

**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)**

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## 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**

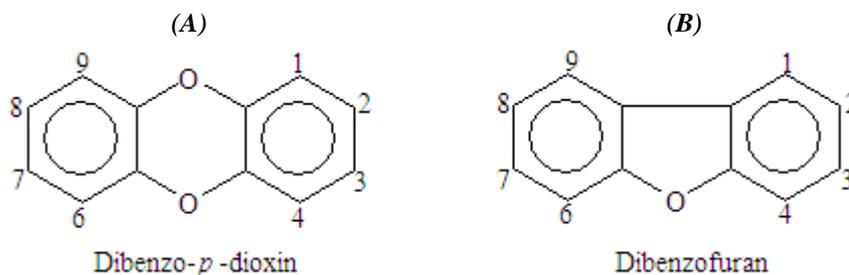
1. The present technical guidelines provide guidance for the environmentally sound management (ESM) of wastes containing or contaminated with unintentionally produced polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), hexachlorobenzene (HCB) or polychlorinated biphenyls (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 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)

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 <sup>1</sup> containing components such as accumulators and other batteries included on list A, mercury-switches, glass from cathode-ray tubes and other activated glass and 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) <sup>2</sup> |
| 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 <sup>3</sup>                                                                                                                                                    |
| A4110 | Wastes that contain, consist of or are contaminated with any of the following: <ul style="list-style-type: none"> <li>• Any congener of polychlorinated dibenzo-furan</li> <li>• Any congener of polychlorinated dibenzo-dioxin</li> </ul>                                                                                                                                                                                                                                                  |

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) <sup>4</sup>         |
| 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) <sup>5</sup> – 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                                                                                                                                                                                          |
| 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 <sup>6</sup>                                                                                                                                     |
| A4100 | Wastes from industrial pollution control devices for cleaning of industrial off-gases but excluding such wastes specified on list B                                                                                            |

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

<sup>2</sup> Where PCBs are at a concentration level of 50 mg/kg or over. B1110: Electrical and electronic assemblies.

<sup>3</sup> 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.

<sup>4</sup> B2080: Waste gypsum arising from chemical industry processes not included on list A.

<sup>5</sup> B2050: Coal-fired power plant fly-ash, not included on list A.

<sup>6</sup> This entry does not include wood treated with wood-preserving chemicals.

- 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)<sup>7</sup>

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;
- (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.

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<sup>7</sup> 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.

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<sup>8</sup>
- For PCDDs/PCDFs: 15 µg TEQ/kg<sup>9</sup>
- For HCB: 50 mg/kg<sup>10</sup>

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 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.

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<sup>8</sup> Determined according to national or international methods and standards.

<sup>9</sup> TEQ as referred to in Annex C, part IV, paragraph 2, of the Stockholm Convention, but only for PCDDs and PCDFs.

<sup>10</sup> Determined according to national or international methods and standards.

## **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.

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