of the Parties to the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal; decisions OEWG-I/4, OEWG-II/10, OEWG-III/8, OEWG-IV/11 and OEWG-V/12 of the Open-ended Working Group of the Basel Convention; resolution 5 of the Conference of Plenipotentiaries to the Stockholm Convention on Persistent Organic Pollutants; decisions INC-6/5 and INC-7/6 of the Stockholm Convention Intergovernmental Negotiating Committee for a Legally Binding Instrument for Implementing International Action on Certain Persistent Organic Pollutants and decisions SC-1/21 and SC-2/6 of the Conference of the Parties of the Stockholm Convention.

2. The technical guidelines cover all pesticides listed as persistent organic pollutants (POPs) in Annex A of the Stockholm Convention. The pesticide 1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane (dichlorodiphenyltrichloroethane – DDT) is covered by Annex B of the Stockholm Convention in consideration of its importance for malaria vector control in many tropical countries and is in the subject of separate technical guidelines (UNEP, 2006a).

3. The technical guidelines also cover HCB as an industrial chemical as the wastes generated are broadly similar to wastes consisting of, containing or contaminated with HCB as a pesticide. ESM for this substance as an industrial chemical is consequently similar to its ESM as a pesticide.

4. Unintentionally produced HCB is not covered by these technical guidelines. It is covered in the technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with unintentionally produced PCDDs, PCDFs, HCB or PCBs (UNEP, 2006b).

5. The present document should be used in conjunction with the document entitled “*General technical guidelines for environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants*” (“the general technical guidelines”) (UNEP, 2006c). That document provides more detailed information on the nature and occurrence of wastes consisting of, containing or contaminated with pesticide POPs for purposes of their identification and management.

B. Description, production, use and wastes

1. Aldrin

(a) Description

6. Aldrin (CAS no. 309-00-2) takes the form of white, odourless crystals when it is pure. Technical grades are tan to dark brown with a mild chemical odour (Ritter et al., 1995). Aldrin contains no less than 95 per cent 1,2,3,4,10,10-hexachloro1,4,4a,5,8,8a-hexahydro-endo-1,4-exo-5,8-dimethanonaphthalene (HHDN). HHDN is a white, crystalline, odourless solid with a melting point of 104–104.5°C. Technical aldrin is a tan to dark brown solid with a melting range from 49 to 60°C. It is almost insoluble in water, moderately soluble in petroleum oil and stable to heat, alkalis and mild acids (ATSDR, 2002; IPCS INCHEM, no date; WHO-FAO, 1979). Pure aldrin is stable at < 200°C and within a pH range from pH 4 to pH 8; however, oxidizing agents and concentrated acids attack the unchlorinated ring under any conditions. Aldrin is non-corrosive or slightly corrosive to metals because of the slow formation of hydrogen chloride during storage. Aldrin and dieldrin (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo-1,4-exo-5,8,-dimethanonaphthalene, CAS no. 60-57-1) are the common names of two insecticides which are chemically closely related. Aldrin is readily converted to dieldrin in the environment (Global Pesticides Release Database, Environment Canada, no date).

(b) Production

7. Aldrin was first synthesized as a pesticide in the United States of America in 1948. Aldrin was manufactured by the Diels-Alder reaction of hexachlorocyclopentadiene with bicyclo[2.2.1]-2,5-heptadiene. The final condensation was usually performed at approximately 120°C

and at atmospheric pressure. Excess bicycloheptadiene was removed by distillation. The final product was usually further purified by recrystallization. Commercial manufacture of aldrin began in 1950 and the substance was used throughout the world up to the early 1970s (ATSDR, 2002; UNEP, 2003d). See annex I for a more detailed list of trade names and synonyms and section D of chapter IV below for considerations regarding precautions to take when using trade names in inventory exercises.

(c) Use

8. Aldrin has been manufactured commercially since 1950 and was used throughout the world up to the early 1970s to control soil pests such as corn rootworm, wireworms, rice water weevil and grasshoppers. It was also used to protect wooden structures and plastic and rubber coverings of electrical and telecommunication cables (ATSDR, 2002; UNEP, 2002a). In 1966, aldrin use in the United States peaked at 8,550 Mg, but by 1970 use had decreased to 4,720 Mg.

9. In 1970, the United States Department of Agriculture cancelled all uses of aldrin and dieldrin because of the concern that they could cause severe environmental damage to aquatic ecosystems and because of their potentially carcinogenic properties. In early 1971, the United States Environmental Protection Agency (EPA) initiated cancellation proceedings for aldrin and dieldrin but did not order the suspension of aldrin and dieldrin use. In 1972, under the authority of the Federal Insecticide, Fungicide and Rodenticide Act as amended by the Federal Pesticide Control Act of 1972, an EPA order lifted the cancellation of aldrin and dieldrin use in three cases: subsurface ground insertion for termite control; dipping of non-food plant roots and tops; and mothproofing in manufacturing processes using completely closed systems. Most of the information on aldrin is also applicable to dieldrin.

2. Chlordane

(a) Description

10. Technical chlordane (CAS no. 57-74-9) is a viscous mixture of at least 23 different compounds, including chlordane isomers, other chlorinated hydrocarbons and by-products. The principal constituents of technical chlordane are trans-chlordane (gamma-chlordane) (about 25 per cent), cis-chlordane (alpha-chlordane) (70 per cent), heptachlor, trans-nonachlor and cis-nonachlor (< 1 per cent). Heptachlor is one of the most active components of technical chlordane, which is a viscous, colourless or amber-coloured liquid with a chlorine-like odour. Pure cis-chlordane has a melting point of 106°C and pure trans-chlordane 104°C. They are not soluble in water and are stable in most organic solvents, including petroleum oils. They are unstable in the presence of weak alkalis (ATSDR, 1994; EXTOXNET, no date; Holoubek et al., 2004; IPCS INCHEM, no date; Ritter et al., 1995; UNEP, 2002a; WHO-FAO, 1978).

(b) Production

11. Chlordane is produced by chlorinating cyclopentadiene to form hexachlorocyclopentadiene and condensing the latter with cyclopentadiene to form chlordene. The chlordene is further chlorinated at high temperature and pressure to chlordane (ATSDR, 1994; UNEP, 2003d).

12. The raw materials for the manufacturing process are cyclopentadiene, hexachlorocyclopentadiene and chlorine or some other chlorinating agent. Chlordane is manufactured in a two-step reaction. In the first step, hexachlorocyclopentadiene reacts with cyclopentadiene in a Diels-Alder reaction. The reaction is exothermic and proceeds readily at a temperature of up to about 100°C. The intermediate is called chlordene. In the next step, chlorine is added to the unsubstituted double bond. Various chlorinating agents, e.g., sulphuryl chloride and catalysts such as ferrochloride, have been described as making addition dominant over substitution, but it is believed that only chlorine is used in actual practice (De Bruin, 1979). See annex I for a more detailed list of trade names and synonyms and section D of chapter IV below for considerations regarding precautions to take when using trade names in inventory exercises.

(c) Use

13. Chlordane, which was introduced onto the market for the first time in 1945, is a broad-spectrum contact insecticide which was employed on agricultural crops and on lawns and gardens. It was also used extensively in the control of termites, cockroaches, ants and other household pests (Fiedler et al., 2000; UNEP, 2002a). In China, chlordane is still used as a termiticide in buildings and dams (UNEP, 2002b).

14. In 1988, the commercial use of chlordane was cancelled in the United States of America. Between 1983 and 1988 the sole and core use for chlordane was to control subterranean termites. For

that purpose, chlordane was applied primarily as a liquid which was poured or injected around the foundations of buildings. Chlordane, in conjunction with heptachlor, was at one time widely used as a pesticide for the control of insects on various types of agricultural crops and other vegetation. The use pattern for chlordane in the mid-1970s was as follows: 35 per cent was used by pest control operators, mostly on termites; 28 per cent was used on agricultural crops, including maize and citrus; 30 per cent was used for home lawn and garden use; and 7 per cent was used on turf and ornamentals. In 1978, a final cancellation notice was issued which called for the suspension of the use of chlordane except for subsurface injection to control termites and for dipping roots and tops of non-food plants. Minor use of chlordane for treating non-food plants was cancelled by 1983. The use of chlordane decreased drastically in the 1970s when EPA cancelled all uses other than subterranean termite control (ATSDR, 1994).

3. Dieldrin

(a) Description

15. Dieldrin (CAS no. 60-57-1) is a technical product containing 85 per cent 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo-1,4-exo-5,8,-dimethanonaphthalene (HEOD). Dieldrin is closely related to its precursor aldrin. The pure major ingredient, HEOD, is a white crystalline solid with a melting point of 176–177°C. Technical dieldrin is a light tan, flaky solid with a melting point of 150°C. It is almost completely insoluble in water and slightly soluble in alcohol. Pure HEOD is stable in alkalis and dilute acids but reacts with strong acids (ATSDR, 2002; IPCS INCHEM, no date; WHO-FAO, 1975).

(b) Production

16. Dieldrin was manufactured by epoxidation of aldrin. The epoxidation of aldrin was obtained by reaction with a peracid (producing dieldrin and an acid by-product) or with hydrogen peroxide and a tungstic oxide catalyst (producing dieldrin and water). Peracetic acid and perbenzoic acid were generally used as the peracid. When using a peracid, the epoxidation reaction was performed non-catalytically or with an acid catalyst such as sulphuric acid or phosphoric acid. When using hydrogen peroxide, the catalyst was generally tungsten trioxide (ATSDR, 2002; UNEP, 2003d). See annex I for a more detailed list of trade names and synonyms and section D of chapter IV below for considerations regarding precautions to take when using trade names in inventory exercises.

(c) Use (see also aldrin)

17. Dieldrin was mainly used for the control of soil insects such as corn rootworms, wireworms and cutworms (UNEP, 2002a). Also, dieldrin was and is still used in public health protection to control several insect vectors (ATSDR, 2002; Fiedler et al., 2000). In India, its manufacture and import were banned by an order dated 17 July 2001, but marketing and restricted use (locust control) was permitted for a period of two years from the date of the ban, or up to the date of expiry, whichever was earlier. Restricted use of dieldrin is reported from Bangladesh, Myanmar and Nepal (UNEP, 2002c).

4. Endrin

(a) Description

18. Endrin (CAS no. 72-20-8), when pure, is a white crystalline solid and has a melting point of 200°C. It decomposes at temperatures above 245°C (boiling point). The technical product is a light tan powder with a characteristic odour. It is nearly insoluble in water and slightly soluble in alcohol. It is stable in alkalis and acids, but it rearranges to less insecticidally active substances in the presence of strong acids, on exposure to sunlight or on heating above 200°C (ATSDR, 1996; IPCS INCHEM, no date; WHO-FAO, 1975).

(b) Production

19. Endrin is a stereoisomer of dieldrin produced by the reaction of vinyl chloride and hexachlorocyclopentadiene to yield a product which is then dehydrochlorinated and condensed with cyclopentadiene to produce isodrin. This intermediate is then epoxidized with peracetic or perbenzoic acid to yield endrin. An alternative production method involves condensation of hexachlorocyclopentadiene with acetylene to yield the intermediate for condensation with cyclopentadiene (ATSDR, 1996; UNEP, 2003d).

20. It is estimated that 2,345 Mg of endrin were sold in the United States of America in 1962, whereas under 450 Mg were produced in 1971. More recent estimates of domestic production of endrin

could not be found. As with many toxic chemicals, information on production or use of pesticides is often proprietary, and quantitative estimates of production of endrin are almost impossible to obtain. No information on the production of endrin was available from the United States Toxic Release Inventory because endrin is not one of the chemicals on which producers are required to report. Endrin aldehyde and endrin ketone were never commercial products but occurred as impurities of endrin or as degradation products. Whereas commercial preparations of solid endrin were typically 95–98 per cent pure, the following chemicals (in addition to endrin aldehyde and endrin ketone) have been found as trace impurities in commercial endrin products: aldrin, dieldrin, isodrin, heptachloronorbornadiene and heptachloronorborene (HSDB, no date). The active ingredient would often be mixed with one or more organic solvents for application in a liquid form. Carriers included xylene, hexane, and cyclohexane (ATSDR, 1996; UNEP, 2003d). See annex I for a more detailed list of trade names and synonyms and section D of chapter IV below for considerations regarding precautions to take when using trade names in inventory exercises.

(c) Use

21. Beginning in 1951, endrin was first used as an insecticide, rodenticide and avicide to control cutworms, mice, voles, grasshoppers, borers and other pests on cotton, sugar cane, tobacco, apple orchards and grain. It was also used as an insecticide agent on bird perches, but was never used extensively for termite-proofing or other applications in urban areas, despite its many chemical similarities to aldrin and dieldrin. Endrin's toxicity to non-target populations of raptors and migratory birds was a major reason for the cancellation of its use in the United States as a pesticide agent. Except for use as a toxicant on bird perches, which was cancelled in 1991, the manufacturer voluntarily cancelled all other uses of endrin in the United States in 1986. It has been estimated that 6,250 kg of endrin were used annually in the United States before 1983. Both EPA and the United States Food and Drug Administration revoked all food tolerances for endrin in 1993 (ATSDR, 1996; Fiedler et al., 2000).

5. Heptachlor

(a) Description

22. Pure heptachlor (CAS no. 76-44-8) is a white crystalline solid with a melting point of 95–96°C. Technical heptachlor is a soft, waxy solid with a melting range between 46 and 74°C. It is nearly insoluble in water and slightly soluble in alcohol. It is stable up to temperatures between 150 and 160°C and also to light, air moisture, alkalis and acids. It is not readily dechlorinated but is susceptible to epoxidation (ATSDR, 1993; IPCS INCHEM, no year; WHO-FAO, 1975).

(b) Production

23. Heptachlor was first registered for use as an insecticide in the United States of America in 1952. Commercial production began in 1953. Heptachlor is commercially produced by free-radical chlorination of chlordane in benzene containing 0.5 per cent to 5.0 per cent fuller's earth. The production process is run for up to eight hours as the reaction rate is very low. The chlordane starting material is prepared by the Diels-Alder condensation of hexachlorocyclopentadiene with cyclopentadiene. Technical-grade heptachlor usually consists of 72 per cent heptachlor and 28 per cent impurities such as trans-chlordane, cis-chlordane and nonachlor (De Bruin, 1979; ATSDR, 1993). See annex I for a more detailed list of trade names and synonyms and section D of chapter IV below for considerations regarding precautions to take when using trade names in inventory exercises.

(c) Use

24. Heptachlor is a persistent dermal insecticide with some fumigant action. It is non-phytotoxic at insecticidal concentrations. Heptachlor was used extensively from 1953 to 1974 as a soil and seed treatment to protect maize, small grains and sorghum from pests. It was used to control ants, cutworms, maggots, termites, thrips, weevils, and wireworms in both cultivated and uncultivated soils. Heptachlor was also used non-agriculturally during that time period to control termites and household insects (ATSDR, 1993; Fiedler et al., 2000).

6. Hexachlorobenzene (HCB)

(a) Description

25. Hexachlorobenzene (HCB) (CAS no. 118-74-1) is a chlorinated monocyclic aromatic compound in which the benzene ring is fully substituted by chlorine. HCB is a white crystalline solid (melting point 231°C) which is nearly insoluble in water but is soluble in ether, benzene and chloroform

(NTP, 1994). It has a high octanol-water partition coefficient, low vapour pressure, moderate Henry’s Law constant and low flammability. HCB is found almost exclusively in the gas phase (as is predicted by its vapour pressure), with under 5 per cent associated with particles in all seasons except winter, where levels are still below 10 per cent particle-bound (Cortes et al., 1998).

(b) Production

26. The industrial production of HCB is normally by the direct chlorination of benzene at 150–200°C over a ferric chloride catalyst. Other routes which are believed to have been used to some extent are the chlorination of hexachlorocyclohexane isomers with sulphuryl chloride or chlorosulphonic acid in the presence of a ferric chloride or other catalyst, and the distillation of heavy-end residues from perchloroethylene production (Brooks, 1984). Most of the HCB produced was technical-grade material for pesticide use. This contained about 98 per cent HCB. Known impurities in technical-grade HCB include 1,2,4,5-tetrachlorobenzene, pentachlorobenzene, decachlorobiphenyl and the higher congeners (tetrachloro- and above) of the PCDDs and PCDFs (IPCS, 1997). Smaller quantities, usually of purer HCB, were produced for other industrial uses and as a chemical intermediate for the production of other chemicals. See annex I for a more detailed list of trade names and synonyms and section D of chapter IV below for considerations regarding precautions to take when using trade names in inventory exercises.

27. Industrial production of HCB began in 1945 in the United States of America. It was subsequently produced in Canada, Mexico, Europe (former Czechoslovakia, Germany), India and the former Union of Soviet Socialist Republics, and possibly elsewhere. Global production reached 1,000–2,000 Mg per year by the early 1970s and is believed to have peaked at some 10,000 Mg per year in the late 1970s and early 1980s (Barber et al., 2005; Rippen and Frank, 1986). Approximately 80 per cent of HCB production in 1978 is believed to have been in Europe (Rippen and Frank, 1986). Production of HCB has declined as a result of restrictions on its use starting in the 1970s. In the United States, 360 Mg per year was used around 1960 and an estimated 300 Mg was produced by three manufacturers in the United States in 1973 (IARC, 1979). United States production in 1977 was 454 Mg (SMOC Mexico, 1998). HCB was produced at a maximum rate of 3,500 Mg per year in Mexico in the 1970s, with a total of 39,000 Mg produced between 1970 and the end of production in 1991 (SMOC Mexico, 1998). Most of that HCB was used within Mexico for agricultural purposes, with significant use continuing right up until it was banned in 1992 (SMOC Mexico, 1998). Approximately 1,500 Mg of HCB were manufactured annually in Germany for the production of the rubber auxiliary pentachlorothiophenol (IPCS, 1997), but this production was discontinued in 1993. In Germany HCB was produced at rates of approximately 4,000 Mg per year in 1974 and 2,600 Mg per year in 1976 (Rippen and Frank, 1986). In former Czechoslovakia, HCB production was terminated in Spolana Neratovice (Czech Republic) in 1968. No further centres of HCB manufacture in Europe or North America have been identified. India produced 42,612 Mg of technical-grade HCB during 1995–1997 (Ministry of Chemicals and Fertilisers, 2000). About 15,390 Mg of HCB were imported by Pakistan during 1970–1992 and 12,162 Mg was used (1979–1988). There is evidence that HCB is still produced commercially in China. There is no information on the current state of HCB production in the countries of the former Union of Soviet Socialist Republics. Although HCB has continued to be offered for sale in the Russian Federation, it is unclear whether this arises from domestic production or is imported and re-exported.

28. HCB is also produced as a by-product of the manufacture of perchloroethylene (also known as tetrachloroethylene, PER or PERC), carbon tetrachloride and, to some extent, trichloroethylene (Government of Canada, 1993). In some cases, there is a potential for the production of significant quantities. Historically, when and where HCB had commercial value the by-product stream was isolated as a “heavy” fraction from distillation operations and purified to yield intentionally produced technical-grade HCB for sale as a pesticide. As a result, substantial quantities of HCB may be contained in the wastes generated through the past manufacture of such chlorinated solvents. In the 1980s, the concentration of HCB in distillation “heavies” was estimated to be between 5 per cent and 25 per cent by weight (Jacoff, 1986). There are at least two identified stockpiles of over 10,000 Mg of waste HCB, one in Australia and the other in Ukraine. It is reasonable to assume that there are other smaller stockpiles elsewhere associated with similar historical manufacturing operations. The present-day manufacture of chlorinated solvents, however, gives rise to only trace quantities of HCB.

(c) Use

29. Historically, the major use of HCB was as a fungicide. It was used worldwide as an agricultural fungicide from early in the twentieth century, particularly as a seed dressing to prevent fungal diseases

of grain and other field crops. Its use in the former Soviet Union was particularly extensive and has given rise to significant environmental concerns in the countries of that region. Pesticide uses of HCB have now been effectively discontinued in most countries, with reductions beginning in the 1970s and near-complete phase-out by the early 1990s. Emissions of "old" pesticide HCB is, however, believed to be continuing from soils, stockpiles and wastes.

30. HCB was used extensively as a fungicide to control bunt (Tilletia caries, T. tritici and T. foetida) in wheat, representing a major breakthrough for that disease. HCB was applied as a dust. There is little information available as to the amounts of HCB which were used for that purpose, however. HCB was used briefly as a fungicide in small quantities in Australia and New Zealand in the 1960s and 1970s. In the 1960s in Australia, 12 million bushels (326.6 million Mg) of seed wheat were treated annually with HCB dust, requiring 200 Mg of technical HCB (FAO-WHO, 1970). A smaller proportion of the total crop was probably treated in the Canada, the United States, the United Kingdom and some other European countries, but there was extensive use in France, Germany, Italy, the Netherlands Spain and Turkey and also in some Eastern European countries (FAO-WHO, 1970). Approximately 610 Mg were used in the former Soviet Union until HCB was banned for agricultural purposes in 1986. In Canada, HCB was used as a seed dressing for several crops from 1948 to 1972.

31. Industrial uses, including as a chemical intermediate, represent a relatively small proportion of cumulative global production. However, those uses have not declined as rapidly as the pesticide applications and the relatively small remaining production is probably mostly for non-pesticide use.

32. Historically there were a number of potentially dispersive non-pesticide end uses for HCB. It was used as a wood preservative, for impregnating paper, as a means of controlling porosity in the manufacture of graphite electrodes for electrolytic processes, as a fluxing agent in the manufacture of aluminium and in the formulation of military pyrotechnic products and tracer bullets. Those uses have been discontinued almost completely and the only reference found to end-product use since 2000 is in pyrotechnic and smoke-generating products in the Russian Federation (Shekhovtsov, 2002).

33. HCB has also been used as a chemical intermediate in the manufacture of other substances, as in its use as a peptizing agent in the production of nitroso- and styrene rubbers for use in vehicle tyres (Mumma and Lawless, 1975). Other uses as a chemical intermediate have included the manufacture of certain dyestuffs (ATSDR, 2002), the production of pentachlorophenol and the production of aromatic fluorocarbons. It is believed that those chemical intermediate applications have ceased in most countries (Bailey, 2001) except China (Kunisue et al., 2004) and the Russian Federation.

7. Mirex

(a) Description

34. Mirex (CAS no. 2385-85-5) is a white, odourless crystalline substance with a melting point of 485°C and as such is fire-resistant. It is soluble in several organic solvents including tetrahydrofuran (30 per cent), carbon disulphide (18 per cent), chloroform (17 per cent) and benzene (12 per cent), but is nearly insoluble in water. Mirex is considered to be extremely stable. It does not react with sulphuric, nitric, hydrochloric or other common acids and is unreactive with bases, chlorine and ozone. In the environment, it degrades to photomirex when exposed to sunlight (ATSDR, 1995; IPCS, 1997; EPA, 2000b).

(b) Production

35. Although it was originally synthesized in 1946, mirex was not commercially introduced in the United States of America until 1959, when it was produced under the name GC-1283 for use in pesticide formulations and as an industrial fire retardant under the trade name Dechlorane®. Mirex was produced by the dimerization of hexachlorocyclopentadiene in the presence of an aluminium chloride catalyst (ATSDR, 1995). Technical-grade preparations of mirex contained about 95 per cent mirex with about 2.6 mg/kg chlordecone as a contaminant. Several formulations of mirex were prepared in the past for various pesticide uses. Some of the more commonly used formulations of mirex used as bait were made from ground maize cobs (maize cob grit) impregnated with vegetable oil and various concentrations of mirex. Insect bait formulations for aerial or ground applications contained 0.3–0.5 per cent mirex, and fire ant formulations contained 0.075–0.3 per cent mirex (IARC, 1979). See annex I for a more detailed list of trade names and synonyms and section D of chapter IV below for considerations regarding precautions to take when using trade names in inventory exercises.

(c) Use

36. Because it is non-flammable, mirex was marketed as a flame retardant additive in the United States of America from 1959 to 1972 under the trade name Dechlorane® for use in various coatings, plastics, rubber, paint, paper and electrical goods.

37. Mirex was most commonly used in the 1960s as an insecticide to control the imported fire ant in nine southern states of the United States. Mirex was chosen for fire ant eradication programmes because of its effectiveness and selectiveness for ants. It was originally applied aerially at concentrations of 0.3–0.5 per cent. However, aerial application of mirex was replaced by mound application because of suspected toxicity to estuarine species. Also, the goal of the fire ant programme was altered from eradication to selective control. Mirex was also used successfully in controlling populations of leaf cutter ants in South America, harvester termites in South Africa, western harvester ants in the United States, mealybugs in pineapples in Hawaii, and common (yellowjacket) wasps in the United States. All registered products containing mirex were effectively cancelled in December 1977. Selected ground application, however, was allowed until June 1978, at which time the product was banned in the United States with the exception of continued use in Hawaii on pineapples until stocks on hand were exhausted.

38. China has applied for an exemption from the Stockholm Convention for the production and use of mirex as a termiticide. There is limited production and some local use for that purpose (ATSDR, 1995; UNEP, 2002b).

8. Toxaphene

(a) Description

39. Toxaphene (CAS no. 8001-35-2) is an insecticide containing over 670 polychlorinated bicyclic terpenes consisting predominantly of chlorinated camphenes. Toxaphene formulations included wettable powders, emulsifiable concentrates, dusts, granules, baits, oils, and emulsions (IARC, 1979; ATSDR, 1996). In its original form, it is a yellow to amber waxy solid which smells like turpentine (see below). Its melting range is from 65 to 90 °C. Its boiling point in water is above 120°C, which is the temperature at which it starts to decompose. Toxaphene tends to evaporate when in solid form or when mixed with liquids and does not burn. Toxaphene is also known as camphechlor, chlorocamphene, polychlorocamphene and chlorinated camphene (ATSDR, 1996; Fiedler et al., 2000; IPCS INCHEM, no date; EPA, 2000b).

(b) Production

40. Technical toxaphene can be produced commercially by reacting chlorine gas with technical camphene in the presence of ultraviolet radiation and catalysts, yielding chlorinated camphene containing 67–69 per cent chlorine by weight. It has been made available in various forms: a solid containing 100 per cent technical toxaphene; a 90 per cent solution in xylene or oil; a wettable powder containing 40 per cent toxaphene; dusts containing 5–20 per cent and 40 per cent toxaphene; granules containing 10 or 20 per cent toxaphene; emulsifiable concentrates in concentrations of 4, 6 and 9 per cent toxaphene; baits containing 1 per cent toxaphene; a 2:1 toxaphene:DDT emulsion; and a dust containing 14 per cent toxaphene and 7 per cent DDT. In 1982, EPA cancelled the registrations of toxaphene for most uses as a pesticide or pesticide ingredient, except for certain uses under specific terms and conditions (ATSDR, 1996).

41. Especially in the United States of America, the definition of “technical toxaphene” was patterned after the Hercules Incorporated product (Hercules code number 3956) marketed under the trademark name “Toxaphene”. In recent years, Hercules Incorporated has essentially let the name of toxaphene lapse into the public domain so that many products with similar properties are referred to as toxaphene. Other companies used slightly different manufacturing processes, leading to chlorinated camphene mixtures with degrees of total chlorination and distributions of specific congeners which are not the same as in the Hercules Incorporated product. For example, the toxaphene-like product commonly marketed under names such as “Stroban(e)” had a slightly lower degree of chlorination and used slightly different camphene or pinene feedstocks. In 1996, toxaphene-like pesticide agents were still being produced and were in wide use in many countries. Although it is impossible to quantify production figures or usage rates, India and many countries in Latin America, Eastern Europe, the former Soviet Union and Africa are still using various toxaphene products as pesticides (ATSDR, 1996).

42. Toxaphene was introduced in 1949 and became the most heavily used organochlorine pesticide in the United States until its ban in 1982. High production rates were also reported for Brazil, the former Union of Soviet Socialist Republics and the former German Democratic Republic, and also for Central America (Voldner and Li, 1993). Although most attention has been focused on the intentional production of polychlorinated camphenes (PCCs) as pesticide agents, there is growing evidence that PCC congeners may be an unintentional by-product of manufacturing processes which use chlorination, such as those for paper and pulp. Studies concerning places as far-flung as New Zealand, Japan, the Great Lakes region in the United States and Scandinavia suggest that PCCs can be found in many parts of the world where toxaphene mixtures have never been used as pesticide agents (ATSDR, 1996). See annex I for a more detailed list of trade names and synonyms and section D of chapter IV below for considerations regarding precautions to take when using trade names in inventory exercises.

(c) Use

43. Toxaphene was one of the most heavily used insecticides in the United States until 1982, when it was cancelled for most uses; all uses were banned in 1990. Voldner and Li (1993) estimated a global usage of 1.3 million Mg from 1950 to 1993.

44. Toxaphene was formerly used as a non-systemic stomach and contact insecticide with some acaricidal activity. Being non-phytotoxic (except to cucurbits), it was used to control many insects thriving on cotton, corn, fruit, vegetables, and small grains and to control the *Cussia obtusifola* soybean pest. Toxaphene was also used to control livestock ectoparasites such as lice, flies, ticks, mange and scab mites. Its relatively low toxicity to bees and its long-persisting insecticidal effect made it particularly useful in the treatment of flowering plants. Toxaphene was not used to control cockroaches because its action on them is weaker than that of chlordane. Toxaphene was used at one time in the United States to eradicate fish. The principal use was for pest control on cotton crops. In 1974, an estimated 20,000 Mg used in the United States was distributed as follows: 85 per cent on cotton; 7 per cent on livestock and poultry; 5 per cent on other field crops; 3 per cent on soybeans; and under 1 per cent on sorghum. Based on the estimates of von Rumker et al. (1974) for 1972, 75 per cent of the toxaphene production for that year was for agricultural use, 24 per cent was exported and 1 per cent was used for industrial and commercial applications. Toxaphene solutions were often mixed with other pesticides partly because toxaphene solutions appear to help solubilize other insecticides of low water solubility. Toxaphene was frequently applied with methyl or ethyl parathion, DDT or lindane. Until the early 1970s, toxaphene or mixtures of toxaphene with rotenone were used widely in lakes and streams by fish and game agencies to eliminate biological communities which were considered undesirable for sport fishing (ATSDR, 1996).

9. Wastes

45. Wastes consisting of, containing or contaminated with pesticide POPs, except HCB as an industrial chemical, are found in a number of physical forms including:

(a) Obsolete stockpiles of pesticide POPs in original packages which are no longer usable because their shelf life has been exceeded or the packaging has deteriorated;

(b) Liquid technical-grade pesticide POPs diluted with solvents such as gas oil;

(c) Solid technical-grade pesticide POPs diluted with inert materials;

(d) Demolition wastes such as storage walls and slabs, foundations, beams and so forth;

(e) Equipment such as shelves, spray pumps, hoses, personal protective materials, vehicles and storage tanks;

(f) Packaging materials such as drums, bags, bottles and gas cylinders;

(g) Soil, sediment, sewage sludge and water;

(h) Spent treatment media such as activated carbon;

(i) Foodstuffs and animal feeds.

46. Wastes consisting of, containing or contaminated with HCB as an industrial chemical are found in a number of physical forms including:

(a) Solids, sludges, suspensions and solutions containing significant concentrations of HCB (typically > 1,000 mg/kg):

(i) Residual material from operations which intentionally produce or use HCB, particularly from discontinued operations (see also subsections I.B.6 (b) and (c));

(ii) Residual material from discontinued operations which produced HCB in significant amounts as a by-product from the manufacture of chlorinated solvents, and which may have used that by-product as a source of technical HCB;

(b) Contaminated wood, paper and plastic materials in which HCB was used for impregnation or as an additive;

(c) Old graphite electrodes from certain obsolete electrolytic processes;

(d) Pyrotechnic products and smoke-generating products and equipment of civilian or military origin;

(e) Solids, sludges, suspensions and solutions containing low concentrations or trace amounts of HCB (typically < 50 mg/kg):

(i) Wastes which are contaminated with PCDDs or PCDFs may also be contaminated with HCB;

(ii) Residues from the waste treatment of “heavy” fractions occurring as by-products in the manufacture of chlorinated solvents;

(iii) Contaminated soils from the vicinity of stockpiles of HCB or of processes which produced HCB intentionally or in significant quantities as an unintended by-product;

(iv) Contaminated soil, ground water and biota from the vicinity of dumpsites and landfills used for the disposal of wastes containing high concentrations of HCB;

(v) Containers contaminated through the storage of waste consisting of, containing or contaminated with HCB.

II. Relevant provisions of the Basel and Stockholm conventions

A. Basel Convention

47. Article 1 (“Scope of the Convention”) defines the waste types subject to the Basel Convention. Subparagraph 1 (a) of that Article sets forth 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”), and second, the waste must possess at least one of the characteristics listed in Annex III to the Convention (“List of Hazardous Characteristics”).

48. Annex I lists some of the wastes which may consist of, contain or be contaminated with pesticide POPs and HCB as an industrial chemical:

(a) For pesticide POPs, the wastes include:

Y2	Wastes from the production and preparation of pharmaceutical products
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
Y15	Wastes of an explosive nature not subject to other legislation
Y18	Residues arising from industrial waste disposal operations

(b) For HCB as an industrial chemical, the wastes include:

Y5	Wastes from the manufacture, formulation and use of wood-preserving chemicals
Y6	Wastes from the production, formulation and use of organic solvents
Y15	Wastes of an explosive nature not subject to other legislation
Y41	Halogenated organic solvents
Y43	Any congener of polychlorinated dibenzo-furan
Y44	Any congener of polychlorinated dibenzo-p-dioxin

49. Wastes listed in Annex I are presumed to exhibit an Annex III hazardous characteristic such as H11 “Toxic (Delayed or Chronic)”, H12 “Ecotoxic” or H6.1 “Poisonous (Acute)” unless, through “national tests”, they can be shown not to exhibit such characteristics. National tests may be useful for a particular hazardous characteristic listed 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.

50. List A of Annex VIII describes wastes which are “characterized as hazardous under Article 1 paragraph 1 (a) of this Convention” 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” (Annex I, paragraph (b)). List B of Annex IX lists wastes which “will not be wastes covered by Article 1, paragraph 1 (a), of this Convention unless they contain Annex I material to an extent causing them to exhibit an Annex III characteristic”. The following Annex VIII waste categories are applicable to pesticide POPs and HCB as an industrial chemical:

(a) For pesticide POPs, the waste categories include:

A4010	Wastes from the production, preparation and use of pharmaceutical products but excluding such wastes specified on list B
A4030	Wastes from the production, formulation and use of biocides and phytopharmaceuticals, including waste pesticides and herbicides, which are off-specification, outdated,[165] or unfit for their originally intended use
A4040	Wastes from the manufacture, formulation and use of wood-preserving chemicals[166]
A4080	Wastes of an explosive nature (but excluding such wastes specified on list B)

(b) For HCB as an industrial chemical, the waste categories include:

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)[167]
A4080	Wastes of an explosive nature (but excluding such wastes specified on list B)

51. Annex VIII includes a number of wastes or waste categories which have the potential to contain or be contaminated:

(a) With pesticide POPs resulting from past applications of those substances, such as:

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[165]

---

[165] “Outdated” means unused within the period recommended by the manufacturer.

[166] This entry does not include wood treated with wood-preserving chemicals.

[167] B4010: Wastes consisting mainly of water-based/latex paints, inks and hardened varnishes not containing organic solvents, heavy metals or biocides to an extent to render them hazardous.

chemicals corresponding to Annex I categories and exhibiting Annex III hazard characteristics

(b) With HCB as an industrial chemical resulting from past applications of that substance, such as:

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

- Any congener of polychlorinated dibenzo-furan
- Any congener of polychlorinated dibenzo-dioxin

A4130 Waste packages and containers containing Annex I substances in concentrations sufficient to exhibit Annex III hazard characteristics

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

B. Stockholm Convention

53. The Stockholm Convention aims to eliminate all pesticide POPs listed in its Annex A. Nevertheless, under Article 4 of the Convention, any State may, on becoming a Party, by means of a notification in writing to the Secretariat, register for one or more types of specific exemptions listed in Annex A. Article 4 also establishes a register for the purpose of identifying the Parties which have specific exemptions listed in Annex A. The register for specific exemptions is maintained by the Secretariat and is available to the public at www.pops.int. All registrations of specific exemptions must expire five years after the date of entry into force of the Stockholm Convention for that Party. The Conference of the Parties may, upon request from the Party concerned, decide to extend the expiry date of a specific exemption for a period of up to five years.

54. For HCB, note (iii) of Annex A sets forth a further procedure under which a Party to the Stockholm Convention may give notification of its production and use as a closed-system site-limited intermediate. Such production or use is not considered a production or use specific exemption. Such production and use must cease after a 10-year period unless the Party concerned submits a new notification, in which case the production and use may be extended for an additional 10 years unless the Conference of the Parties, after a review of the production and use, decides otherwise. The notification procedure can be repeated.

55. For further information, see section II.B.2 of the general technical guidelines.

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

A. Low POP content

56. The following provisional definition for low POP content should be applied for aldrin, chlordane, dieldrin, endrin, heptachlor, HCB, mirex and toxaphene: 50 mg/kg each/individually.[168] For further information, see section III.A of the general technical guidelines.

B. Levels of destruction and irreversible transformation

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

C. Methods which constitute environmentally sound disposal

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

---

[168] Determined according to national or international methods and standards.

IV. Guidance on environmentally sound management (ESM)

A. General considerations: Basel and Stockholm conventions and Organisation for Economic Co-operation and Development

1. Basel Convention

59. One of the principal 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 see subsection IV.A.1 of the general technical guidelines.

60. Parties planning or reviewing a national ESM programme should consult, inter alia, *Destruction and Decontamination Technologies for PCBs and Other POPs Wastes under the Basel Convention*, vols. A, B and C (UNEP, 2001).

2. Stockholm Convention

61. The term “environmentally sound management” is not defined in the Stockholm Convention. Environmentally sound methods for disposal of wastes consisting of, containing or contaminated with pesticide POPs are, however, to be determined by the Conference of the Parties in cooperation with the appropriate bodies of the Basel Convention.

62. Parties should consult *Interim Guidance for Developing a National Implementation Plan for the Stockholm Convention* (UNEP, 2004c).

3. Organisation for Economic Co-operation and Development

63. For information regarding the Organisation for Economic Co-operation and Development and ESM, see subsection IV.A.3 of the general technical guidelines.

B. Legislative and regulatory framework

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

65. Elements of a regulatory framework applicable to pesticide POPs could also include the following:

(a) Environmental protection legislation setting release limits and mandating environmental quality criteria;

(b) Prohibitions on the manufacture, sale, import and export (for use) of pesticide POPs;

(c) Phase-out dates for pesticide POPs which are in use or in stock;

(d) Transportation requirements for hazardous materials and waste;

(e) Specifications for containers, equipment, bulk containers and storage sites;

(f) Specification of acceptable analytical and sampling methods for pesticide POPs;

(g) Requirements for waste management and disposal facilities;

(h) A 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, as for waste prevention and minimization, inventory development and emergency response.

66. A link should be established in legislation between the phase-out dates for production and use of pesticide POPs (including in products and articles) and the disposal of the pesticide POPs once they have become waste. The legislation should include a time limit for disposal of wastes consisting of, containing or contaminated with pesticide POPs so as to prevent the creation of stockpiles which have

no clear phase-out date.

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

C. Waste prevention and minimization

68. Both the Basel and Stockholm conventions advocate waste prevention and minimization, while pesticide POPs are targeted in the Stockholm Convention for complete elimination. Pesticide POPs should be taken out of service and disposed of in an environmentally sound manner. Pesticide producers, formulators and users of products and articles containing pesticide POPs may be required to develop waste management plans which cover all hazardous wastes, including wastes consisting of, containing or contaminated with pesticide POPs. The issue of waste prevention and minimization is being considered by the Stockholm Convention Expert Group on Best Available Techniques and Best Environmental Practices; in that connection, see also the draft *Guidelines on best available techniques and provisional guidance on best environmental practices relevant to Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutants* (UNEP, 2006). A final text of the guidelines is expected to be adopted by the Conference of the Parties of the Stockholm Convention in mid-2007.

69. Quantities of waste containing pesticide POPs should be minimized through isolation and source separation in order to prevent mixing with and contamination of other waste streams or environmental resources (air, water and soil). For example, at those locations where pesticide POPs are directly leaking from unstable containers which have undergone deterioration, the risks of further damage to the environment and population should be minimized as soon as possible and the following options should be considered:

(a) Stabilization of the site: leaking pesticides should be segregated and repacked;

(b) Reduction of the number of storage sites, repackaging of pesticide POPs and safe storage at a limited number of centralized storage sites.

70. Mixing of wastes with a pesticide POPs 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. Nevertheless, mixing of materials before waste treatment may be necessary in order to optimize treatment efficiencies.

71. For further information, see paragraph 6 and section IV.C of the general technical guidelines.

72. FAO has developed *Guidelines for the management of small quantities of unwanted and obsolete pesticides* (FAO, 1999) in order to protect farmers and urban dwellers, who often use small quantities of pesticides (as opposed to bulk quantities) and are not aware of the inherent dangers of pesticides.

D. Identification and inventories

1. Identification

73. The identification of pesticide POPs cannot be considered as an isolated activity, even though the pesticide POPs fall under the obligations of the Stockholm Convention. It is highly recommended when identifying pesticide POPs to include other pesticides, particularly DDT, thus making sure that the problem as a whole is taken into account. Present experiences in Africa indicate that between 15 and 30 per cent of obsolete pesticides may be pesticide POPs (ASP, 2004).

74. Pesticide POPs, except HCB as an industrial chemical, are typically found:

(a) In residues from pesticide POP production and at sites where they were produced and formulated;

(b) In government storage under health and agriculture ministries;

(c) In storage facilities at farms, stables and other livestock facilities;

(d) In homes (domestic storage), outlets for drugs and pesticides, shopping centres, schools, hospitals, industrial facilities, office and apartment buildings and so on;

(e) In contaminated materials including protective clothing, application equipment and accessories, empty packaging materials, containers, floors, walls, windows and mosquito nets;

(f) At dumpsites and in landfills;

(g) In soils, sediment and sewage sludge and in water which has been contaminated by spills;

(h) In commercial products containing pesticide POPs such as paints, household insect sprays and mosquito coils.

75. HCB as industrial chemical is typically found:

At manufacturing plants which produce HCB;

In wastes at or arising from manufacturing plants which formerly produced HCB, as described in subsection I.B.6 above,

In wastes at or arising from manufacturing plants which use or formerly used HCB for those uses discussed in paragraph 31 above;

In wastes at or arising from manufacturing plants which use or used HCB as a chemical intermediate in the manufacture of the chemicals discussed in paragraph 32 above.

76. It should be noted that, normally, experienced and well trained technical persons will be able to determine the nature of an effluent, substance, container or piece of equipment by its appearance or markings. In many countries, however, large stocks of unidentified agricultural chemicals exist. Experienced inspectors may be able to determine the original contents from information on the container labels, the type and colour of the original containers or by smell or appearance of the chemical (colour, physical characteristics). Accurate identification and determination of the level of contamination in a sample through chemical analysis is especially needed for sound environmental management. Some treatment technologies are extremely sensitive to the presence of other substances, such as metals.

77. In identifying pesticide POPs, the common trade names listed in annex I may be found useful.

78. For further information, see subsection IV.D.1 of the general technical guidelines.

2. Inventories

79. For information, see subsection IV.D.2 of the general technical guidelines. It is advisable also to refer to the FAO *Pesticide storage and stock control manual* (FAO, 1996), the FAO provisional guidelines entitled "Prevention *of accumulation of obsolete pesticide stocks*" (FAO, 1995) and the draft guidance document entitled "*The preparation of inventories of pesticides and contaminated materials*" (FAO, 2005).

80. A complete inventory of pesticide POPs may be very difficult to compile, mainly because of the dispersed nature of the uses and storage of these chemicals over broad rural and urban areas. In that connection, national and local governments responsible for pesticides and pesticide wastes may be able to provide valuable assistance. In developing a complete inventory, it should be borne in mind that the security of the inventoried site should match the effort put into carrying out the inventory itself. If the inventory is detailed, then the inventoried stock should be secured so that only known additions to or removals from the stock occur and so that contamination of or mixing with other materials is prevented. Consequently, an inventory should also provide a summary of categories of possible destination for pesticide POPs (see, for example, UNEP, 2001).

81. The development of a national inventory also requires a sound administrative process for the collection of information on an ongoing basis in accordance with FAO guidelines and standardized methods.

E. Sampling, analysis and monitoring

82. For general information, see section IV.E of the general technical guidelines.

1. Sampling

83. For information on sampling, see subsection IV.E.1 of the general technical guidelines.

2. Analysis

84. For information on analysis, see subsection IV.E.2 of the general technical guidelines.

3. Monitoring

85. Monitoring programmes should be implemented for facilities managing wastes consisting of, containing or contaminated with pesticide POPs. For further information, see subsection IV.E.3 of the general technical guidelines.

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

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

1. Handling

87. The main concerns when handling wastes consisting of, containing or contaminated with pesticide POPs are human exposure, accidental release to the environment and contamination of other waste streams with pesticide POPs. Such wastes should be handled separately from other waste types in order to prevent contamination of other waste streams. Recommended practices towards that end, and which, as such, should be verified, supervised and monitored, include:

(a) Inspecting containers for leaks, holes, rust, high temperature (resulting from chemical reactions), and appropriate repackaging as necessary;

(b) Handling wastes at temperatures below 25ºC, if possible, because of the increased volatility at higher temperatures;

(c) Ensuring that spill containment measures are in good condition and adequate to contain liquid wastes if spilled, i.e., the total volume plus 10 per cent;

(d) Placing plastic sheeting or absorbent mats under containers before opening them if the surface of the containment area is not coated with a smooth surface material (paint, polymers or polymeric resin);

(e) Removing liquid wastes either by removing the drain plug or by pumping using a peristaltic pump (safeguarded against ignition and fire risks) and suitable chemical-resistant 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 specific absorbent materials;

(h) Triple rinsing of contaminated empty packaging materials (such as metal drums) with a solvent such as kerosene to remove all residual pesticide POPs so that the rinsed containers can be disposed of for recycling;

(i) Treating all solvents and contaminated absorbent materials from triple rinsing and contaminated disposable protective equipment and plastic sheeting as pesticide wastes.

88. Staff should be trained in the correct methods for handling hazardous wastes using national or international methods and standards and following FAO guidelines (FAO, 2004).

89. For further information, see subsection IV.F.2 of the general technical guidelines.

2. Collection

90. A significant fraction of total national inventories of pesticide POPs may be held in small quantities at small storage sites belonging to farmers' cooperatives, distributors, business owners and homeowners. It is difficult for small-quantity owners to dispose of those materials. For example, logistical considerations may prevent or discourage pick-up (e.g., no hazardous waste pick-up available or no suitable disposal facility available in that country), and costs may be prohibitive. In some countries national, regional and municipal governments may wish to consider establishing collection stations for those small quantities so that each small-quantity owner does not have to make individual transport and disposal arrangements.

91. Collection depots and collection activities related to pesticide POPs should be managed according to appropriate guidelines and separately from those for all other wastes if necessary.

92. It is imperative that collection depots do not become long-term storage facilities for pesticide POPs wastes.

93. For further information, see subsection IV.F.2 of the general technical guidelines.

3. Packaging

94. Wastes consisting of, containing or contaminated with pesticide POPs should be properly packaged before storage or transport:

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

(b) Regulations governing transport often specify containers of a certain quality (e.g., 16-gauge steel coated on the inside with epoxy resins); consequently, containers used for storage should meet transport requirements given that they may be transported in the future;

(c) Large amounts of wastes or equipment consisting of, containing or contaminated with pesticide POPs may be placed inside large containers (overpack drums) or heavy plastic wrap if leakage is a concern;

(d) 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 the same drum so long as an adequate amount of absorbent material is present in the drum. Loose absorbents may be purchased from safety suppliers. Sawdust, vermiculite or peat moss may also be used;

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

95. Waste packages and consignments must be handled in a manner which prevents damage during processing, loading and transportation and must conform to the national and international requirements of the relevant legislation.

96. Repackaged pesticide POPs wastes should be fixed with wooden structures and/or straps in sea containers before shipping. Repackaging should be carried out in such a way that different types of hazard represented by the chemicals are not mixed. Packaging materials to be used in the European Union should comply with ADR 2005 (the latest European Agreement concerning the International Carriage of Dangerous Goods by Road). Certificates of packaging material should always be checked.

97. Adequate precautions should be taken to ensure that pesticide containers cannot be used for other purposes, particularly the storage of food or water for human or animal consumption.

98. The United Nations (UN) codes[169] normally used on packaging materials for pesticide POPs (which should be embossed on steel drums, printed on plastic bags and so on) are as follows:

UN1H1/….. for polyethylene drums for liquid wastes (closed top)

UN1H2/….. for polyethylene drums for solid wastes (open top)

UN1A1/….. for steel drums for liquid wastes (closed top)

UN1A2/….. for steel drums for solid wastes (open top)

99. Certificates for the UN code used should be requested from the contractor. In the event that no UN codes are visible on new packaging materials, the materials should be considered as not being United Nations approved.

100. In packaging for air transport, the International Civil Aviation Organization (ICAO) Technical Instructions should be applied and for rail transport, the Regulations concerning the International Carriage of Dangerous Goods by Rail (RID).

101. For further information, see subsection IV.F.3 of the general technical guidelines.

4. Labelling

102. All containers containing pesticide POPs should be clearly labelled with both a hazard warning label and a label which gives the details of the container and a serial number. The details should preferably include the contents of the container (exact counts of volume and weight), the type of waste, the trade name, the name of the active ingredient (including percentage), the name of the original manufacturer, the name of the site from which it originated so as to allow traceability, the date of repackaging and the name and telephone number of the responsible person during the repackaging operation. Each new package should bear identification labels as specified in the FAO training manual

---

[169] See the International Maritime Dangerous Goods (IMDG) Code for details and other codes.

for inventory taking of obsolete pesticides (FAO, 2001). Additional and separate labels are required for materials classified as marine pollutants.

103. For further information, see subsection IV.F.4 of the general technical guidelines.

5. Transportation

104. For information, see subsection IV.F.5 of the general technical guidelines.

6. Storage

105. Although, generally, there are few specific regulations or guidelines for the storage of pesticide POPs, those regulations and guidelines developed for pesticide products should provide a minimum level of protection. In that regard, the FAO guidelines for pesticide storage and stock control (FAO, 1996) and for the design and structure of pesticide stores (ibid.) should be followed as a minimum. In addition, pesticide POPs should be stored as hazardous waste. Authorization from local authorities will be needed.

106. It is important to verify the authorization documents (for example, maximum quantities, permission if repackaging is allowed on a temporary storage site, maximum period of temporary storage, permission if substandard temporary storage conditions are allowed and so on).

107. For further information, see subsection IV.F.6 of the general technical guidelines.

G. Environmentally sound disposal

1. Pre-treatment

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

2. Destruction and irreversible transformation methods

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

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

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

4. Other disposal methods when the POP content is low

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

H. Remediation of contaminated sites

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

I. Health and safety

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

1. Higher-risk situations

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

2. Lower-risk situations

115. For information, see subsection IV.I.2 of the general technical guidelines.

J. Emergency response

116. Emergency response plans should be in place for expected pesticide POPs in storage, in transit and at disposal sites. Emergency response plans should also be in place for pesticide POPs which are in service, in storage, in transport and at disposal sites. Further information on emergency response plans is given in section IV.J of the general technical guidelines.

K. Public participation

117. Parties to the Basel or Stockholm Convention should have an open public participation process. For further information see section IV.K of the general technical guidelines. See also the FAO draft guidance document *The selection of waste management options for the disposal of obsolete pesticides and contaminated materials* (draft under preparation) (FAO, 2004).

Appendix I

Synonyms and trade names for pesticide POPs

(See also Helsinki Commission, 2001; “The National Implementation Plan for Implementation of the Stockholm Convention in the Czech Republic”, Ministry of the Environment of the Czech Republic; PAN Pesticides Database – Chemicals; Ritter, EPA, Substance Registry System, STARS.)

Chemical	Some synonyms and trade names[a]
Aldrin (CAS no. 309-00-2)	1,4:5,8-dimethano-naphtalin; GGDN*; 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-endo-1,4-exo-5,8-dimethanonaphthalene; 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-endo-5,8-exo-dimethano-naphthalene; 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a hexahydro (1.alpha., 4.alpha., 4a.beta., 5.alpha., 8.alpha., 8abeta); 1,2,3,4,10,10-hexachlor-1,4,4a,5,8,8a-hexahydro-1,4,5,8- dimethanonaphthalin 1R,4S,4as,5S,8R,8ar-; 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4,5,8-dimethanonaphthalene; 1.2.3.4.10.10-hexachlor-(4arh.8ach)-1.4.4a.5.8.8a-hexahydro-1c.4c:5t.8t-dimethano-naphth; 1.2.3.4.10.10-hexachloro-(4arh.8ach)-1.4.4a.5.8.8a-hexahydro-1c.4c:5t.8t-dimethano-napht; 1,4:5,8-dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4 a,5,8,8a-hexahydro-,(1alpha,4alpha,4abe 1,4:5,8-dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-, endo,exo-; 1,4:5,8-dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-,(1alpha,4alpha,4abet (1R,4S,4aS,5S,8R,8aR)-1,2,3,4,10,10-hexachlor-1,4,4a,5,8,8a-hexahydro-1, 4:5,8-dimethanonaphthalin; Aglyucon*, Agronex TA; Aldocit; Aldrec; Aldrex; Aldrex 30; Aldrex 30 E.C.; Aldrex 40; Aldrin cast solid; Aldrin mixture, dry (with 65 % or less aldrin); Aldrin mixture, dry (with more then 65 % aldrin); Aldrin mixture, liquid (with 65 % or less aldrin); Aldrin mixture, liquid (with 65 % or less aldrin); Aldrin 2.5; Aldrin 5; Aldrin [1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-(1.alpha.,4.alpha.,4a.beta.,5.alpha.,8.al]; Aldrite; Aldrosol; Altox; Alvit 55; Compound 118; 4:5,8-Dimethanonaphthalene; 22DN*; Drinox; Eldrin; ENT-15949; Eruzin*; exo-Hexachlorodimethanonaphthalene; Hexachlorhexahydro-dimethano-naphtaline; Hexachlorohexahydro-endo, exo-dimethanonaphthalene; Hexachloro-1,2,3,4,10,10 hexahydro-1,4,4a,5,8,8a exodimethano-1,4,5,8 naphtalene; Hexachlor-1,4,4a,5,8,8a-hexahydro-1,4,5,8-dimethanonaphthalin; Hexachlor-1,4,4a,5,8,8a-hexahydro-1,4,5,8-dimethano-naphtalin, (1R,4S,4aS,5S,8R,8aR)-1,2,3,4,10,10-; Hexachlor-1,4,4a,5,8,8a-hexahydro-1,4-endo-5,8-exodimethanonaphtalin, 1,2,3,4,10,10-; HHDM; HHDN; HHPN; Kartofin*; Kortofin; Latka 118; NA 2761; NA 2762; NCI-C00044; OMS-194; Octalene; Octalin*;Seedrin; SD 2794; Sojedinenie (= compound) 118*; Tatuzinho; Tipula; Veratox*

Chemical	Some synonyms and trade names[a]
Chlordane (CAS no. 57-74-9)	1-exo,2-endo,4,5,6,7,8,8-Octachloro-2,3,3a,4,7,7a-hexahydro-4,7methanoindene; 1,2,4,5,6,7,8,8-octachloro-3a,4,7,7a-tetra-hydro-4,7-methan-; 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-; 1,2,4,5,6,7,8,8-octachloro-4,7-methano-3a,4,7,7a-tetrahydroindane oindane; 1,2,4,5,6,7,8,8-octachloro-3a,4,7,7a-tetrahydro-4,7-endo-methano-indene; 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methano-1H-indene; 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methanoindene 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-1H-4,7-methano-indene; 1,2,4,5,6,7,8,8-octachloro-4-7-methano-3.alpha.,4,7,7,.alpha.-tetrahydroindane; 1,2,4,5,6,7,8,8-octachloro-3a,4,7,7a-tetrahydro- 1-exo,2-endo,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methanoindene); AG Chlordane; Aspon; Aspon-Chlordane; Belt; CD 68; chloordaan, zuiver; chlordan, kemisk rent; Chlordan, rein; Chlordane; Chlordane (gamma); chlordane, pur; Chlordane technical; Chlordane [4,7-methanoindan, 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-]; Chloriandin; Chlorindan; Chlorkil; Chlorodane; gamma.-Chlordan; Clordan; Clordano, puro; Corodan(e); Chlordane HCS 3260; Chlordasol; Cortilan-Neu; Dichlorochlordene: Dowchlor; Dow-Klor; Ent 9932; Ent 25552-X; HCS 3260; Kilex lindane; Kypchlor; M140; M 410; Latka 1068;4,7-methanoindan; 4,7-methano-1H-indene; NCI-C00099; 4,7-methanoindan, 1,2,4,5,6,7,8,8-octachloro-3a,4,7,7a-tetrahydro-; 4,7-methano-1H-indene, 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-; Niran; Octachlor; Octachloro-4,7-methanotetrahydroindane; Octachlorodihydrodicyclopentadiene; Octachlorohexahydromethanoindene; Octachlor-2,3,3a,4,7,7a-hexahydro-4,7-methano-(1H)-inden, 1,2,4,5,6,7,8,8-; Octachlor-3a,4,7,7a-tetrahydro-4,7-endomethanoindan, 1,2,4,5,6,7,8,8-; Octa-Klor; Oktaterr; Ortho-Klor; SD 5532; Shell SD-5532; Starchlor; Synklor; Tat chlor 4; t-chlordan; Topichlor; Topichlor 20; Toxichlor; Unexan-koeder;Veliscol-1068

Chemical	Some synonyms and trade names[a]
Dieldrin (CAS no. 60-57-1)	**(1alpha,2beta,2alpha,3beta,6beta,6alpha,7beta,7alpha- 2,7:3,6-Dimethano-3,4,5,6,9,9-hexachlor-1a,2,2;** (1R,4S,4aS,5R,6R,7S,8S,8aR)-1,2,3,4,10,10-Hexachlor-1,4,4a,5,6,7,8,8a-octahydro-6,7-epoxy-1,4:5,8-di; (1R,4S,4aS,5R,6R,7S,8S,8aR)-1,2,3,4,10,10-Hexachlor-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4:5,8-di; **1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro,endo,exo-1,4:5,8-dimethanonaphthalene** 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-5,8-exo-dimethano-naphthalene **1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-exo-1,4-endo-5,8-dimethanonaphthalene** 1,4:5,8-dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-, endo,; 2,7:3,6-dimethanonaphth(2,3-b)oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-,(1aalph; 2,7:3,6-dimethanonaphth(2,3-b)oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-; 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a7,7a-octahydro-2,7:3,6-dimethanonapht[2,3-b]oxirene; 5,6,7,8,9,9-hexachlor-2t,3t-epoxy-(4ar,8ac)-1,2,3,4,4a,5,8,8a-octahydro-1t,4t;5c8c-d; Aldrin epoxide; Alvit; Alvit 55; Compound 497; D-31; Diel’drin*; Dieldrin; Dieldrin, dry weight; Dieldrin (hexachloroepoxyoctahydro-endo,exo-dimethanonaphthalene 85 % and related compounds 15 %); Dil’drin*; Dieldrina; Dieldrine; Dieldrite; Dieldrex; Dieldrix; Dieldrex B, Dielmoth; D-31; DD; dimethanonaphth[2,3-b]-oxirene; DLD; Dorytox; ENT-16225; ENT 16,225; exo-dieldrin; GEOD*; HEOD; Hexachloroepoxyoctahydro-endo,exo-dimethanonaphthalene; Hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-2,7:3,6-dimethanonaphth(2,3-b)oxirene, 3,4,5,6,9,9-; Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4:5,8-dimethano-naphthalene, (1R,4S,4aS,5R,6R,7S,8S; Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4:5,8-dimethanonaphthalene, 1,2,3,4,10,10-; Hexachloro-epoxyoctahydro-dimethanonaphthalene; HOED; Illoxol; Insektalox*; Insecticide No. 497; Insectlack; Kombi-Albertan; Lakta 497; Moth Snub D; NCI C00124; Octalox; OMS18; Oxralox; Panoram D-31; Quintox; Red Shield; SD 3417; Sojedinenie (=compound) 497*; Termitox

Chemical	**Some synonyms and trade names**[a]
Endrin (CAS no. 72-20-8)	1a.alpha.,2.beta.,3.alpha.,6.alpha; (1aalpha,2beta,2abeta,3alpha,6alpha,6abeta,7beta,7aalpha)-2,7;3,6-dimethano-3,4,5,6,9,9-hexachlor-1a; (1Aalpha,2beta,2abeta,3alpha,6alpha,6abeta,7beta,7Aalpha)3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-; (1R,4S,4aS,5S,7R,8R,8aR)-1,2,3,4,10,10-hexachloro-1,4,4a,5,6,7,8,8a-octahydro-6,7-epoxy-1,4:5,8-dime; 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo,endo-; 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a- octahydro-1,4-endo-,8-endo-dimethano-naphthalen; 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-2,7:3,6-dimethanonaphth[2,3-b]oxirene; 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo, endo-5,8-dimethanonaphthalen; 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-5,8-endodimethanonaphthalen; 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4:5,8-dimethanonaphthalen; 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4:5,8-dimethanonaphthalen; 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo-1,4-endo-5,8-dimethanonaphthalen; 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-exo-5,8-dimethanonaphthalen; 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-§octahydro-1,4-endo, endo-5,8-dimethanonaphthali; 1,2,3,4,10,10-hexachloro-6,7-oxido-1,4-endo-5,8-endo-dimethano-1,4,4a,5,6,7,8-octahydronaphthalen; 1,2,3,4,10,10-hexachloro-1r,4s,4as,5s,6,7r,8r,8ar-octahydro-6,7-epoxy-1,4:5,8-dimethanonaphthalene; 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4,5,8-endo-endo-dimethanonaphthalen; 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo,endo-5,8-dimethanonaphthalen; 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4:5,8-dimethanonaphthalene; 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo,endo-1,4:5,8-dimethanonaphthalen; 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-exo-1,4-exo-1,4-exo-5,8-dimethanonaph; 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-exo-1,4-exo-5,8-dimethanonaphthalene; 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-§1,4-endo-5,8-endo-dimethanonaphthali; 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-§octahydro-1,4-endo-endo-5,8-dimethanonaphthale;

Chemical	Some synonyms and trade names[a]
	2,7:3,6-dimethanonaphth(2,3-b)oxirene, 3,4,5,6,9,9-hexachoro-1a,2,2a,3,6a,7,7a-octahydro-,(1aalpha,2; 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-2,7:3,6- dimethanonaphth(2,3-B)oxirene; 3,4,5,6,9,9-hexachloro-1aalpha,2beta,2abeta,3alpha,6alpha,6abeta,7beta,7aalpha-octahydro-2,7:3,6-dim; Compound 269; 1,4:5,8-dimethanonaphthalene; endo,endo-1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4:5,8-dimethanonaphthalen; Endrex; Endrin; Endrin 20; Endrin mixture; endrin,endo-endo-isomeres; Endrina; Endrine; ENT-17251; Experimental Insecticide No. 269; Hexachlor; Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-5,8-endodimethanonaphthalene, 1,2,3,4,10,10-; Hexachloro-oxido-dimethano-octahydronaphthalene; hexachloroepoxyoctahydro-endo-endo-dimethanonaphthalene; Hexachlorooctahydro-endo, endo-dimethanonaphthalene; hexachloroxido-endo-endo-dimethanooctahydronaphthalin; Hexachloroxido-endo-endo-dimethanooctahydronaphthalene; hexachloroxidotetracyclododecen; hexachloräpoxyoctahydro-bis(endo-methylen)naphthalin; Hexachloroepoxyoctahydro-endo,endo-dimethanonaphthalene; Hexadrin; Isodrin Epoxide; Lakta 269; Mendrin; NCI C00157; Nendrin; OMS 197
Heptachlor (CAS no. 76-44-8)	1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methano-1H-indene; 1,4,5,6,7,8,8-heptachlorotetrahydro-4,7-methanoindene; 1,4,5,6,7,8,8-heptachloro-3a,4,7,7,7a-tetrahydro-4,7-endo-methanoindene; 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7- methanoindene; 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-1H-4,7-methano-indene; 2,4-bis-(thylamino)-6-chlor-1,3,5-triazin; 2-Chlor-4,6-bis(ethylamino)-1-triazin; 3,4,5,6,7,8,8-heptachlorodicyclopentadiene; 3-chlorochlordene; 4,7-methano-1,4,5,6,7,8,8-heptachlor-3a,4,7,7a-tetrahydro-1H-inden; 4,7-methano-1H-indene, 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-; 4,7-methanoindene, 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-; Aahepta; Arbinex 30TN; Agronex Hepta; Agronex Hepta T 30; Agroceres; Basaklor; Bis(ethylamino)-chlortriazin; Chlor-bis(ethylamino)-triazin; Chlordiethyltriazindiamin; Drinox; Drinox H-34; E 3314; ENT-15152; Eptacloro; Geptachlor*; Geptazol*; Gesatop; Gold Crest H-60; GPKh; H-34; H-60; Hepta; Heptachloor; Heptachlorane; Heptachlor [1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methano-1H-indene]; Heptacloro; Heptachlorotetrahydro-4,7-methanoindene; Heptagran; Heptagranox; Heptamak; Heptamul; Heptasol; Heptox; Latka 104; NCI-C00180; Soleptax; Rhodiachlor; Termide; Tetrahydro; Veliscol 104; Veliscol heptachlor
Hexachlorobenzene (CAS no. 118-74-1)	Agronal H; Amaticin; Amatin; AntiCarie; Benzene, hexachloro-; benzol, Hexachlor; Bunt-cure; Bunt-no-more; Chlorbenzol, hexa; Co-op Hexa; Ceku C.B.; ENT-1719; esaclorobenzene; GChB*; Gexachlorbenzol*; Granox; Granox nm; HCB; HCBz; hexachloorbenzeen; Hexachlorobenzen; Hexachloro-; Hexa CB; Hexa c.b.; Hexachlorbenzol; Julian’s carbon chloride; julin’s carbonchloride; julin’s chloride; No Bunt; No Bunt 40; No Bunt 80; No Bunt Liquid; Pentachlorophenyl chloride; Perchlorobenzene; Perchlorbenzol; Phenyl perchloryl; Sanocid; Sanocide; Smut-Go; Snieciotox; Snieciotox 40; Zaprawa nasienna sneciotox;

Chemical	Some synonyms and trade names[a]
Mirex (CAS no. 2385-85-5)	1,1a,2,2,3,3a,4,5,5,5a,5b,6-dodecachloro-octahydro-1,3,4-metheno-1H-cyclobuta[cd]pentalene; 1,2,3,4,5,5-hexachloro-; 2,3,4,5,5-hexachloro-1,3-cyclopentadiene dimer; **1,3,4-metheno-1,1a,2,2,3,3a,4,5,5,5a,5b,6-dodecachlorooctahydro-1H-cyclobuta<cd>pentalene;** 1,3,4-metheno-1H-cyclobuta(cd)pentalene, 1,1a,2,2,3,3a,4,5,5,5a,5b,6-dodecachlorooctahydro-; 1,3,4-metheno-1H-cyclobuta<cd>pentalene, dodecachlorooctahydro-; 1,3-cyclopentadiene; 1,3-cyclopentadiene, 1,2,3,4,5,5-hexachloro-, dimer; Bichlorendo, CG-1283, Dechlorane, Dechlorane 4070, Dechlorane Plus, Dimer; 1,2,3,4,5,5-dodecachloropentacyclodecane; Dodecachlororpentacyclo(5.2.1.O’2,6.O’3,9.O’5,8)decane; Dodecachloro-decahydro-1,3-cyclo-dicyclobuta<cd,gh>pentalene; Dodecachloroctahydro-1,3,4-metheno-1H-cyclobuta(cd)pentalen, 1,1a,2,2,3,3a,4,5,5,5a,5b,6-; Dodecachlorooctahydro-1,3,4-metheno-2H-cyclobuta<cd>pentalene; Dodecachloropentacyclo(5.2.1.O’2,6.O’3,9.O’5,8)decane; Dodecachloropentacyclo<5.2.1.0 %2,6.0 %3,9.0 %5,8>decane; Dodecacloropentaciclo(5.2.1.O’2,6.O’3,9.O’5,8)decano; ENT-25719; Ferriamicide; GC1283; Hexachloropentadiene Dimer, Hexachloro-1,3-cyclopentadiene dimer; Hrs 1276, NCI-C06428; Paramex; Perchlordecone, Perchloropentacyclodecane; Perchloropentacyclo(5.2.1.02,6.03,9.05,8)decane; Perchlorodihomocubane
Toxaphene (CAS no. 8001-35-2)	2,2-dimethyl-3-methylennorbornanchlorid; Agricide; Maggot Killer (f); Alltex; Alltox; Attac; Attac 4-2; Attac 4-4; Attac 6; Attac 6-3; Attac 8; Camphechlor; Camphechlor, polychloriert; Camphechlore; Camphene, chlorinated; Camfechlor*; Camphochlor; Campheclor; Chem-Phene; Chemphene M5055; Camphofene Huileux; Chlorinated Camphene; chloriertes 2,2-dimethyl-3-methylennorbornan; Chloriertes Camphen; Chlorinated camphene, chlorinated camphene, 67%<conc chlorine<69%; technical; Chloro-Camphene; Clor Chem T-590; Compound 3956; Coopertox; Crestoxo; Cristoxo; Cristoxo 90; Delicia Fribal; Dimethyl-3-methylennorbornanchlorid, 2,2-; Estonox; ENT-9735; Fasco-Terpene; Geniphene; Gy-Phene; Hercules 3956; Hercules toxaphene; Huilex; Kamfochlor; Liro Toxaphen 10; M 5055; maggot killer (f); Melipax; Melipax 60 EC; Melipax do zamgławiania; Melipax plynny; Melipax pylisty; Melipex; Motox; NCI-C00259; Octachlorocamphene; PCC; Penphene; Phenacide; Phenatox; Phenphane; Polichlorcamfen*; Polychlorocamphene; polychloriertes Camphechlor; (Poly)chlorinated camphene; Strobane-T; Strobane T-90; Taxaphene; Terpentol plynny 60; Toxadust; Toxafen*; Toxakil; Toxaphene (Campechlor); Toxaphene (polychlorinated camphenes); Toxaphene (technical chlorinated camphene (67–69% chlorine); Toxon 63; Toxaphen 10; Toxaphen 50; Toxyphene; Vertac Agricide; Vertac 90 %

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

* Russian trade names.

Appendix II

Bibliography

ASP, 2004. The First Africa Stockpiles Programme – Project I (ASP-P1). Environmental and Social Assessment. Synthesis Report, ASP, 2004. Available at www-wds.worldbank.org.

ATSDR, 2002. Toxicological Profile Information Sheet for aldrin and dieldrin, update September 2002. Available at www.atsdr.cdc.gov/toxprofiles/.

ATSDR, 1994. Toxicological Profile Information Sheet for chlordane, update May 1994. Available at www.atsdr.cdc.gov/toxprofiles/.

ATSDR, 1996. Toxicological Profile Information Sheet for endrin, update August 1996. Available at www.atsdr.cdc.gov/toxprofiles/.

ATSDR, 1993. Toxicological Profile Information Sheet for heptachlor and heptachlor epoxide, update April 1993. Available at www.atsdr.cdc.gov/toxprofiles/.

ATSDR, 2002. Toxicological Profile Information Sheet for hexachlorobenzene, update September 2002. Available at www.atsdr.cdc.gov/toxprofiles/.

ATSDR, 1995. Toxicological Profile Information Sheet for mirex and chlordecone, update August 1995. Available at www.atsdr.cdc.gov/toxprofiles/.

ATSDR, 1996. Toxicological Profile Information Sheets for toxaphene, update August 1996. Available at www.atsdr.cdc.gov/toxprofiles/.

Bailey, R.E., 2001. Global hexachlorobenzene emissions. Chemosphere 43, pp. 167–182.

Barber, J. L.; Sweetman, A. J. et al., 2005. Hexachlorobenzene in the global environment: emissions, levels, distribution, trends and processes. Science of the Total Environment 349 (1–3), pp. 1–44.

Brooks, G.; Hunt, G., 1984. Source assessment for hexachlorobenzene. Radian Corporation, final report. Prepared for EPA, Research Triangle Park, NC.

Cortes, D.R.; Basu, I.; Sweet, C.W.; Brice, K.A.; Hoff, R.M. and Hites, R.A., 1998. Temporal trends in gas-phase concentrations of chlorinated pesticides measured at the shores of the Great Lakes. Environmental Science and Technology 32, pp. 1920–1927.

De Bruin, Jan, 1979. "Reduction of chlordane, DDT, heptachlor, hexachlorobenzene and hexachlorocyclohexane isomers contained in effluents taking into account the best technical means available", Commission of the European Communities, Environment and Consumer Protection Service.

Environment Agency, 2001. SEPA and Environment and Heritage Service, Bristol, UK.

EPA, 1991. *Applying Pesticides Correctly: A Guide for Private and Commercial Applicators.* EPA, USDA and Extension Service.

EPA, 2000a. *The Bioremediation and Phytoremediation of Pesticide-contaminated Sites*. Available at www.epa.gov.

EPA, 2000b. Draft PBT National Action Plan for the Level 1 Pesticides Public Review Draft Prepared by the USEPA Persistent, Bioaccumulative and Toxic Pollutants (PBT) Pesticides Work Group August 24, 2000.

EPA, 2002. *RCRA Waste Sampling Draft Technical Guidance*. Available at www.epa.gov.

EPA, no date. Substance Registry System. Available at oaspub.epa.gov/srs/.

EXTOXNET, Extension Toxicology Network Pesticide Information Profiles. Available at www.pmep.cce.cornell.edu/profiles/extoxnet/.

FAO, 1995. *Prevention of accumulation of obsolete pesticide stocks.* Provisional guidelines. Series no. 2, ref. no. V7460.

FAO, 1996. *Pesticide storage and stock control manual.* Pesticide disposal series, ref. no. V8966.

FAO, 2001. *Training manual on inventory taking of obsolete pesticides*, series no. 10, ref. no. X9899.

FAO, 2000. *Assessing soil contamination, a reference manual,* series no. 8, ref. no. X2570.

FAO, 1999. *Guidelines for the management of small quantities of unwanted and obsolete pesticides,* series no. 7 and ref. no. X1531.

FAO Guidance Document, 2004. *The selection of waste management options for the disposal of obsolete pesticides and contaminated materials*. (Draft under preparation)

FAO, 2005. Draft guidance document "*The preparation of inventories of pesticides and contaminated materials*", prepared by Richard Thompson, version 1.07.

FAO/WHO, 1970. Hexachlorobenzene evaluation session of the Codex Committee on Pesticide Residues (JMPR).

Federal Register, 1999. National Emissions Standards for Hazardous Air Pollutants. EPA. Final Rule, Part II, 40 CFR part 60.

Fiedler, H.; Hutzinger, O.; Welsch-Pausch, K. and Schmiedinger, A., 2000. *Final Report, Evaluation of the Occurrence of PCDD/PCDF and POPs in Wastes and Their Potential to Enter the Foodchain*, Co-ordination by the Joint Research Centre, Environment Institute Study on behalf of the European Commission

FRTR, 2002. *Remediation Technologies Screening Matrix and Reference Guide, Version 4.0*. Available at www.frtr.gov/matrix2/top_page.html.

Global Pesticides Release Database, Environment Canada. Available at www.msc-smc.ec.gc.ca/data/gloperd/basic_knowledge_e.cfm.

Government of Canada, 1993. Hexachlorobenzene. Priority substance risk assessment report. Canadian Environmental Protection Act (CEPA).

Helsinki Commission, Baltic Marine Environment Protection Commission, 2001. *The Pesticides Selected for Immediate Priority Action: A compilation and evaluation of the information given by the Contracting Parties with the focus on use and legislation.* Available at www.helcom.fi.

Holoubek et al, 2004. Project GF/CEH/01/003, Enabling Activities to Facilitate Early Action on the Implementation of the Stockholm Convention on Persistent Organic Pollutants (POPs) in the Czech Republic, Proposal of the National Implementation Plan for Implementation of the Stockholm Convention in the Czech Republic (TOCOEN REPORT) No. 252, Brno.

HSDB, no date. United States National Library of Medicine, National Toxicology Program (via TOXNET).

ten Hulscher, 1992. Environ. Tox. Chem., 11, pp. 1595–1603.

Kunisue, T.; Someya, M.; Kayama, F.; Jin, Y. and Tanabe, S., 2004. *Persistent organochlorines in human breast milk collected from primiparae in Dalian and Shenyang, China*. Environ.Pollut. 48, pp. 1076–1083.

IARC, 1979: Mirex. IARC Monographs on the evaluation of carcinogenic risk of chemicals to humans. Lyon, France: WHO, IARC 20, pp. 283–301.

ILO, 1999a. *Basics of Chemical Safety*. Available at www.ilo.org.

ILO, 1999b. *Safety in the use of chemicals at work: Code of Practice*. Available at www.ilo.org.

IMO, 2002. International Maritime Dangerous Goods Code. Available at www.imo.org.

Indian Ministry of Chemicals and Fertilisers (MC&F), 2000. Information compiled by Plant Protection Adviser, Department of Agriculture and Cooperation, Ministry of Agriculture and Cooperation, New Delhi.

IPCS, 1997. Hexachlorobenzene. Environmental Health Criteria 195. WHO.

IPCS INCHEM, no date. Health and Safety Guides (HSGs). Available at www.inchem.org.

IPCS INCHEM, no date. Pesticide Data Sheets. Available at www.inchem.org.

Jacoff, F.S.; Scarberry, R. and Rosa, D., 1986. *Source assessment of hexachlorobenzene from the organic chemical manufacturing industry.* In: Morris, C. R. and Cabral, J. R. P. (eds.), Hexachlorobenzene: Proceedings of an International Symposium. IARC Sci. Publ. 77, Lyon, pp. 31–37.

Indian Ministry of Chemicals and Fertilisers, 2000. Information compiled by Plant Protection Adviser, Department of Agriculture and Cooperation, Ministry of Agriculture and Cooperation, New Delhi.

Mumma, C.E. and Lawless, E.W., 1975. *Survey of Industrial Processing, Data – Task 1 – Hexachlorobenzene and Hexachlorobutadiene Pollution from Chlorocarbon Processes*, EPA Rpt. EPA-560/3-75-004, Prepared by Midwest Res. Inst.

NTP, 1994. Seventh annual report on carcinogens. Summary, 1994. Research Triangle Park North Carolina, US Department of Health and Human Services, National Toxicology Program.

OECD, 2004. Draft Recommendation of the Council on the Environmentally Sound Management (ESM) of Waste C(2004)100. Adopted June 9, 2004. Available at www.oecd.org.

PAN Pesticides Database – Chemicals (www.pesticideinfo.org/List_ChemicalsAlpha.jsp?ChemName).

Ritter, L.; Solomon, K.R.; Forget, J.; Canadian Network of Toxicology Centres; Stemeroff, M. and O'Leary, C., 1995. Deloitte and Touche Consulting Group, Persistent Organic Pollutants, An Assessment Report on: DDT-Aldrin-Dieldrin-Endrin-Chlordane, Heptachlor-Hexachlorobenzene, Mirex-Toxaphene, Polychlorinated Biphenyls, Dioxins and Furans For: The International Programme on Chemical Safety (IPCS) within the framework of the Inter-Organization Programme for the Sound Management of Chemicals (IOMC).

Rippen, G., 1989. *Handbuch der Umwelt-Chemikalien.* 4th Supplementary Instalment, 11/89. Landsberg/Lech.

Rippen, G; Frank, R., 1986. *Estimation of hexachlorobenzene from the technosphere into the environment.* In: Morris, C. R. and Cabral, J. R. P. (eds.), Hexachlorobenzene: Proceedings of an International Symposium. IARC Sci. Publ. 77, Lyon, pp. 45–52.

von Rumker, R.; Lawless, E. W.; Meiners, A. F.; Lawrence, K. A.; Kelso, G. L. and Horay, F., 1974. *Production, Distribution, Use, and Environmental Impact Potential of Selected Pesticides*. EPA.

Secretariat of the Basel Convention, 2002. *Destruction and Decontamination Technologies for PCBs and other POPs wastes under the Basel Convention, a Training Manual for Hazardous Waste Project Managers, volumes A and B.* Available at www.basel.int/pub/pcb1.pdf.

Shekhovtsov, A., 2002. *The Main Sources of Pollution in the Asian Part of Russia by PTS – Technical Report*. Presented at the 1st Technical Workshop of UNEP/GEF Regionally-based Assessment of PTS, Central Asia and NE Asia Region (Region VII). 18–20 March 2002, Tokyo

SMOC Mexico, 1998. Nomination Dossier for Hexachlorobenzene. Sound Management of Chemicals (SMOC) Working Group, 6 June 1998. Available at www.cec.org/files/pdf/POLLUTANTS/hcbmex_en.PDF.

STARS Version 4.0, Stoffdatenbank für bodenschutz- /umweltrelevante Stoffe. At www.stoffdaten-stars.de/.

UK Health and Safety Executive, 1991. Guidance note HS(G)66, *Protection of workers and the general public during the development of contaminated land.* HSE books.

UNEP, 1995a. *Basel Convention: Manual for Implementation*. Available at www.basel.int.

UNEP, 1995b. *Technical Guidelines on Incineration on Land (D10)*. Available at www.basel.int.

UNEP, 1998. *Inventory of World-Wide PCB Destruction Capacity.* Available at www.chem.unep.ch.

UNEP, 2000. *Survey of Currently Available Non-Incineration PCB Destruction Technologies*. Available at www.chem.unep.ch.

UNEP, 2001. *Destruction and Decontamination Technologies for PCBs and Other POPs Wastes under the Basel Convention, volumes A, B and C.* Available at www.basel.int.

UNEP, 2002a. *Europe Regional Report, Regionally Based Assessment of Persistent Toxic Substances.* Available at www.chem.unep.ch.

UNEP, 2002b. *Central and North East Asia Regional Report, Regionally Based Assessment of Persistent Toxic Substances*. Available at www.chem.unep.ch.

UNEP, 2002c. *Indian Ocean Regional Report, Regionally Based Assessment of Persistent Toxic Substances.* Available at www.chem.unep.ch.

UNEP, 2003d. *Global Report 2003, Regionally Based Assessment of Persistent Toxic Substances*. Available at www.chem.unep.ch/pts.

UNEP, 2004a. *Review of the Emerging, Innovative Technologies for the Destruction and Decontamination of POPs and the Identification of Promising Technologies for Use in Developing Countries.* Available at www.unep.org/stapgef.

UNEP, 2004c. *Interim guidance for developing a national implementation plan for the Stockholm Convention*. Revised December 2004. Available at www.pops.int.

UNEP, 2005. *Standardized Toolkit for the Identification and Quantification of Dioxin and Furan Releases, 2nd ed.* Available at www.pops.int.

UNEP, 2006. Draft *Guidelines on best available techniques and provisional guidance on best environmental practices relevant to Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutants*. (A final text of the guidelines is expected to be adopted by the Conference of the Parties of the Stockholm Convention in mid-2007.) Available at www.pops.int.

UNEP, 2006a. *Technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with 1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane (DDT).* Available at www.basel.int.

UNEP, 2006b. *Technical guidelines on the environmentally sound management of wastes containing or contaminated with unintentionally produced polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), hexachlorobenzene (HCB) or polychlorinated biphenyls (PCBs).* Available at www.basel.int.

UNEP, 2006c. *General technical guidelines for environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants*. Available at www.basel.int.

United States Army Corps of Engineers, 2003. *Safety and Health Aspects of HTRW Remediation Technologies*. Available at www.usace.army.mil.

Voldner, E. C. and Li, Y. F., 1993. *Global usage of toxaphene.* Chemosphere, vol. 27, no. 10.

WHO-FAO, 1979. Datasheets on pesticides no. 41, aldrin.

WHO-FAO, 1978. Datasheets on pesticides no. 36, chlordane.

WHO-FAO, 1975. Datasheets on pesticides no. 17, dieldrin.

WHO-FAO, 1975. Datasheets on pesticides no. 1, endrin.

WHO-FAO, 1975. Datasheets on pesticides no. 19, heptachlor.

WHO-FAO, 1977. Datasheets on pesticides no. 26, hexachlorobenzene.

Annex V

Technical guidelines on the environmentally sound management of wastes containing or contaminated with unintentionally produced polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), hexachlorobenzene (HCB) or polychlorinated biphenyls (PCBs)

Contents

Abbreviations and acronyms

2,4,5-T	2,4,5-trichlorophenoxyacetic acid
AOP	advanced oxidation process
BAT	best available techniques
BCD	base-catalysed decomposition
BEP	best environmental practices
CCMS	Committee on the Challenges of Modern Society
DDT	1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane (dichlorodiphenyltrichloroethane)
ESM	environmentally sound management
GPCR	gas-phase chemical reduction
HCB	hexachlorobenzene
IPCS	International Programme on Chemical Safety
I-TEFs	international toxic equivalency factors
LTTD	low-temperature thermal desorption
MSO	molten-salt oxidation
NATO	North Atlantic Treaty Organisation
OECD	Organisation for Economic Co-operation and Development
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzofuran
PER, PERC	perchloroethylene
POPs	persistent organic pollutants
SCWO	supercritical water oxidation
SET	solvated electron technology
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TEFs	toxic equivalency factors
TEQ	toxic equivalence
WHO	World Health Organization

Units of measurement

µg	microgram
mg	milligram
µg/kg	microgram(s) per kilogram. Corresponds to parts per billion.
mg/kg	milligram(s) per kilogram. Corresponds to parts per million.
ppb	parts per billion
ppm	parts per million

I. Introduction

A. Scope

1. The present technical guidelines provide guidance for the environmentally sound management (ESM) of wastes containing or contaminated with unintentionally produced polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), hexachlorobenzene (HCB) or polychlorinated biphenyls (PCBs) pursuant to decisions IV/17, V/26, VI/23, VII/13 and VIII/16 of the Conference of the Parties to the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal; decisions OEWG-I/4, OEWG-II/10, OEWG-III/8, OEWG-IV/11 and OEWG-V/12 of the Open-ended Working Group of the Basel Convention; resolution 5 of the Conference of Plenipotentiaries to the Stockholm Convention on Persistent Organic Pollutants; decisions INC-6/5 and INC-7/6 of the Stockholm Convention Intergovernmental Negotiating Committee for an International Legally Binding Instrument for Implementing International Action on Certain Persistent Organic Pollutants and decisions SC-1/21 and SC-2/6 of the Conference of the Parties to the Stockholm Convention.

2. The guidelines cover all persistent organic pollutants (POPs) which are formed and released unintentionally from anthropogenic sources as listed in Annex C of the Stockholm Convention (“Unintentional Production”), i.e., PCDDs, PCDFs, HCB and PCBs.

3. Intentionally produced POPs such as PCBs, pesticides (aldrin, chlordane, dieldrin, endrin, heptachlor, HCB, mirex and toxaphene), HCB as an industrial chemical and DDT are not covered by the present technical guidelines but are the subjects of the following separate and specific technical guidelines:

(a) 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) (“the technical guidelines on PCBs”) (UNEP, 2006a);

(b) Technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with the pesticides aldrin, chlordane, dieldrin, endrin, heptachlor, hexachlorobenzene (HCB), mirex or toxaphene or with HCB as an industrial chemical (“the technical guidelines on POPs pesticides”) (UNEP, 2006b);

(c) Technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with 1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane (DDT) (UNEP, 2006c).

4. The present document should be used in conjunction with the document entitled “*General technical guidelines for environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants*” (“the general technical guidelines”) (UNEP, 2006d). That document provides more information on the nature and occurrence of wastes consisting of, containing or contaminated with unintentionally produced PCDDs, PCDFs, HCB or PCBs for purposes of their identification and management.

5. In the present document, reference is made to the technical guidelines on PCBs and the technical guidelines on POPs pesticides where the information is common to both unintentionally and intentionally produced POPs.

B. Description, production and wastes

1. Description

(a) PCDDs and PCDFs

6. PCDDs and PCDFs are tricyclic halogenated aromatic hydrocarbons consisting of two benzene rings connected by two oxygen atoms at adjacent carbons on each of the benzene rings in PCDDs and by one oxygen atom and one carbon-carbon bond at adjacent carbons in PCDFs. The basic structures of the unchlorinated compounds are shown in Figure 1 below.

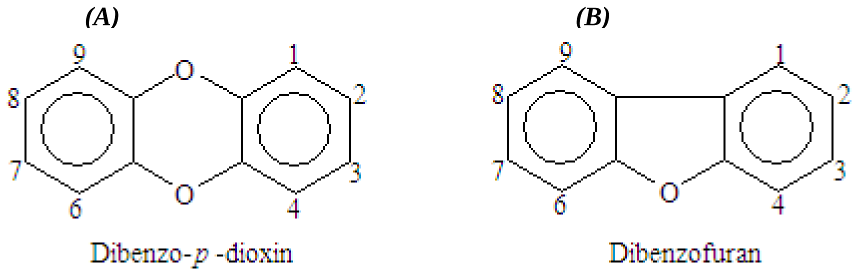

Figure 1. The structures of dibenzo-p-dioxin (A) and dibenzofuran (B)

7. Both groups of chemicals may have up to eight chlorine atoms attached at carbon atoms 1 to 4 and 6 to 9. Each of the compounds resulting from chlorine substitution is referred to as a congener. The number and position of chlorine atoms around the aromatic nuclei distinguish each specific congener. In total, there are 75 possible PCDD congeners and 135 possible PCDF congeners. The most widely studied of the PCDDs and PCDFs is 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD).

8. Congeners with up to three chlorine atoms are thought to be of little toxicological significance. However, 17 congeners with chlorine atoms substituted in the 2, 3, 7 and 8 positions (i.e., in the lateral positions of the aromatic rings) are thought to pose a health and environmental risk. Increasing substitution from four to eight chlorine atoms generally results in a marked decrease in potency.

9. PCDDs and PCDFs have very low water solubility, high octanol-water partition coefficients, low vapour pressures, strong adsorptivity to particles and surfaces and are resistant to chemical and biochemical degradation under environmental conditions. Consequently, they are persistent in the environment and their high fat solubility and inherent stability results in bioconcentration and accumulation in the food chain. Almost all 210 PCDD and PCDF congeners have been identified in emissions from thermal and industrial processes and as a result they are found as mixtures in environmental matrices such as soil, sediment, air, plants and lower animals, although their low aqueous solubility means that they can hardly be detected in water and are largely immobile in soils.

10. When found in the environment, biological tissues and industrial sources, PCDDs and PCDFs are usually present as complex mixtures and the various congeners vary significantly in their toxicity. The potency of PCDDs and PCDFs has been ranked relative to 2,3,7,8-TCDD, the most toxic member of the dioxin class. Those rankings are known as toxicity equivalency factors (TEFs). To be included in the TEF scheme, a PCDD or PCDF must bind to the cellular aryl hydrocarbon (Ah) receptor, elicit Ah receptor-mediated biochemical and toxic responses, must be persistent and must accumulate in the food chain (WHO, 1998). To estimate the toxic potency of a given mixture of PCDDs and PCDFs, the mass concentration of each congener is multiplied by its TEF and the products are summed to give the toxic equivalence (TEQ) of the mixture.

11. The most recent review of TEFs was that carried out by an expert group for the World Health Organization International Programme on Chemical Safety (WHO-IPCS) in 1998 (Van den Berg et al., 1998). Under the WHO TEF scheme, TCDD is assigned a TEF of 1.0 and other PCDDs and PCDFs have TEF values ranging from 1.0 down to 0.0001. The WHO TEF scheme also includes those PCB congeners which are considered to exhibit dioxin-like characteristics; their TEFs range from 0.1 down to 0.00001. The WHO TEF scheme has established three separate schemes, one for humans and other mammals and two others for birds and fish, respectively. For human risk assessment, the human/mammalian TEFs should of course be applied.

12. It should be noted that much national legislation still applies the earlier international TEF (I-TEF) scheme, which was established by the North Atlantic Treaty Organisation Committee on the Challenges of Modern Society (NATO/CCMS) in 1988. That I-TEF includes only the 17 PCDD and PCDFs congeners with chlorine atoms substituted in the 2, 3, 7 and 8 positions and does not include dioxin-like PCBs.

13. Under Annex C of the Stockholm Convention, concentrations should be reported according to the most recent international standards, commencing with the 1998 WHO TEF scheme.

(b) PCBs

14. For information, see subsection I.B.1 (a) of the technical guidelines on PCBs.

(c) HCB

15. For information, see subsection I.B.5 (a) of the technical guidelines on POPs pesticides.

2. Unintentional production

16. Under Article 5 of the Stockholm Convention, Parties are required to reduce total releases from anthropogenic sources of the chemicals listed in Annex C (unintentionally produced POPs: PCDDs, PCDFs, HCB and PCBs) with the goal of continuing minimization and, where feasible, ultimate elimination.

(a) PCDDs and PCDFs

17. PCDDs and PCDFs have never been intentionally produced or used commercially except in very small quantities for analytical and research purposes.

18. PCDDs and PCDFs are regarded as trace contaminants in a number of chemical products. They may also be formed as unintentional by-products in certain industrial and combustion processes, mainly at temperatures between 200 and 650°C with a peak around 300°C. Consequently, they may be formed as unintended and undesirable waste products during certain processes in which carbonaceous material is heated in the presence of organic or inorganic chlorinated substances (including sodium chloride, i.e., common salt) together with oxygen or oxygen-containing compounds. Those processes include the manufacture of chemicals including chlorophenols/herbicides such as 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) and 2,4-dichlorophenoxyacetic acid (2,4-D), and in combustion processes under certain conditions of temperature, residence time, humidity, catalyst presence and so on.

19. PCDDs and PCDFs may also enter the environment from other sources, including domestic wood and waste burning, forest fires, vehicle emissions and tobacco smoke.

(b) PCBs

20. PCBs may also be emitted from combustion-related sources where there is incomplete thermal decomposition of wastes resulting from the inappropriate operation of incinerators, or from combustion at inadequate temperatures, especially open-air and other open burning of wastes, i.e., under the same conditions which can lead to the generation of PCDD and PCDF emissions.

(c) HCB

21. HCB is unintentionally produced as a by-product of the manufacture of perchloroethylene (also known as tetrachloroethylene, PER or PERC), carbon tetrachloride and, to some extent, trichloroethylene. For further information, see subsection I.B.6 (b) of the technical guidelines on POPs pesticides.

22. HCB may also be emitted from combustion-related sources where there is incomplete thermal decomposition of wastes resulting from the inappropriate operation of incinerators or from combustion at inadequate temperatures, especially open burning of wastes, i.e., under the same conditions which can lead to the generation of PCDD and PCDF.

3. Wastes

23. Wastes containing or contaminated with unintentionally produced PCDDs, PCDFs, PCBs and HCB are found in a number of physical forms, including:

(a) Solids:

- (i) Contaminated soils and sediments (sites contaminated by the use of certain pesticides (for reference, see the UNEP *Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases* (UNEP, 2005)), treated wood, open burning and chemical industries);
- (ii) Contaminated rock and mine aggregates (excavated bedrock, gravel, rubble, slag and spent shale);
- (iii) Contaminated sludge (containing industrially produced chemicals, solids and liquids);
- (iv) Contaminated solid waste (paper, metal products, plastic, vehicle shredder fluff, painted objects, demolition waste and so on);

(v) Bottom ashes and air pollution control system residues such as sludges and fly ashes from high-temperature processes (incinerators, power plants, cement kilns, secondary metallurgical industry);

(vi) Drained equipment with liquid residues (electrical, hydraulic or heat transfer equipment, internal combustion engines, pesticide application equipment);

(vii) Drained containers with liquid residues (oil drums, plastic drums, pesticide bottles, storage tanks);

(viii) Contaminated wood (PCB-contaminated, pesticide-impregnated);

(ix) Leather wastes;

(b) Liquids:

(x) Contaminated oils (contained within or drained from internal combustion engines and electrical, hydraulic or heat transfer equipment);

(xi) Certain pesticide formulations (herbicides, wood preservatives);

(xii) Mixed organic liquid wastes (paints, dyestuffs, oils, solvents);

(xiii) Contaminated process water (industrial effluent, water from pollution control scrubbers and curtains, quench waters, sewage);

(xiv) Landfill leachates.

24. In addition, parts II and III of Annex C of the Stockholm Convention list source categories which have the potential to include wastes containing or contaminated with unintentionally produced PCDDs, PCDFs, HCB, or PCBs. See section B of chapter II below.

II. Relevant provisions of the Basel and Stockholm conventions

A. Basel Convention

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

26. Annex I lists some of the wastes that may contain or be contaminated with unintentionally produced PCDDs, PCDFs, HCB or PCBs. These include:

Y5	Wastes from the manufacture, formulation and use of wood preserving chemicals
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)
Y18	Residues arising from industrial waste disposal operations
Y39	Phenols; phenol compounds including chlorophenols
Y41	Halogenated organic solvents
Y42	Organic solvents excluding halogenated solvents
Y43	Any congenor of polychlorinated dibenzo-furan
Y44	Any congenor of polychlorinated dibenzo-p-dioxin
Y45	Organohalogen compounds other than substances referred to in this Annex

(e.g., Y39, Y41, Y42, Y43, Y44)

27. Wastes listed in Annex I are presumed to exhibit an Annex III hazardous characteristic such as H11 “Toxic (Delayed or Chronic)”, H12 “Ecotoxic” or H6.1 “Poisonous (Acute)” unless, through “national tests”, they can be shown not to exhibit the characteristics. National tests may be useful for a particular hazard characteristic listed 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.

28. List A of Annex VIII describes wastes that are “characterized as hazardous under Article 1 paragraph 1 (a) of this Convention” 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.” (Annex I, paragraph (b)). List B of Annex IX lists wastes that “will not be wastes covered by Article 1, paragraph 1 (a), of this Convention unless they contain Annex I material to an extent causing them to exhibit an Annex III characteristic”. The following Annex VIII waste categories are applicable to unintentionally produced PCDDs, PCDFs, HCB, or PCBs:

A1180	Waste electrical and electronic assemblies or scrap[170] containing components such as accumulators and other batteries included on list A, mercury-switches, glass from cathode-ray tubes and other activated glass and PCBs-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)[171]
A3180	Wastes, substances and articles containing, consisting of or contaminated with polychlorinated biphenyl (PCBs), 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[172]
A4110	Wastes that contain, consist of or are contaminated with any of the following: • Any congener of polychlorinated dibenzo-furan • Any congener of polychlorinated dibenzo-dioxin

29. List A of Annex VIII includes a number of wastes or waste categories which have the potential to contain or be contaminated with unintentionally produced PCDDs, PCDFs, HCB, or PCBs, 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)[173]
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)[174] – but allowed in cement- and brick-making
A3020	Waste mineral oils unfit for their originally intended use
A3040	Waste thermal (heat transfer) fluids
A3070	Waste phenols, phenol compounds including chlorophenol in the form of liquids or sludges
A3120	Fluff – light fraction from shredding

---

[170] This entry does not include scrap assemblies from electric power generation.

[171] Where PCBs are at a concentration level of 50 mg/kg or over. B1110: Electrical and electronic assemblies.

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

[173] B2080: Waste gypsum arising from chemical industry processes not included on list A.

[174] B2050: Coal-fired power plant fly-ash, not included on list A.

A3150	Waste halogenated organic solvents
A3160	Waste halogenated or unhalogenated non-aqueous distillation residues arising from organic solvent recovery operations
A4040	Wastes from the manufacture, formulation and use of wood-preserving chemicals[175]
A4100	Wastes from industrial pollution control devices for cleaning of industrial off-gases but excluding such wastes specified on list B
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)[176]

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

B. Stockholm Convention

31. For POPs which are unintentionally generated as the result of human activity, Article 5 of the Convention ("Measures to reduce or eliminate releases from unintentional production") stipulates that each Party must take "measures to reduce the total releases derived from anthropogenic sources of each of the chemicals listed in Annex C, with the goal of their continuing minimization and, where feasible, ultimate elimination". In Annex C ("Unintentional production"), PCDDs, PCDFs, HCB and PCBs are listed in part I.

32. Part II of Annex C lists the following industrial source categories which have the potential for comparatively high levels of formation and release of unintentionally produced PCDDs, PCDFs, HCB and PCBs:

(a) Waste incinerators, including co-incinerators of municipal, hazardous or medical waste or of sewage sludge;

(b) Cement kilns firing hazardous waste;

(c) Production of pulp using elemental chlorine or chemicals generating elemental chlorine for bleaching;

(d) The following thermal processes in the metallurgical industry:

  (i) Secondary copper production;

  (ii) Sinter plants in the iron and steel industry;

  (iii) Secondary aluminium production;

  (iv) Secondary zinc production.

33. Part III of Annex C lists source categories from which PCDDs, PCDFs, HCB and PCBs may also be unintentionally formed and released, including:

(a) Open burning of waste, including burning at landfill sites;

(b) Thermal processes in the metallurgical industry not mentioned in part II of Annex C;

(c) Residential combustion sources;

(d) Fossil-fuel-fired utility and industrial boilers;

(e) Firing installations for wood and other biomass fuels;

(f) Specific chemical production processes releasing unintentionally formed persistent organic pollutants, especially production of chlorophenols and chloranil;

---

[175] This entry does not include wood treated with wood-preserving chemicals.

[176] B2060: Spent activated carbon not containing any Annex I constituents to an extent they exhibit Annex III characteristics, for example, carbon resulting from the treatment of potable water and processes of the food industry and vitamin production.

(g) Crematoria;

(h) Motor vehicles, particularly those burning leaded gasoline;

(i) Destruction of animal carcasses;

(j) Textile and leather dyeing (with chloranil) and finishing (with alkaline extraction);

(k) Shredder plants for the treatment of end-of-life vehicles;

(l) Smouldering of copper cables;

(m) Waste oil refineries.

34. Part V of Annex C provides general guidance to Parties on best available techniques and best environmental practices (BAT/BEP) for preventing or reducing releases of unintentionally produced POPs.

35. For further information, see section II.B of the general technical guidelines.

III. Provisions of the Stockholm Convention to be addressed cooperatively with the Basel Convention

A. Low POP content

36. The following provisional definitions for low POP content should be applied:

- For PCBs: 50 mg/kg[177]
- For PCDDs/PCDFs: 15 µg TEQ/kg[178]
- For HCB: 50 mg/kg[179]

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

B. Levels of destruction and irreversible transformation

37. For information, see section III.B of the general technical guidelines.

C. Methods which constitute environmentally sound disposal

38. For information, see section G of chapter IV below and section IV.G of the general technical guidelines.

IV. Guidance on environmentally sound management (ESM)

A. General considerations: Basel Convention, Stockholm Convention and Organisation for Economic Co-operation and Development

1. Basel Convention

39. One of the principal 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 see subsection IV.A.1 of the general technical guidelines.

40. Parties planning or reviewing a national ESM programme should consult, inter alia, the Basel Convention document entitled "*Preparation of a National Environmentally Sound Management Plan for PCBs and PCB-Contaminated Equipment: Training Manual*" (UNEP, 2003a).

2. Stockholm Convention

41. The term "environmentally sound management" is not defined in the Stockholm Convention. Environmentally sound methods for disposal of wastes containing or contaminated with unintentionally

---

[177] Determined according to national or international methods and standards.

[178] TEQ as referred to in Annex C, part IV, paragraph 2, of the Stockholm Convention, but only for PCDDs and PCDFs.

[179] Determined according to national or international methods and standards.

produced PCDDs, PCDFs, HCB and PCBs are, however, to be determined by the Conference of the Parties in cooperation with the appropriate bodies of the Basel Convention.

42. Parties should consult *Interim guidance for developing a national implementation plan for the Stockholm Convention* (UNEP, 2003b).

3. Organisation for Economic Co-operation and Development

43. For information regarding the Organisation for Economic Co-operation and Development and ESM, see subsection IV.A.3 of the general technical guidelines.

B. Legislative and regulatory framework

44. Parties to the Basel and Stockholm conventions should examine national controls, standards and procedures to ensure that they are in keeping with the conventions and with their obligations under them, including those which pertain to ESM of wastes consisting of, containing or contaminated with PCDDs, PCDFs, HCB and PCBs.

45. Elements of a regulatory framework applicable to PCDDs, PCDFs, HCB and PCBs could also include the following:

(a) Environmental protection legislation establishing a regulatory regime, setting release limits and mandating environmental quality criteria;

(b) Transportation requirements for hazardous materials and wastes;

(c) Specifications for containers, equipment, bulk containers and storage sites;

(d) Specification of acceptable analytical and sampling methods;

(e) A general requirement for public notification and review of proposed government regulations, policy, certificates of approval, and licenses and inventory information and national releases/emissions data;

(f) Requirements for identification and remediation of contaminated sites;

(g) Requirements for health and safety protection of workers;

(h) Other potential legislative controls, as for waste prevention and minimization, inventory development and emergency response;

(i) Requirements for BAT/BEP to be used for destruction technologies for the POPs content of hazardous waste and for waste management facilities and landfills; regulations imposing restrictions on open burning of the POP content of domestic waste; and regulations for ash disposal (including disposal of ashes from the burning of agricultural wastes);

(j) Environmental impact assessment of new facilities for which emission limits for PCDDs and PCDFs may be a consideration.

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

C. Waste prevention and minimization

47. Both the Basel and Stockholm conventions advocate waste prevention and minimization. The issue of waste prevention and minimization is being considered by the Stockholm Convention Expert Group on Best Available Techniques and Best Environmental Practices; in that connection, see also the draft *Guidelines on best available techniques and provisional guidance on best environmental practices relevant to Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutants*. (UNEP, 2006). A final text of the guidelines is expected to be adopted by the Conference of the Parties of the Stockholm Convention in April/May 2007.

48. Efforts to reduce the formation and release of PCDDs and PCDFs are likely also to reduce the formation and release of unintentionally produced HCB and PCBs generated by the same processes.

49. Mixing of wastes with a POPs 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. Nevertheless, mixing of materials before waste treatment may be necessary in order to optimize treatment efficiencies.

50. For further information, see paragraph 6 and section IV.C of the general technical guidelines, the *Standardized Toolkit for the Identification and Quantification of Dioxins and Furan Releases* ("the Standardized Toolkit") (UNEP, 2005) and the Stockholm Convention draft guidelines on best available techniques and best environmental practices referred to in paragraph 47 above.

D. Identification and inventories

1. Identification

51. PCDDs, PCDFs, HCB and PCBs may be found in association with the following industries, equipment and locations (see also parts II and III of Annex C of the Stockholm Convention):

(a) Waste incineration;

(b) Cement kilns;

(c) Pulp and paper production;

(d) Metallurgical industries;

(e) Fossil-fuel-fired utility and industrial boilers;

(f) The production and use of certain pesticides;

(g) Motor vehicle breaking and recovery;

(h) Drained equipment with liquid residues (electrical, hydraulic or heat transfer equipment, internal combustion engines, pesticide application equipment, shredders for end-of-life vehicles and other consumer goods);

(i) Drained containers with liquid residues (oil drums, plastic drums, pesticide bottles, storage tanks);

(j) Painted objects, including wood, concrete and wallboard;

(k) Mixed organic liquid wastes (paints, dyestuffs, oils, solvents);

(l) Treated or contaminated wood (PCB-contaminated, pesticide-impregnated);

(m) Contaminated soils, sediments, rock and mine aggregates;

(n) Contaminated solid waste, including demolition waste;

(o) Contaminated sludge;

(p) Contaminated oils (contained within or drained from internal combustion engines and electrical, hydraulic or heat transfer equipment);

(q) Contaminated process water (industrial effluent, water from pollution control scrubbers and curtains, quench waters, sewage);

(r) Open-air and other open burning of agricultural residues such as crop residues, stubble and bagasse;

(s) Landfill leachates.

52. It should be noted 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. Consequently, the information on production, use and waste types provided in section B of chapter I of the present document may be found useful in identifying PCDDs, PCDFs, HCB and PCBs.

53. For further information, see subsection IV.D.1 of the general technical guidelines.

2. Inventories

54. It is impossible to compile a complete inventory of all wastes containing or contaminated with PCDDs, PCDFs, HCB and PCBs, principally because of the dispersed nature of emissions of those chemicals.

55. For further information, see subsection IV.D.2 of the general technical guidelines.

E. Sampling, analysis and monitoring

56. For general information, see section IV.E of the general technical guidelines.

1. Sampling

57. For information on sampling, see subsection IV.E.1 of the general technical guidelines.

58. The types of matrix which are typically sampled for analysis of unintentionally produced PCDDs, PCDFs, HCB and PCBs include:

(a) Stack gases from high-temperature processes or off-gases from other treatment processes;

(b) Chemicals and pesticides containing chlorine, especially chlorophenols and its derivatives and other chlorinated aromatics;

(c) Consumer goods known to be contaminated with PCDDs or PCDFs, such as chemically bleached paper, textiles, leather and so on.

2. Analysis

59. For information on analysis, see subsection IV.E.2 of the general technical guidelines.

60. Analysis for PCDDs and PCDFs and also for HCB and PCBs as unintentionally produced POPs differs from the analysis of intentionally produced POPs insofar as, typically, the concentrations to be determined are many orders of magnitude lower than for other POPs. This requires special expertise and equipment; for example, only mass-selective detectors are acceptable for quantification. Certain matrices, such as stack emissions, biological samples (human as well as food and vegetation) require high-resolution mass spectrometry for detection if acceptable results are to be generated using internationally recognized methods.

3. Monitoring

61. Monitoring programmes should be implemented for facilities managing wastes containing or contaminated with PCDDs, PCDFs, HCB and PCBs. For further information, see subsection IV.E.3 of the general technical guidelines.

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

62. For general information on handling, collection, packaging, labelling, transportation and storage, see the first two paragraphs of section F of the general technical guidelines.

1. Handling

63. For information, see subsection IV.F.1 of the general technical guidelines.

2. Collection

64. A significant fraction of the total national inventory of wastes containing or contaminated with PCDDs, PCDFs, HCB or PCBs may not be adequately identified.

65. Costs may be prohibitive and national, regional and municipal governments should consider establishing schemes for the collection and removal of those wastes in certain situations (see chapter IV, section I, subsection 1 below on higher-risk situations).

66. Collection operations and collection depots for wastes containing or contaminated with PCDDs, PCDFs, HCB or PCBs should ensure that such wastes are handled and stored separately from all other wastes.

67. It is imperative that collection depots do not become long-term storage facilities for wastes containing or contaminated with PCDDs, PCDFs, HCB or PCBs.

68. For further information, see subsection IV.F.2 of the general technical guidelines.

3. Packaging

69. Wastes containing or contaminated with PCDDs, PCDFs, HCB or PCBs should be properly packaged before storage or transport:

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

(b) Regulations governing transport often specify containers of a certain quality (e.g., 16-gauge steel coated on the inside with epoxy); consequently, containers used for storage should meet transport requirements given that they may be transported in the future;

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

(d) 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 the same drum so long as an adequate amount of absorbent material is present in the drum. Loose absorbents may be purchased from safety suppliers. Sawdust, vermiculite or peat moss may also be used;

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

70. For further information, see subsection IV.F.3 of the general technical guidelines.

4. Labelling

71. All containers containing wastes containing or contaminated with PCDDs, PCDFs, HCB or PCBs should be clearly labelled with both a hazard-warning label and a label which gives the details of the container. The details should include the contents of the container (exact counts of weight or volume of liquid), the type of waste, the name of the site from which it originated so as to allow traceability, the date of repackaging where appropriate and the name and telephone number of the responsible person.

72. For further information, see subsection IV.F.4 of the general technical guidelines.

5. Transportation

73. For information, see section IV.F.5 of the general technical guidelines.

6. Storage

74. The storage procedures for PCDD, PCDF, HCB and PCB wastes should be similar to those for other POPs as the properties and toxicity are broadly similar.

75. For further information, see subsection IV.F.6 of the general technical guidelines.

G. Environmentally sound disposal

1. Pre-treatment

76. Techniques which separate unintentionally produced POPs from the waste matrix are of particular relevance. Those techniques include solvent washing and thermal desorption as, in most cases, wastes contaminated by unintentionally produced POPs are solid substances such as fly ashes and other residues from off-gas cleaning. Oil-water separation may also be important.

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

2. Destruction and irreversible transformation methods

78. For listed destructions and irreversible transformation methods, see subsection IV.G.2 of the general technical guidelines.

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

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

4. Other disposal methods when the POP content is low

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

H. Remediation of contaminated sites

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

I. Health and safety

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

1. Higher-risk situations

83. Unintentionally produced HCB and PCBs are not covered by this subsection because they are very unlikely to be generated in concentrations or volumes larger than those from intentional production.

84. For further information on higher risk-situations, see subsection IV.I.1 of the general technical guidelines. Potential higher-risk situations specific to PCDDs and PCDFs may include:

(a) Sites with residues from air pollution control systems;

(b) Sites with graphite electrodes;

(c) Production and application sites of chlorinated phenols and its derivatives and sludges and other wastes from processes using elemental chlorine;

(d) Consumption of dioxin-contaminated food.

85. As any PCB-containing site will also have high concentrations of PCDFs, see also section IV.I of the technical guidelines on PCBs.

2. Lower risk-situations

86. For information on lower-risk situations, see subsection IV.I.2 of the general technical guidelines. Lower-risk situations specific to PCDDs and PCDFs may include facilities where unintentionally produced POPs occur in low concentrations and low volumes.

J. Emergency response

87. Emergency response plans should be in place for wastes containing or contaminated with PCDDs, PCDFs, HCB or PCBs in storage, in transport or at disposal sites. Further information on emergency response plans is given in section IV.J of the general technical guidelines.

K. Public participation

88. Parties to the Basel and Stockholm conventions should have an open public participation process. For further information see section IV.K of the general technical guidelines.

Appendix

Bibliography

IMO, 2002. International Maritime Dangerous Goods Code. Available at www.imo.org.

UNEP, 2003. *Preparation of a National Environmentally Sound Management Plan for PCBs and PCB-Contaminated Equipment: Training Manual.* Available at www.basel.int.

UNEP, 2004a. *Interim guidance for developing a national implementation plan for the Stockholm Convention.* Available at www.pops.int/documents/guidance/.

UNEP, 2005: *Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases*, Second edition, February 2005. Available at www.pops.int or www.chem.unep.ch/pops/.

UNEP, 2006. Draft *Guidelines on best available techniques and provisional guidance on best environmental practices relevant to Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutants*. (A final text of the guidelines is expected to be adopted by the Conference of the Parties of the Stockholm Convention in mid-2007.) Available at www.pops.int.

UNEP, 2006a. *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)*.

UNEP, 2006b. *Technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with the pesticides aldrin, chlordane, dieldrin, endrin, heptachlor, hexachlorobenzene (HCB), mirex or toxaphene or with HCB as an industrial chemical*.

UNEP, 2006c. *Technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with 1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane (DDT).*

UNEP, 2006d. *General technical guidelines for environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants.*

EPA, 2000. Draft exposure and health assessment for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and related compounds. Part III: *Integrated summary and risk characterization for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and related compounds*. EPA/600/P-00/001Bg. Washington D.C. NCEA Office of Research and Development, EPA.

Van den Berg, M.; Birnbaum, L.; Bosveld, A. T. C.; Brunström, B.; Cook, P.; Feeley, M.; Giesy, J. P.; Hanberg, A.; Hasegawa, R.; Kennedy, S.W.; Kubiak, T.; Larsen, J. C.; van Leeuwen, F. X. R.; Liem, A. K. D.; Nolt, C.; Peterson, R. E.; Poellinger, L.; Safe, S.; Schrenk, D.; Tillitt, D.; Tysklind, M.; Younes, M.; Wærn, F.; Zacharewski, T., 1998. *Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife*. Environmental Health Perspectives 106, no. 12, pp. 775–792. Available through www.ehponline.org.

WHO, 1998. Assessment of the health risks of dioxins: re-evaluation of the tolerable daily intake (TDI). Executive summary of the WHO consultation, 25–29 May 1998, Geneva.

Annex VI

Updated technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with polychlorinated biphenyls (PCBs), polychlorinated terphenyls (PCTs) or polybrominated biphenyls (PBBs)

Contents

Annexes

Abbreviations and acronyms

ABS	acrylonitrile-butadiene-styrene copolymers (plastics)
ESM	environmentally sound management
HASP	health and safety plan
HCB	hexachlorobenzene
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

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

I. Introduction

A. Scope

1. This document supersedes the Basel Convention's technical guidelines on wastes comprising or containing PCB, PCT and PBB (Y10) of February 1997.

2. The present technical guidelines provide guidance for the environmentally sound management (ESM) of wastes consisting of, containing or contaminated with polychlorinated biphenyls (PCBs) pursuant to decisions V/8, VI/23, VII/13 and VIII/16 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 and decisions SC-1/21 and SC-2/6 of the Conference of the Parties to the Stockholm 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 are addressed in the technical guidelines for the environmentally sound management of wastes containing or contaminated with unintentionally produced polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), hexachlorobenzene (HCB) or polychlorinated biphenyls (PCBs).

5. The present document should be used in conjunction with the document entitled "*General technical guidelines for environmentally sound management of wastes consisting of, containing or* contaminated *with persistent organic pollutants* ("the general technical guidelines") (UNEP, 2006). That 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 10 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 10 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.

(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 (IPCS, 1994). They are solids or waxy substances at room temperature. They are virtually insoluble in water and highly resistant to degradation.

10. Congenors of PBBs have not been assigned toxicity equivalency factors by the World Health Organization.

2. Production

(a) PCBs

11. 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.

12. 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 (Artic Monitoring and Assessment Programme, 2000); and from 1954 to 1972 in Japan.

13. 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 per cent PCBs in hydraulic fluid, transformer fluid and heating fluids. At room temperature, the majority of them are oily liquids or waxy solids.

14. 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)
Fenchlor (Italy)
Kanechlor (Japan)
Phenoclor (France)
Pyralene (France)
Pyranol (United States)
Pyroclor (United States)
Santotherm (Japan)
Sovol (USSR)
Sovtol (USSR)

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

16. 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.

17. The cumulative worldwide production of PCBs has been estimated at 750,000–2 million tonnes.

(b) PCTs

18. 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.

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

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

(c) PBBs

21. Information on the production of PBBs is scarce. It is estimated that at least 11,000 tonnes 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).

22. 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 per cent hexa- and up to 25 per cent 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

23. 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).

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

25. 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

26. 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

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

4. Wastes

28. 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.

29. It should be noted 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

30. Article 1 ("Scope of Convention") outlines the waste types subject to the Basel Convention. Subparagraph 1 (a) of that Article sets forth a two-step process for determining whether a "waste" is a "hazardous waste" subject to the Convention: first, the waste must belong to any category contained in Annex I to the Convention ("Categories of Wastes to be Controlled"), and second, the waste must possess at least one of the characteristics listed in Annex III to the Convention ("List of Hazardous Characteristics").

31. 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)

32. Annex I wastes are presumed to exhibit an Annex III hazardous characteristic such as H11 "Toxic (Delayed or Chronic)", H12 "Ecotoxic", or H6.1 "Poisonous (Acute)" unless, through "national tests", they can be shown to not exhibit such characteristics. National tests may be useful for identifying a particular hazard characteristic listed 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.

33. List A of Annex VIII describes wastes that are "characterized as hazardous under Article 1 paragraph 1(a) of this Convention" 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" (Annex I, paragraph (b)). List B of Annex IX lists wastes which "will not be wastes covered by Article 1, paragraph 1 (a), of this Convention unless they contain Annex I material to an extent causing them to exhibit an Annex III characteristic". The following Annex VIII waste categories in particular are applicable to PCBs, PCTs or PBBs:

A1180 Waste electrical and electronic assemblies or scrap[180] 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)[181]

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[182]

34. 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 183 chemicals corresponding to Annex I categories and exhibiting Annex III hazard characteristics

---

[180] This entry does not include scrap assemblies from electric power generation.

[181] PCBs are at a concentration level of 50 mg/kg or more.

[182] 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.

[183] “Outdated” means unused within the period recommended by the manufacturer.

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)

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

B. Stockholm Convention[184]

36. The present document covers 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 of the Stockholm Convention.

37. 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;

---

[184] This section does not apply to PCTs and PBBs.

(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".

38. For further information, see section II.B of the general technical guidelines.

III. Issues under the Stockholm Convention to be addressed cooperatively with the Basel Convention[185]

A. Low POP content

39. The provisional definition for low POP content for PCBs is 50 mg/kg.[186] For further information, see section III.A of the general technical guidelines.

B. Levels of destruction and irreversible transformation

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

C. Methods that constitute environmentally sound disposal

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

IV. Guidance on environmentally sound management (ESM)

A. General considerations

1. Basel Convention

42. One of the principal 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 see section IV.A.1 of the general technical guidelines.

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

2. Stockholm Convention

44. The term "environmentally sound management" 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.

45. Parties should consult "*Guidance for developing a NIP for the Stockholm Convention*" (UNEP 2005).

3. Organisation for Economic Co-operation and Development

46. For information regarding the Organisation for Economic Co-operation and Development and ESM, see subsection IV.A.3 of the general technical guidelines.

B. Legislative and regulatory framework

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

---

[185] This section does not apply to PCTs and PBBs.

[186] Determined according to national or international methods and standards.

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

(a) Environmental protection legislation setting release limits and establishing 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) A general requirement for public notification and review of proposed government regulations, policy, certificates of approval, licences, inventory information and national emissions data;

(i) Requirements for identification and remediation of contaminated sites;

(j) Requirements for health and safety of workers;

(k) Other potential legislative controls, as for waste prevention and minimization, inventory development and emergency response).

49. 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.

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

C. Waste prevention and minimization

51. 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.

52. Quantities of waste containing these compounds should be minimized through isolation and source separation to prevent mixing and contamination of other waste streams. For example, 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.

53. 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. Nevertheless, mixing of materials before waste treatment may be necessary in order to optimize treatment efficiencies.

54. For further information, see paragraph 6 and section IV.C of the general technical guidelines.

D. Identification and inventories

1. Identification

55. PCBs, PCTs and PBBs have historically been found in a number of 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.

56. It should be noted 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.

57. The information on production, use and waste types provided in section I.B of the present document may be useful in identifying PCBs, PCTs and PBBs.

58. For further information, see subsection IV.D.1 of the general technical guidelines.

2. Inventories

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

60. For further information, see subsection IV.D.2 of the general technical guidelines.

E. Sampling, analysis and monitoring

61. For general information, see section IV.E. of the general technical guidelines.

1. Sampling

62. For information on sampling, see section IV.E.1 of the general technical guidelines.

63. The types of matrices that are of special interest for analysis of PCBs, PCTs and PBBs include:

(a) Askarel (PCBs and PCTs) liquid from transformers or other equipment or in bulk storage;

(b) Mineral oil from transformers contaminated with PCBs or in bulk storage;

(c) Waste motor oil and other waste oils, fuels and organic liquids;

(d) Fire suppressants and retardants (PBBs).

2. Analysis

64. For information on analysis, see subsection IV.E.2 of the general technical guidelines.

65. For PCBs, there may be a special interest in determining dioxin-like PCBs. To do so, internationally accepted methods like those for analysing PCDDs/PCDFs should be applied.

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

3. Monitoring

67. Monitoring programmes should be implemented for facilities managing wastes consisting of, containing or contaminated with PCBs, PCTs and PBBs. For further information see subsection IV.E.3 of the general technical guidelines.

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

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

1. Handling

69. For information, see subsection IV.F.1 of the general technical guidelines.

2. Collection

70. A significant fraction of total national inventories 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 must 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 and municipal governments should consider establishing collection stations for those small quantities so that each small-quantity owner does not have to make individual transport and disposal arrangements.

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

72. 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 large amounts of wastes, even if properly stored, than for small quantities scattered over a large area.

73. For further information, see subsection IV.F.2 of the general technical guidelines.

3. Packaging

74. Wastes consisting of, containing or contaminated with PCBs, PCTs or PBBs should be properly packaged before storage or transport:

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

Regulations governing transport often specify containers of a certain quality (e.g., 16-gauge steel coated inside with epoxy resin/polymer); consequently, containers used for storage should meet transport requirements given that they may be transported in the future;

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 the same drum so long as an adequate amount of absorbent material is present in the drum. Loose absorbents may be purchased from safety suppliers. Sawdust or peat moss may also be used;

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

75. For further information, see section IV.F.3 of the general technical guidelines.

4. Labelling

76. All containers and equipment containing or contaminated with PCBs, PCTs or PBBs should be clearly labelled with both a hazard-warning label and a label which gives the details of the equipment or container. The details should include the contents of the container or equipment (exact counts of equipment or volume of liquid), the type of waste, the name of the site from which it originated so as to allow traceability, the date of repackaging where appropriate and the name and telephone number of the responsible person.

77. For further information, see subsection IV.F.4 of the general technical guidelines.

5. Transportation

78. For information, see subsection IV.F.5 of the general technical guidelines.

6. Storage

79. Whereas many countries have adopted storage regulations or developed storage guidelines concerning PCBs, most do not have specific storage regulations or guidance concerning PCTs and

PBBs. Nevertheless, it can be assumed that storage procedures should be similar since the properties and toxicities of PCTs and PBBs are similar. Although recommended practice varies somewhat from country to country, there are many common elements to safe storage of these wastes.

80. For further information, see subsection IV.F.6 of the general technical guidelines.

G. Environmentally sound disposal

1. Pre-treatment

81. Cutting and milling of capacitors for purposes of size reduction should be carried out only immediately before destruction in a dedicated facility.

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

2. Destruction and irreversible transformation methods

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

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

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

4. Other disposal methods when the POP content is low

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

H. Remediation of contaminated sites

86. For information, see subsection IV.H of the general technical guidelines.

I. Health and safety

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

1. Higher-risk situations

88. For information on higher-risk situations, see subsection IV.I.1 of the general technical guidelines. Potential higher-risk situations specific to PCBs, PCTs or PBBs may include:

(a) Electrical rooms with large or multiple PCB transformers, circuit breakers or capacitors;

(b) Sites at which PCB-containing transformers, circuit breakers, hydraulic equipment or vacuum pumps have been used or maintained.

2. Lower-risk situations

89. For information on lower risk situations, see subsection IV.I.2 of the general technical guidelines. Lower-risk situations specific to PCBs, PCTs, PBBs may include:

(a) Those that involve only products or articles that contain or are contaminated with PCBs in small quantities or at low concentrations (e.g., light ballasts containing PCBs in fluorescent fixtures);

(b) Electrical transformers or other equipment with low-level PCB-contaminated mineral oil;

(c) Consumer goods containing PBBs as flame retardants.

J. Emergency response

90. 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 is given in section IV.J of the general technical guidelines and in "*Preparation of a National Environmentally Sound Plan for PCB and PCB-Contaminated Equipment: Training Manual*" (UNEP, 2003a).

K. Public participation

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

Appendix I

Synonyms and trade names for PCBs, PCTs and PBBs

Chemical	Some synonyms and trade names[187]
PCBs	Abestol, Aceclor, Adkarel, ALC, Apirolio (Italy), Apirorlio, 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), Fenclor (Italy), Fenocloro, Gilotherm, Hexol, Hivar, Hydelor, 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), Santothern, Santovac, Sat-T-America, Siclonyl, Solvol, Sorol, Soval, Sovol (USSR), Sovtol, Tarnol (Poland), Terphenychlore, Therminal, 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_{10}, Bromkal 80, Firemaster BP-6, Firemaster FF-1, Flammex B-10, hbb, hexabromobiphenyl, HFO 101, obb, BB-8

---

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

Appendix II

Bibliography

AMAP (Arctic Monitoring and Assessment Programme). 2000. *Multilateral co-operative project on phase-out of PCB use and management of PCB-contaminated wastes in the Russian Federation – Phase I: Arctic Monitoring and Assessment Programme*. Oslo, Norway.

China State Environmental Protection Agency. 2002. *Terms of reference: Development of a PCB inventory methodology and a draft strategy on PCB reduction and disposal in China (draft).* Document prepared for the World Bank. Beijing, China.

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

Holoubek, I. 2000. *Polychlorinated biphenyls (PCB) world-wide contaminated sites.* Downloaded from www.recetox.chemi.muni.cz/PCB/content173.htm.

IMO (International Maritime Organization). 2002. *International maritime dangerous goods code*. Avaliable at www.imo.org.

IPCS (International Programme on Chemical Safety). 1992. *Environmental Health Criteria 140: Polychlorinated biphenyls and polychlorinated terphenyls*. Published by UNEP, ILO and WHO, Geneva.

IPCS (International Programme on Chemical Safety). 1994. *Environmental Health Criteria 152: Polybrominated biphenyls*. Published by UNEP, ILO and WHO, Geneva.

Jensen, A.A. and K.F. Jørgensen. 1983. *Polychlorinated terphenyls (PCT) uses, levels and biological effects.* Sci. Total Environ. 27:231–250.

Lassen, C., S. Løkke and L.I. Andersen. 1999. *Brominated flame retardants – substance flow analysis and assessment of alternatives*. Environmental Project No. 494, Danish EPA, Copenhagen. Available at www.mst.dk/udgiv/Publications/1999/87-7909-416-3/html/default_eng.htm.

UNECE (United Nations Economic Commission for Europe). 2002. *Report on production and use of PCT (draft)*. Prepared for the UNECE Expert Group on POPs.

UNEP (United Nations Environment Programme). 1995a. *Basel Convention: Manual for implementation.* Available at www.basel.int.

UNEP (United Nations Environment Programme). 1999. *Guidelines for the identification of PCB and materials containing PCB.* Available at www.chem.unep.ch.

UNEP (United Nations Environment Programme). 2003. *Preparation of a national environmentally sound plan for PCB and PCB-contaminated equipment: Training manual*. Available at www.basel.int.

UNEP (United Nations Environment Programme). 2005. *Guidance for developing a NIP for the Stockholm Convention.* Available at www.pops.int.

UNEP, 2006. *General technical guidelines for environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants.* Available at www.basel.int.