Stockholm Convention on Persistent Organic Pollutants

Persistent Organic Pollutants Review Committee (POPRC)

DRAFT RISK MANAGEMENT EVALUATION

for

Pentachlorobenzene

Draft prepared by:
The ad hoc working group on pentachlorobenzene

April, 2008

Draft Risk Management Evaluation for Pentachlorobenzene

Note:

In accordance with the procedure laid down in Article 8 of the Stockholm Convention, this draft was prepared by the Persistent Organic Review Committee (POPRC) during its intersessional work.

Parties and observers to the Stockholm Convention are invited to provide technical and substantive comments on this draft. Comments received will be considered by the ad hoc working group and the revised draft will be made available for the fourth meeting of the POPRC (13-17 October 2008 in Geneva). Please submit your comments to the Secretariat of the Stockholm Convention preferably by e-mail no later than **18 May, 2008** to:

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This draft risk management evaluation is based on the draft prepared by RIVM for the European Commission, DG Environment

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Executive Summary

The European Community and its Member States being Parties to the Stockholm Convention have proposed pentachlorobenzene (PeCB) to be listed in Annex A, B and/or C to the Convention pursuant to paragraph 1 of Article 8 of the Convention. The risk profile of PeCB was adopted on the third meeting of the Persistent Organic Pollutants Review Committee in November 2007. The Committee decided, in accordance with paragraph 4 (a) of Article 8 of the Convention, that the screening criteria have been fulfilled for PeCB. The Committee recommended to make an additional effort in order to distinguish between the environmental burden caused by intentional use and the burden caused by unintentional production in order to support the risk management evaluation.

Past uses mentioned in the risk profile concern PeCB as a component in PCB products, in dyestuff carriers, as a fungicide and a flame retardant and as a chemical intermediate e.g. for the production of quintozene. There is no quantitative information available on historic production and use. PeCB is presently only produced and used in relatively small amounts of analytical grade PeCB by laboratories for the preparation of standard solutions used for analytical purposes. Furthermore, the use in the worldwide production of quintozene can not be excluded. The information indicating that PeCB is not used anymore for the production of quintozene only covers the UNECE region[1].

The most efficient control measure would be the prohibition of all production and uses of PeCB and PeCB containing products. As no remaining production or uses of PeCB have been identified except the use in laboratories and the possibility that some use for quintozene production takes place, listing of PeCB in Annex A without any specific exemptions would be the primary control measure under the Convention. Listing of PeCB in Annex A would also ensure that the provisions of Article 3 on export and import and of Article 6 on identification and sound disposal of stockpiles and waste would apply. As the production of PeCB has ceased some decades ago in the main producing countries, there are now alternatives available with comparable efficacy, and without cost implications. Based on this background, significant negative impact on society of listing PeCB in Annex A is expected to be very limited. No requests have been received nor particular needs identified for specific exemptions on PeCB. A beneficial effect could be expected as any currently unidentified production and use around the world should end. Also re-introduction of PeCB is effectively excluded if listed in Annex A.

Unintentional anthropogenic sources can be divided into point sources and diffuse sources. As regards point sources, combustion and thermal processes and industrial processes are most important and emissions are controlled by abatement and substitution techniques and/or legislation. For PeCB formed as by-product in combustion processes there is a clear relation to PCDD/F emissions formed by combustion. Most measures taken to reduce PCDD/F emissions, as described in the Stockholm Convention's BAT/BEP guidelines for incinerators and other thermal processes, will undoubtedly lead to a significant reduction of the emissions of PeCB. **However, further work may be needed to expand the BAT/BEP guidelines to consider the advisability of abatement techniques that are less effective for PeCBs than they are for PCDD/F.** The most relevant diffuse sources are impurities in products such as, solvents, pesticides and wood preservative products, and barrel burning, open fire places, **and** accidental fires. For these sources abatement techniques are not feasable and emission reduction measures can only be enacted by legislation and/or providing information and education by the national and local authorities.

Deleted: and forest burning for agricultural purposes

[1] United Nations Economic Commission for Europe: http://www.unece.org/oes/member_countries/member_countries.htm

An Annex C listing would subject PeCB to the measures under Article 5 of the Convention and establish the goal of continuing minimization and, where feasible, ultimate elimination of PeCB emissions. This would include an obligation to promote Best Available Techniques (BAT) and Best Environmental Practices (BEP) for PeCB sources. Countries already have obligations to take these control measures for other unintentionally produced POPs (PCDD/F**, PCBs,** and HCB) under the Convention.

1. Introduction

1.1 Chemical identity of the proposed substance

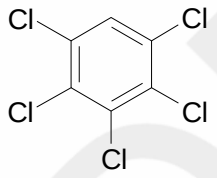
Background
The European Community and its Member States being Parties to the Stockholm Convention have proposed pentachlorobenzene (PeCB) to be listed in Annex A, B and/or C to the Convention pursuant to paragraph 1 of Article 8 of the Convention. The complete original proposal is contained in document UNEP/POPS/POPRC.2/INF/5. A summary of the proposal prepared by the Secretariat was provided in document UNEP/POPS/POPRC.2/13. The risk profile of PeCB was adopted on the third meeting of the Persistent Organic Pollutants Review Committee in November 2007 (UNEP/POPS/POPRC.3/20/Add.7).

Chemical identity of the proposed substance
PeCB belongs to the group of chlorobenzenes, which are characterised by a benzene ring in which the hydrogen atoms are substituted by one or more chlorines. The chlorobenzenes are neutral, thermally stable compounds with increasing stability and higher melting and boiling points with increasing chlorine substitution. PeCB has a very low solubility in water.

IUPAC Name: pentachlorobenzene
CAS Chemical Name: benzene, pentachloro-
Synonyms: 1,2,3,4,5-pentachlorobenzene; Pentachlorobenzene; PCB; PeCB; QCB; quintochlorobenzene
CAS Registry Number: 608-93-5
EINECS Number: 210-172-0
Trade names: -

Structure:

1,2,3,4,5-Pentachlorobenzene



1.2 Conclusion of the Review Committee, Annex E information

The Committee has conducted and evaluated the risk profile in accordance with Annex E at the third meeting in Geneva 19-23 November 2007 (UNEP, 2007). The Committee decided, in accordance with paragraph 4 (a) of Article 8 of the Convention, that it is satisfied that the screening criteria have been fulfilled for pentachlorobenzene.

PeCB is persistent in the environment and is bioaccumulative. The small spatial variability in the ranges of air concentrations across the Northern Hemisphere indicates that PeCB has a very long atmospheric residence time and is widely distributed in the global hemisphere. There are monitoring data from remote areas, backed up by modelling results that suggest that PeCB can be transported over long distances. PeCB is moderately toxic to humans, but is very toxic to aquatic organisms.

As a result of the long range transport of PeCB, neither a single country nor a group of countries alone can abate the pollution caused by this substance. Unintentional release of PeCB as a byproduct of incomplete combustion appears to be the largest current source.

Measures to reduce these releases can only be taken at a global scale. Although the production and use of PeCB is ceased in most countries, its reintroduction remains possible. This reintroduction could lead to increased releases and levels in the environment. Based on the available evidence, PeCB is likely, as a result of its long range environmental transport, to lead to significant adverse human health and/or environment effects, such that global action is warranted.

As the distinction between the environmental burden caused by intentional use and the burden caused by unintentional production could support the preparation of the risk management evaluation and making the final recommendation, the Committee considers that an additional effort should be made to fill this gap.

1.3 Data sources

The draft Risk Management Evaluation is based on information that has been provided by Parties to the Convention and observers. The following parties and observers have answered the request for information specified in Annex F of the Stockholm Convention (risk management): Armenia, Canada, Croatia, Czech Republic, International POPs Elimination Network (IPEN), Moldova, Monaco, Mozambique, Myanmar, Netherlands, Qatar, United States and World Chlorine Council (WCC).

In addition, information is gathered from the open literature. Relating to the UNECE region also additional information is obtained from a paper 'Exploration of management option for Pentachlorobenzene (PeCB)' prepared for the 6th meeting of the UNECE CLRTAP Task Force on Persistent Organic Pollutants (4-7 June 2007) (UNECE, 2007) and papers produced within the UNECE framework (UNECE, 2008).

1.4 Status of the chemical under international conventions

PeCB is not included in any international convention. The European Commission has submitted a proposal to include PeCB to the Protocol on Persistent Organic Pollutants to the 1979 Convention on Long Range Transboundary Air Pollution (LRTAP) to the Executive Secretariat of the United Nations Economic Commission for Europe (UNECE) in 2006 (European Commission, 2007). The objective of the LRTAP POPs protocol is to control, reduce or eliminate discharges, emissions and losses of persistent organic pollutants. The UNECE Task Force on POPs identified the following options for possible inclusion of PeCB into the Protocol:

(a) Listing of PeCB in annex I to the Protocol in order to prevent production and use;
(b) Listing of PeCB in annex I and annex III to the Protocol.

The conclusions of the Task Force have been discussed at the 40th session of the Working Group of Strategies and Review (WGSR) under the UNECE POP protocol. The WGSR took note of the Task Force conclusions on PeCB and agreed to submit it to the Executive Body for consideration. In their meeting of December 2007 the Executive Body mandated the WGSR to negotiate draft amendments to the Protocol on POPs for presentation to the twenty-sixth session of the Executive Body in 2008 that covers inclusion of PeCB and six other POPs in the Protocol Annexes (UNECE, 2008).

1.5 Any national or regional control actions taken

Canada

In Canada PeCB is included under the *Prohibition of Certain Toxic Substances Regulations, 2005* (hereinafter referred to as the Regulations) under the Prohibited Toxic Substances List in Schedule 2, Part 2 of the Regulations. These regulations enacted a ban on the manufacture, use, sale, offer for sale and import of PeCB or any mixture or product containing these

substances, but allow use exemptions where they are used with PCBs. PCBs are regulated under the *Chlorobiphenyls Regulations* and *Storage of PCB Material Regulations*.

Various initiatives indirectly contribute to reductions in PeCB emissions in Canada, such as:

- the Canada-wide Standards for dioxins and furans;
- the regulatory approaches in other Canadian jurisdictions to either prohibit open burning, or permit it only under pre-approved conditions;
- proposed revisions to the PCB regulatory framework;
- the Wood Preservation Strategic Options Process; and
- the regulations for the control of tetrachloroethylene from the dry-cleaning sector.

Czech Republic

In the Czech Republic, PeCB is part of an integrated monitoring program on POPs. This program will provide information on the Central European levels of POPs, the long-term trends in those levels and the impact of various sources and the effectiveness of measures applied to reduce the impact.

European Union

In the EU quintozene is not included as an active substance in Annex I to Directive 91/414/EEC, which means that Member States shall ensure that authorizations for plant protection products containing quintozene are withdrawn and that no authorizations will be granted or renewed (the use of quintozene has stoppped after June 2002).

The EU has identified a number of priority substances within the European Water Framework Directive (2000/60/EC). Within the list of these priority substances so-called priority hazardous substances are identified which are of particular concern for the freshwater, coastal and marine environment. These substances will be subject to cessation or phasing out of discharges, emissions and losses within 20 years after adoption of the Directive. The European Commission has proposed to include pentachlorobenzene as a priority hazardous substance. PeCB is listed on the OSPAR 1998 List of Candidate Substances (UNEP, 2007).

Moldova

PeCB is not included in the official register of permitted of permitted substances for importation and use in agriculture, including individual farms, forestry and household. This substance will be banned in Moldova by the new National Chemicals Management Law, which now is under development. Quintozene was banned in former Soviet Union on 21 March 1986. This prohibition is in force in the Republic of Moldova before approval of the new National Chemicals Management Law.

United States

PeCB is subject to a US Toxic Substances Control Act (TSCA) Significant New Use Role, requiring notification to EPA prior to manufacture, import or processing of 10,000 pounds (4,536 kg) or more of PeCB per year per facility for any use subject to TSCA. No such notification has been received.

The other countries who submitted information did not provide information on specific actions taken to control PeCB. In the submission from IPEN a list of countries is given in which the use of quintozene, endosulfan, chlorpyrifos-methyl, atrazine and clopyralid, which may contain PeCB, is prohibited.

2. Summary information relevant to the risk management evaluation

2.1 Additional information

2.1.1 General information on sources, emissions and measures

At the third meeting of the POPs Review Committee, it was noted that there were information gaps in the risk profile regarding environmental burden caused by intentional use and un-intentional releases of PeCB. Because the emissions of PeCB in the past from several sources, such as waste burning and pesticide use, are not known and changed over time, it is not possible to distinguish the environmental burden from intentional use and unintentional releases.

Assuming that historical contamination in sediments and soils are already controlled by national and international legislation, contaminated sites are not covered in this document. In the past PeCB was used in PCB applications, which are still in use worldwide. But since PCBs are listed on Annex A of the Stockholm Convention, this potential PeCB source will be addressed in countries that are Parties to the Convention. The focus will be, therefore, on the actual intentional and unintentional sources, processes and possible measures. A concise overview of the various current emission sources and related reduction measures is given in Figure 1.

Anthropogenic sources can be divided into intentional and unintentional sources.

In the risk profile past uses mentioned are PeCB as a component in PCB products, in dyestuff carriers, as a fungicide and a flame retardant and as a chemical intermediate e.g. for the production of quintozene. There is no quantitative information available on historic production and use. Based on the information from the risk profile, from the Annex F submissions from parties and observers and from an internet search, there is no indication that (large scale) production or intentional use of PeCB still takes place. However, the use in the production of quintozene can not be excluded. The information indicating that PeCB is not used anymore for the production of quintozene only covers the UNECE region. PeCB is presently only produced and used in relatively small amounts of analytical grade PeCB by laboratories for the preparation of standard solutions used for analytical purposes. According to article 3.5 of the Stockholm convention such an application is not included in the convention.

Unintentional anthropogenic sources can be divided into point sources and diffuse sources. As regards point sources, large scale combustion processes and industrial processes are most important and emissions are controlled by abatement techniques and/or legislation.

The most relevant diffuse sources are;

- as an impurity in products such as, solvents, pesticides and wood preservative products,
- small scale combustion such as barrel burning and open fire places,
- accidental fires and
- forest burning for agricultural purposes.

For these sources abatement techniques are not likely and emission reduction measures can be obtained by legislation and/or providing information and education by the national and local authorities.

Please note below about this section:

~~**Natural sources consisting of forest fires might be a major source of the total emission of PeCB. This is supported by the good correlation between the emission of dioxins and**~~

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~~PeCBs during the open burning of household wastes (Lemieux et al., 2004; EPA 2002), and the information of PCDD/F emissions from forest fire simulations (Gullett and Touati, 2003). Using the latter information, the PCDD/Fs emission from forest fires in the USA appear to have a high contribution of over 50% to the total emission dioxins. The UNEP document (1999) also states that forest fires might lead to a significant emission of PCDD/Fs but emphasizes that estimates are subject to considerable uncertainties. Assuming that emitted concentrations of PeCB and dioxins will be comparable, forest fires might have a significant contribution to the worldwide emission of PeCB. However, in Article 5 of the Stockholm Convention it is clearly stated that measures shall be taken for chemicals listed on Annex C to reduce or eliminate release from unintentional production by anthropogenic sources. Therefore natural sources are excluded from the Convention.~~

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NOTE: Given the large discrepancy between simulations (US experience) and actual measurements (Australia, Spain, Canada) and the fact that the EC does not consider forest fires to be major dioxin sources, I do not think that this text can be scientifically justified, despite the insistence of the World Chlorine Council. The paragraph above does not represent important data from many countries and the RME should not contain a blanket statement that forest fires could be a major source of PeCB. Forest fires are simply NOT a major source of dioxins or PeCB in the world.

Note the following evidence:

1. A TNO report on dioxin emissions in several EU candidate countries does not list forest fires as major sources.[2]

Countries examined included Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovak Republic, Slovenia, and Turkey. The largest contributions of dioxin emissions to air were from incineration of wastes, cement kilns, and iron ore sintering. Forest fire emissions of dioxins were estimated at 5 ug I-TEQ/ton using the UNEP dioxin toolkit. In contrast, dioxin emissions from landfill fires were estimated at 1000 ug I-TEQ/ton.

2. The EC does not regard forest fires as major dioxin sources

Wenborn, M., King, K., Buckley-Golder, D., Gascon, J., 1999. Releases of Dioxins and Furans to Land and Water in Europe. Final Report. Report produced for Landesumwaltamt Nordrhein-Westfalen, Germany on behalf of European Commission DG Environment. September 1999

Quass, U., Fermann, M., Broker, G., 2000. The European Dioxin Emission Inventory, Stage II. Vol. 3: Assessment of dioxin emissions until 2005. Nordrhein-Westfalen, Germany: Landesumweltamt NRW. December 2000

Quass, U., Fermann, M., 1997. Identification of Relevant Industrial Sources of Dioxins and Furans in Europe (The European Dioxin Inventory). Final Report No. 43, Essen, Germany: Landesumweltamt Nordrhein-Westfalen, Germany.

Martinez et al. (2000) analyzed vegetation and soils in forest fire areas in Spain and concluded that "natural fires seem not to be an important source of dioxin-like compounds." [3]

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[2] Pulles T, Kok H, Quass U, Juery C, Mategovicova J (2005) Dioxin emissions in candidate countries, TNO Environment and Geosciences R&I-A R2005/054

3. Studies from Canada indicate that forest fires are not major dioxin sources

Van Oostdam (1995) found no detectable dioxins in three soil samples and four ash samples taken immediately after a forest fire in British Columbia, Canada. [4]

Ikonomou et al. (1999) reported that "data do not show levels high enough and/or distinct patterns that would suggest that the sediments in the streams examined have been impacted by PCDDs/Fs produced from the forest fires." [5]

Gabos et al. (2001) reported only very low concentrations of dioxins in sediments following extensive forest fires in Canada.[6]

4. Studies from Australia indicate that forest fires and bush fires are not major dioxin sources

A recent study of dioxin emissions from crop and bush fires in Australia revised the estimated contribution from these sources downwards by 70%.[7]

An Australian government report notes that the measured dioxin emissions in the field were substantially different from laboratory tests used to estimate inventory values for various open burning sources.[8] Total dioxin emissions to air from these sources was revised downward from 1,708 TEQ to 152 TEQ. For forest fires and wildfires the previous estimates from 2002 were 7 – 400 g TEQ/y. The new results after actual measurements were conducted ranged from 1.2 – 15.2 g TEQ/y.

Measuring PCDD/F emissions at 20 sites across Australia, Ivory and Mobbs (2004) found dioxin emissions from laboratory tests were up to ten times higher than those from field measurements but were comparable to other laboratory tests. [9] Meyer et al. (2004) elaborated further as follows:[10] "Laboratory tests do not adequately simulate the combustion processes occurring in the field. … The key difference between field and laboratory emissions may be the duration for which the smoke plume remains at high

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[3] Martinez, M., Diaz-Ferrero, J., Marti, R., Broto-Puig, F., Comellas, L., Rodriguez-Larena, M., 2000. Analysis of dioxin-like compounds in vegetation and soil samples burned in Catalan forest fires. Comparison with the corresponding unburned material. Chemosphere 41: 1927-1935.

[4] Van Oostdam, J.C. and Ward, J.E.H. (1995) *Dioxins and Furans in the British Columbia Environment*, BC Environment, Environmental Protection Department, Victoria, British Columbia.

[5] Ikonomou, M, Gabos S, Schopflocher D, White J, Prepas E, Prince D, Chen W, 1999. Dioxins, furans and PCBs determinations in sediment and fish tissue following forest fires. Organohalogen Cpds. 43: 299-302.

[6] Gabos S, Ikonomou M, Schopflocher D, Fowler B, White J, Prepas E, Prince D, Chen W, 2001. Characteristics of PAHs, PCDD/Fs and PCBs in sediment following forest fires in northern Alberta. Chemosphere 43: 709-719

[7] Meyer CP, Black RR, Tolhurst KG, McCaw L, Cook G, Symons R, Mueller JF (2007) An emission budget for dioxins from crop and bush fires in Australia, Organohalogen Cpds 69:2419-2422

[8] Meyer CP, Beer T, Mueller J (2004) Technical report No. 1: Dioxins emissions from bushfires in Australia, National Dioxins Program, Department of the Environment and Heritage

[9] Ivory, A., Mobbs C (2004) Dioxin levels in Australia: key findings of studies. Organohalogen Cpds. 66: 3446-3451

[10] Meyer C, Beer T, Muller J, Gillett R, Weeks I, Powell J, Tolhurst K, McCaw L, Cook G, Marney D, Symons R, 2004. Dioxin Emissions from Bushfires in Australia. National Dioxins Program Technical Report No. 1. Canberra: Australian Government Department of the Environment and Heritage. http://www.deh.gov.au/industry/chemicals/dioxins/index.html.

temperature. In field burns, air entrained into the smoke plume rapidly cools to temperatures that will not support the heterogeneous reactions required for dioxin synthesis."

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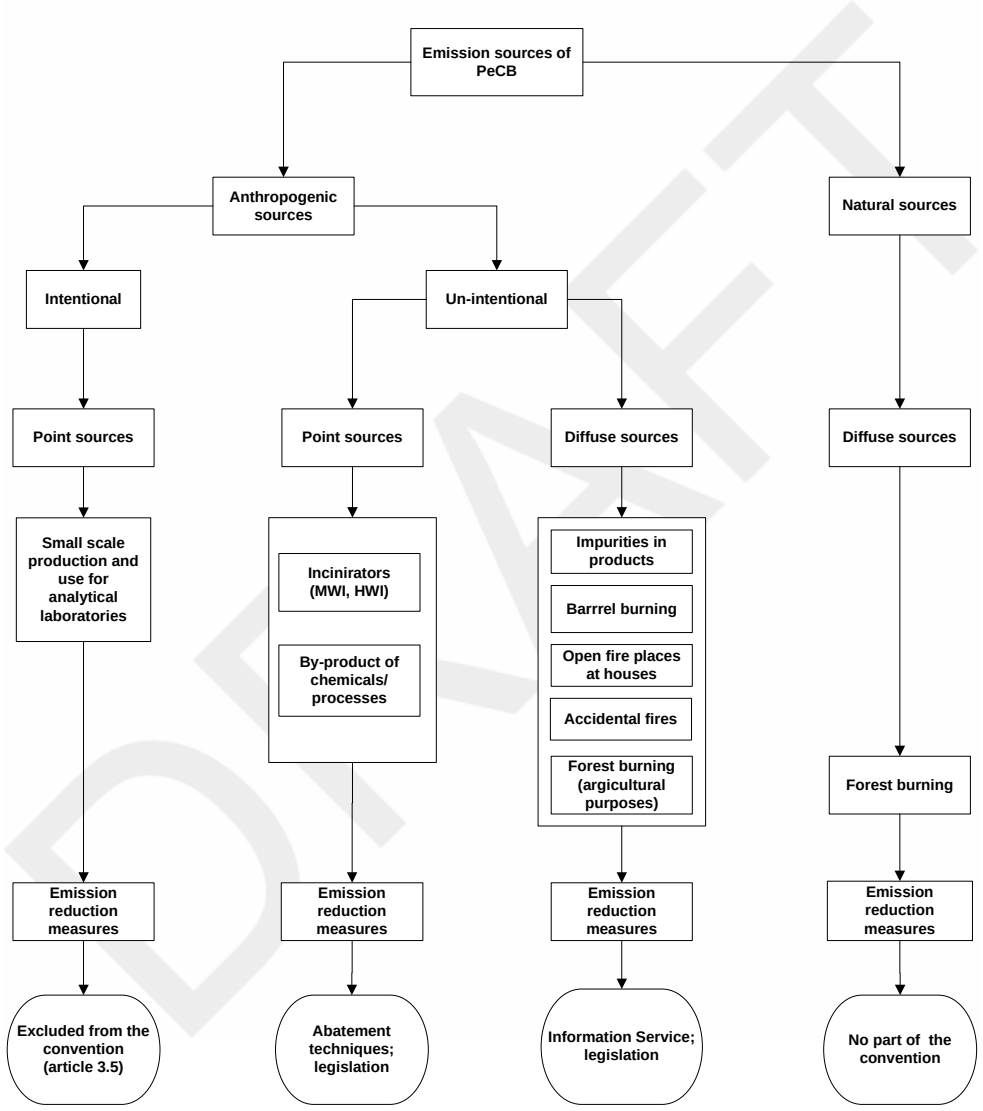

Figure 1. Emission sources of PeCB of current activities and related possible emission reduction measures

Since natural sources and the remaining intentional use (laboratories) are excluded from the Stockholm convention, this risk management evaluation will mainly focus on possible measures relating to unintentional anthropogenic emission sources of PeCB. Total releases for

the US between 2000 and 2004 as reported in the TRI varied between 763 and 1512 kg/year (UNEP, 2007). Based on these releases the World Chlorine Council estimated worldwide emissions to be 85.000 kg. Data on other sources are provided in the risk profile for PeCB.

2.1.2 Pentachlorobenzene production and use

Pentachlorobenzene can be used as an intermediate in the production of quintozene. Major U.S. and European manufacturers of quintozene have changed their manufacturing process to eliminate this use of PeCB. Also the use of quintozene has been stopped in most UNECE countries. The situation outside the UNECE region on production and use at this stage is unknown.

The annex F submissions did not contain much information on quintozene except for the submissions of Canada, Moldova, US, IPEN and World Chlorine Council. Canada reports that PeCB is present as an impurity in this fungicide. Quintozene is currently used, but not produced, in Canada. Moldova reports that quintozene was banned from the USSR in 1986. The US reports that PeCB was formerly used for producing quintozene, but the submission does not report on quintozene production and use in the US. IPEN reports that quintozene was banned in the EU in 1991 and that it is not registered for use in Burkina Faso, Cameroon, Cape Verde, Chad, Gambia, Madagascar, Niger, Tanzania, Uganda, India, Sri Lanka, and Belize. The World Chlorine Council reports that PeCB has been used as an intermediate in the production of quintozene, and that there is an alternative production procedure without PeCB. The available information at this stage does not allow drawing a general conclusion on PeCB content of quintozene and the worldwide production and use of quintozene.

Production in the US was estimated to be 1,300,000 kg in 1972 of which 30-40% was exported (ICPS, 1984). Other data on sales could not be traced back. The Government of British Colombia reported sales for quintozene to be 15,581 kg in 1995 (Government of British Columbia, 2008).

Combining the quintozene sales data for the US as mentioned above, and the percentage of PeCB reported by the US-EPA (1998) (<0.01% PeCB) results in a maximum potential total release of PeCB through application of quintozene in the US of 1,300,000 kg x 0,6 x 0.0001 = 78 kg. Total releases for the US between 2000 and 2004 as reported in the TRI varied between 763 and 1512 kg/year (UNEP, 2007). The data indicate that compared to unintentional releases, pesticide use is of minor importance, but that is still a relevant source to achieve for reduction.

PeCB might still be present as an impurity in quintozene stockpiles (UNECE 2007). Canada reports that PeCB can be found as impurity in several herbicides, pesticides and fungicides currently in use in the country. The US reports in their Annex F submission that PeCB can be found in the quintozene process waste stream as an untreated intermediate. US EPA reported between 93.000 and 140.000 kg of quintozene as waste in 2000 – 2004 (US EPA, 2007). There is no further information available on quintozene and/or PeCB present in stockpiles.

PeCB can still be ordered on the internet. In most cases these sales are related to laboratory use as analytical standards of 100 or 200 ug/ml in various solvents (methylene choride, methanol, isooctane) and sold in quantities of 1 – 1.2 ml. Gerstel Analytical Solutions (2008), for instance describe a liquid-liquid extraction method to identify contaminants in effluents and mentions internal standards of 20 ng PeCB/uL methanol and 1.3 ug PeCB/L. Although laboratory use is not included in the Convention this source is addressed here to indicate that the total releases through laboratory use are negligible compared to the releases mentioned in the risk profile for unintentional releases (between 763 and 1512 kg/year for the US and roughly estimated by the World Chlorine Council to be 85.000 kg worldwide) and the use of pesticides containing PeCB (see estimations below). No remaining intentional use of PeCB above laboratory scale have been identified. This observation is based on the information

provided in the risk profile, and a limited number of questionnaires received in reply to the Annex F information request.

2.1.3 Pentachlorobenzene within the scope of the UNECE Protocol

The Executive Body of the UNECE LRTAP Convention mandated to negotiate the inclusion of PeCB in the Annexes I and III of the UNECE POP Protocol[11]. This decision was based on the fact that commercial production of PeCB within the UNECE region had stopped many years ago. It was concluded that quintozene was still used worldwide, but that it was unclear if PeCB was used in the manufacturing process. It was expected that:

1. inclusion of PeCB in Annex I would not require additional management actions nor additional cost as industry had already replaced PeCB,
2. PeCB emissions related to quintozene would phase out with time, and
3. releases from PCB containing equipment were already covered by the measures taken for PCBs.

No additional management actions for by-product formation in thermal processes were expected as the measures to control PCDD/Fs would also lead to a reduction in the emissions of PeCB. The UNECE indicated that no information was available on cost and impacts of emission reduction addressing residential/domestic combustions sources such as barrel burning. Cost within the UNECE region for State budgets were expected to be negligible and no price increases for consumers were expected (UNECE 2008).

2.2 Intentional point sources

2.2.1 Identification of possible control measures

Intentional anthropogenic sources mentioned in the risk profile are PeCB as a component in PCB products, in dyestuff carriers, as a fungicide and a flame retardant and as a chemical intermediate e.g. for the production of quintozene. Most applications seem to have been ceased. The applications in dye carriers have been discontinued in Canada (Environment Canada, 2005). PeCB may have been used in the past as a fungicide and as a flame retardant. There is no indication that PeCB is still used for these applications. The use in PCB-applications (dielectric fluids, heat transfer equipment) declined considerably in the last decades. All the members of ICCA/WCC/EuroChlor have stopped production and marketing of PCBs. PeCB nowadays is not used anymore for this purpose. Release from histrorical use, stockpiles and waste is unknown. Actions taken to eliminate the use of PCBs will subsequently eliminate any related PeCB emissions (UNEP, 2007).

To limit the possible application for the production of quintozene and prevent re-introduction of other intentional uses, and to reduce or eliminate releases from stockpiles and wastes listing of PeCB in Annex A without any specific exemptions could be the primary control measure for intentional sources under the Convention.

2.2.2 Efficacy and efficiency of possible control measures in meeting risk reduction goals

Except for the quintozene production for which the information does not allow to draw a straightforward conclusion on global scale, no remaining uses have been identified.
The control measure may limit the use of PeCB in the production of quintozene if still in use and prevents re-introduction of other intentional uses.

2.2.3 Information on alternatives (products and processes)

No alternatives have been identified for most past uses as there is no commercial demand for PeCB anymore. For the production of quintozene, an alternative process using the chlorination of nitrobenzene is available.

[11] These are comparable to Annexes A and C of the Stockholm Convention.

2.2.4 Summary of information on impacts on society of implementing possible control measures

No discernible negative impacts on society have been reported from prohibition of phase-out of PeCB within the UNECE region. Most uses seem to be phased out world wide, except for possibly quintozene production and use. The information provided does not allow to draw a conclusion on PeCB use in producing quintozene worldwide. A listing in Annex A would phase out that potential use and prevent future production. This would therefore prevent negative impacts on public, environmental and occupational health that would accrue from any future production or use of PeCB. Costs could arise from elimination of unknown production, use and potential disposal of remaining stocks of quintozene. The cost are expected to be limited based on the data in the UNECE management options (UNECE, 2007), and the information provided by the various countries, IPEN and the World Chlorine Council in the Annex F information request. However, at present it is not possible to provide a quantitative estimate on these costs.

2.3 Un-intentional point sources

2.3.1 Identification of possible control measures

PeCB is formed as an unintentional by-product of large scale combustion processes and industrial processes and its formation and release can be reduced by abatement techniques and legislation. An Annex C listing would subject PeCB to the measures under Article 5 of the Convention and establish the goal of continuing minimization and, where feasible, ultimate elimination of PeCB emissions. This would include an obligation to promote BATs and BEPs for PeCB sources.

For PeCB formed as by-product in combustion processes there is a clear relation to HCB and PCDD/F emissions formed by combustion. Most measures taken to reduce PCDD/F emissions will undoubtedly lead to a significant reduction of the emissions of PeCB. There is no specific information available or measures taken to reduce HCB emissions.

2.3.2 Efficacy and efficiency of possible control measures in meeting risk reduction goals

Comprehensive data on releases of PeCB from incineration and **other thermal** processes and on the effectiveness of control are not (yet) available. BATs and BEPs relevant to unintentionally produced POPs for various types of incinerators **and other thermal sources** are very well documented in the Stockholm Convention BAT/BEP Guidelines (2006) and the reference document (BREF) of the EU (EC, 2006).

In state-of-the-art incineration and other combustions processes good combustion is determined by the so-called '3-T criteria': high Temperature, good Turbulence and sufficient residence Time. Incinerators complying with the EU legal requirement of the limit value for PCDD/Fs (0.1 ng/m^3) apply optimal combustion conditions in combination with abatement techniques. Under such optimal combustion conditions it can be assumed that **virtually** all organic matter is completely converted to carbon dioxide and water vapour. Hence, incinerators complying with the demand of the low PCDD/F emissions will undoubtedly minimize the emissions of PeCB. Efficiencies similar to that of dioxins (> 99.9%) can be obtained, e.g. in case of catalytic destructions above 300° C (Sakurai and Weber, 1998) or the use of carbonaceous adsorbents as cleanup of the flue gas (EC, 2006).

However, different emissions of PCDD/Fs and PeCB formed in *de novo* synthesis in the flue gas might still be possible and will depend on the type of the abatement technology, applied for the specific emission reduction of PCDD/Fs. A variation between the correlation of emissions of PeCB and PCDD/Fs from various incinerators has been observed (Lavric et al., 2005) and there is conflicting information about effectiveness for various abatement techniques (Liljelind et al., 2001). In addition, due to the relatively high volatility of PeCB in comparison to PCDD/Fs the adsorption to particles will be distinctly less, and, therefore,

Comment [J1]: "thermal processes" is the inclusive language directly from Annex C Part II to describe unintentionally formation and release of dioxins, furans, PCBs, and HCB

Deleted: combustion

Comment [J2]: The BAT / BEP guidelines correctly cover a variety of thermal processes, not just incinerators. Naming just incinerators is not sufficient and does not represent the actual Guidelines

Comment [J3]: If all organic matter was converted to carbon dioxide and water, then carbon dioxide would be the only organic compound present in incinerator stack gases. This is demonstrably NOT the case. See Sakurai et al. (2003) Chemosphere 53:619-625

Comment [J4]: Suggested wording: Under optimal combustion conditions and with optimal abatement techniques, emissions in stack gases of organic compounds can be minimized.

compounds like PeCB will be more present in gas phase in comparison to PCDD/Fs (Chen et al., 2007). Hence, abatement techniques focused at the elimination of dust might have a somewhat lower efficiency for the removal of PeCB formed *de novo* in the flue gas

In conclusion, waste incinerators fulfilling the conditions for PCDD/Fs described above will usually have a comparable low emission level for PeCB. Hence, the use of state-of-the-art waste incinerators and inherent abatement technologies can be recommended in order to reduce or possibly eliminate the emission of PeCB during combustion. **Further work may be needed to expand the BAT/BEP guidelines to consider the advisability of abatement techniques that are less effective for PeCBs than they are for dioxins and furans.**

2.3.3 Information on alternatives (products and processes)
Alternatives and methods to reduce POPs when formed and released unintentionally from anthropogenic sources are dealt with under UNEP guidelines (2006).

2.3.4 Summary of information on impacts on society of implementing possible control measures
Countries already have obligations to take control measures for other un-intentionally produced POPs (HCB, PCDD/F) under the Convention. These may for a large part be similar to those for PeCB. Measures to reduce un-intentional emissions of PeCB through listing in Annex C would positively impact human health and the environment.

2.4 Un-intentional diffuse sources

2.4.1 Identification of possible control measures
For these sources of abatement techniques for emission reduction measures will consist of legislation and to provide information and public education by the national and local authorities.

PeCB can be found as an impurity in several biocides and pesticides currently in use. The relative contribution to the total emissions of PeCB as an impurity in quintozene have been provided in 2.1.2. The other pesticides reported to contain PeCB are expected to have a much smaller impact. HCB, which could be up to 1.8% PeCB is already contained in the Convention and it may thus be expected that efforts to reduce and eliminate HCB will also reduce PeCB. Endosulfan, chlorpyrifos-methyl, atrazine, and clopyrilid contain much smaller amounts of PeCB than quintozene (US EPA, 1998)[12]. The review of endosulfan has been suspended until the 4th meeting of the POPRC. However, if endosulfan is added to the Convention actions taken to eliminate or restrict the use will subsequently effect the related PeCB emissions. In cases where PeCB is found as impurity of biocides and pesticides for which the use is continued further legislative measures could be taken to reduce the amounts of impurities.

An Annex C listing would subject PeCB to the measures under Article 5 of the Convention and establish the goal of continuing minimization and, where feasible, ultimate elimination of PeCB emissions. This would include an obligation to promote best available techniques and best environmental practices for PeCB sources, including municipal solid waste incineration,

[12] Personal communication Ian D Rae: On page 12, the presence of PeCB as an impurity in a number of substances is mentioned. While they are all chlorine-containing molecules, I can't see any chemical reason why they should contain PeCB. Is there any evidence? There have been occasional reports in the literature of contaminations of this type, but they usually (I believe) relate to isolated instances of contamination through multiple use of reaction vessels or sheer carelessness, not from inherent production of the impurity during some other process (a valid example would be product of PCDD during production of 2,4,5-T). I don't think the contamination claims should be mentioned here unless they are valid.

hazardous waste incineration, magnesium production, wood treatment plants, barrel burning, open fire places and open burning for agricultural purposes. For example open burning can be prohibited or permitted only under pre-approved conditions (see Annex F submission of Canada).

Deleted: forest

2.4.2 Efficacy and efficiency of possible control measures in meeting risk reduction goals
The PeCB emission as a result of impurities in several biocides is very small and restriction and control of these biocides have the effect of reducing PeCB emissions. Additional measures are not likely to have a significant impact.

Listing PeCB in Annex C will involve control measures that are familiar to countries since they already have obligations for unintentionally-produced POPs under the Convention and will not lead to additional cost.

2.4.3 Information on alternatives (products and processes)
Biocides or pesticides without PeCB impurities can be used as alternatives. Non-chemical alternatives may also be available. For the production of quintozene another process without PeCB is already available and implemented by quintozene producers. This example shows that other production techniques can be a good alternative. An assessment of other biocides and pesticides and non-chemical techniques goes beyond the scope of the risk management evaluation and is not needed because additional measures are not considered.

Alternatives and methods to reduce POPs when formed and released unintentionally from anthropogenic sources are dealt with under **the Stockholm Convention BAT/BEP** guidelines of the UNEP (2006) and the EU (EC, 2006).

2.4.4 Summary of information on impacts on society of implementing possible control measures
Measures to reduce unintentional emissions of PeCB through listing in Annex C would positively impact human health and the environment. Countries already have obligations to take these control measures for other unintentionally produced POPs (PCDD/F) such as dioxins and furans under the Stockholm Convention.

2.5 Other considerations

Information on public information, control and monitoring capacity has been provided by Armenia, Canada, the Czech Republic and Moldova.

In Armenia information to the public is provided through a national electronic database on legislative documents (IRTEC), through the journal "Official bulletin" where the normative-legislative documents are published and by the Centre for Monitoring of Environmental Impacts.

In Canada public access to risk management information on PeCB is available on a website from the government. PeCB is not listed on the National Pollutant Release Inventory. However, Environment Canada is considering adding it to the inventory in order to monitor progress towards the proposed objectives.

In the Czech Republic information on PeCB is part of the SC/UNECE CRLTAP[13] education and awareness raising campaign under the national implementation plan.

[13] UNECE Convention on Long-Range Transboundary Air Pollution

PeCB is not monitored for in Moldova. Access to information and public education is part of the national strategy on the reduction and elimination of POPs and the national implementation plan of the Stockholm Convention.

3. Synthesis of information

According to the risk profile, PeCB meets all screening criteria, i.e. long range transport, bioaccumulation, persistence and toxicity. Generally, environmental concentrations seem to be decreasing. In the past, PeCB was used in PCB products employed for heat transfer, in dyestuff carriers, as an intermediate for the manufacture of quintozene, as fungicide and as flame retardant. Based on all available information, there is no indication that production or intentional use of PeCB still takes place.

PeCB is not included in any international convention. The European Commission has submitted a proposal to include PeCB to the Protocol to the 1979 Convention on Long Range Transboundary Air Pollution (LRTAP). The manufacture, use, sale, offer for sale and import of PeCB is banned in Canada. International actions taken to eliminate the use of PCBs will subsequently eliminate the use of PeCB for this application. Also the use of quintozene is prohibited in many countries.

In this risk management evaluation an overview of emission sources of PeCB of current activities and related possible emission reduction measures is given. Nowadays PeCB is only intentionally used in laboratory applications. According to Article 3.5, laboratory use is excluded from the Stockholm Convention. Unintentional release of PeCB as a by-product of incomplete combustion appears to be the largest current source. Unintentional anthropogenic sources can be divided into point sources and diffuse sources. As regards point sources, combustion processes and industrial processes are probably the most relevant. Emissions from these sources can be controlled by abatement and substitution techniques and/or legislation. The most relevant diffuse sources are **likely to be** (a) an impurity in products such as, solvents, pesticides and wood preservative products, (b) small scale combustion such as barrel burning and open fire places, **and** (c) accidental fires. For these sources abatement techniques are not likely and emission reduction measures can only be enacted by legislation and/or providing information and education by the national and local authorities.

Deleted: and (d) forest burning (for example for agricultural purposes)

Deleted: Natural sources (forest fires) might contribute significantly to the worldwide emission of PeCB. However, natural sources are excluded from the Stockholm Convention. ¶

PeCB and HCB have a many similarities. Both chemicals have intentionally been used in the past for example as biocide and both chemicals are un-intentionally formed as by-product of combustion processes. HCB is already listed on Annex A and Annex C of the Stockholm convention.

To prevent present use and re-introduction of intentional use listing of PeCB in Annex A without any specific exemptions could be the primary control measure for intentional sources under the Convention. As the current information sources do not suggest large scale production and use of PeCB, limited discernible negative impact on society is expected. A listing in Annex A would prevent future production and integration into products. This would therefore prevent negative impacts on public, environmental and occupational health that would accrue from any future production or use of PeCB.

For PeCB formed as by-product in combustion processes there is a clear relation to PCDD/F emissions formed by combustion. Most measures taken to reduce PCDD/F emissions will undoubtedly lead to a significant reduction of the emissions of PeCB. An Annex C listing would subject PeCB to the measures under Article 5 of the Convention and establish the goal of continuing minimization and, where feasible, ultimate elimination of PeCB emissions. This would include an obligation to promote best available techniques and best environmental practices for PeCB sources. Countries already have obligations to take these control measures for other unintentionally produced POPs (PCDD/F**, PCBs,** and HCB) under the Convention.

4. Concluding statement

Having evaluated the risk profile for PeCB, and having prepared its risk management evaluation, the Committee concludes that this chemical is likely, as a result of long-range environmental transport, to lead to significant adverse effects on human health an/or the environment, such that global action is warranted.

The Committee prepared this risk management evaluation and concluded that although PeCB is not known to be currently produced or used, it is important to prevent its re-introduction into commerce and use. Like HCB**, PCBs,** and dioxins/furans, PeCB is formed as an unintentional by-product of combustion **and other thermal** processes and industrial processes. Most measures to reduce unintentional emissions of dioxins/furans will undoubtedly lead to significant reduction of the emissions of PeCB.

Therefore, in accordance with paragraph 9 of Article 8 of the Convention, the Committee recommends the Conference of the Parties to the Stockholm Convention to consider listing and specifying the related control measures of PeCB in Annexes A (without any specific exemptions) and C.

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Comments and responses relating to the draft risk management evaluation on:

name of chemical: Pentachlorobenzene

Minor grammatical or spelling changes have been made without acknowledgement. Matters of substance are detailed below.

Risk Profile Section	Source of Comment	Comment	Response
General remark	WCC	Replace "diffuse sources" by "multiple point sources"	'Diffuse sources' is generally accepted terminology and is thus maintained.
Summary	WCC	Add "use in laboratories" and "outside the UNECE region"	Use in laboratories is accepted as it specifies the use. The addition 'outside the UNECE region is not correct', as production of quintozene within the UNECE region may still take place, see for details para 2.1.2.
Summary	WCC	Add sentence focussing on the overall most important emission source including uncontrolled combustion.	The most important sources are mentioned further in this section. The available data only enable to give relative amounts released. Furthermore, the Convention focusses on unintentional anthropogenic sources: article 5
Summary and section 2.3.2	IPEN	Add following sentence: "More generally, application of the Stockholm Convention's BAT/BEP Guidelines for incinerators and other thermal processes will likely also control PeCB releases, but further work may be needed to expand thse guidelines to consider the advisability of abatement techniques that are less effective for PeCBs than they are for dioxins and furans."	The part on BAT/BEP is incorporated in the text. However expansion of the guidelines on BAT/BEP is the competence of the working group on BAT/BEP and beyond the mandate of this working group
Summary and section 2.1.1, section 2.4.1 and section 3	IPEN	Delete "and forest burning for agricultural purposes"	Forest burning for agricultural purposes is considered to be a relevant emission source of PeCB although the relative contribution is not clear, see chapter 2.. Zie ook comment IPEN bij 2.1.1. Graag reactie Elbert
Summary and section 2.4.1	WCC	Replace "likely" by "available" or "applicable"	Likely has been changed in feasable.
Section 1.1	Australia	PeCB is not an IUPAC name but a CAS Name	Text changed accordingly
Section 1.4	WCC	There is a high risk of duplication with section 2.1.3 and could be deleted from 2.1.3 as it is duplicative	There is some duplication, but section 1.4 covers international conventions in general, whereas section 2.1.3 gives more background information on the possible impact of including of PeCB in Annexes A and C of

			the Stockholm convention.
Section 1.4	WCC	It is doubtful how useful an extensive description of the UNECE process is. Further "no listing" is also an option in the UNECE process.	Since there are many similarities between the process in UNECE and in the Stockholm POP convention, the state of play within the UNECE is valuable. In theory non-inclusion is an option. However, the report of the Working Group of Strategies and Review ECE/EB.AIR/WG.5/88 does not mention the option of non-inclusion.
Section 2.1.1.	Australia	Text changes suggested in para 2 and 3	Accepted
Section 2.1.1	IPEN	Replace "is already controlled" by "will be addressed in countries that are Parties of the Convention"	Change is accepted
Section 2.1.1	IPEN	Suggest not to make a distinction between diffuse and point sources.	The present division in point sources and diffuse sources focusses on the possibity and the type of measures to be taken. Measures applicable to large combustion sources are hard to apply to diffuse sources such as barrel burning and open fire places. Therefore the division between point sources and diffuse sources is maintained.
Section 2.1.1	WCC	Add "outside the UNECE region"	The addition 'outside the UNECE region is not correct', as production of quintozene within the UNECE region may still take place, see for details para 2.1.2.
Section 2.1.1	Australia	Accidental fires are probably not anthropogenic: delete	Here accidental fires in houses, warehouses etc are meant. Accidental (natural) forest burning is not meant.
Section 2.1.1.	IPEN	The forest fire section should be deleted. Figure 1 should be modified as well.	The text has been maintained as it is. The studies cited by IPEN are more than 10 years old and older than the ones cited in the text. It is also indicated in the text that the estimates are subject to considerable uncertainties. In contrast to IPEN, WCC request more attention for these unintentional natural sources
Section 2.1.1	WCC	Natural sources are very relevant in the context of considering efficacy and efficiency of measures on anthropogenic sources and should be considered in that context.	The comment is correct. However, the Convention only focusses on anthropogenic sources (article 5, annex C). Therefore the risk management evaluation focusses on possible measures relating to anthropogenic sources because these sources can be (more or less) controlled. See also the comment of IPEN above.
Section 2.1.1	IPEN	Addition on PVC	This information is already provided in the risk profile para

			2.1.3 and does not additional value in this section.
Section 2.1.1.	IPEN	Deletion of 'Since natural sources and the remaining intentional source (laboratories) are excluded from the Stockholm Convention, ..'	Text is maintained as it indicates the scope and mandate of the Convention.
Section 2.1.1	Australia	Delete figure 1	Although figure 1 is a simplification of reality it provides a rapid overview of the various sources involved in PeCB emissions in relation to the possible measures to be taken.
Section 2.1.2	WCC	Add "maximum potential"	Change is accepted.
Section 2.1.2	WCC	Deletion of 'but that it still may be a relevant source to achieve for reduction'	Correct that the relevance can only be evaluated in the context of all sources. However, it should also be taken into consideration if this measure can be taken at relatively limited effort. Therefore maintained
Section 2.1.2.	IPEN	Addition of 'by the World Chlorine Council'	As the addition is correct, it has been incorporated.
Section 2.1.3	WCC	Delete section 2.1.3 + see comments on section 1.4	Section 1.4 focusses on the process within UNECE, whereas 2.1.3 focusses on the content of the RME within UNECE POPs. As the content of this RME is relevant for decisions within UNEP POPs it is maintained.
Section 2.2.1	WCC	Add "Worldwide chemical companies have stopped production and marketing...emissions of PeCB from the use of PCBs can be considered negligible"	The statement on the production stop of PCBs only applies to members of WCC. Prohibition of PCBs only applies to Parties to the POP. Furthermore it can be expected that worldwide still quite some PCBs are in use. Therefore the text proposal is not incorporated.
Section 2.3.1	IPEN	Replace "abatement techniques" by "alternative processes, techniques or practices, use of substitute or modified materials"	This section focusses on large scale combustion. Thus, abatement techniques apply. It is not clear from the information provided what the alternative processes, techniques or practices or the use of substitute or modified materials are considered here.
Section 2.3.2	IPEN	Suggest to delete most part of second paragraph on incineration	Text is maintained as atate-of-the-art incineration is considered to be a relevant technique to reduce the PeCB emissions .
Section 2.3.2	WCC	Part of this section is not relevant because lower chlorinated PCDD/F may even be more volatile than PeCB. So it seems rather theoretical.	Most PCDD/Fs are removed by optimal combustion techniques in combination with abatement techniques. Abatement techniques focussing on the elimination of dust may be less relevant for PeCB and thus lead to a lower efficiency.
Section 2.3.2	IPEN	Replace "fulfilling the	The RME stress the need for a

		conditions for PCDD/Fs described above will usually have a" by "that conform to EU requirement may have"	more state-of-the-art incineration, not for a compliance to a EU standard. Article 5 of the Convention states: Promote the application of available, feasible and practical measures that can expeditiously achieve a realistic and meaningful level of release reduction or source elimination;
Section 2.3.2	IPEN	Add sentence on BAT/BEP guidelines. And delete last sentence	See reply on comments on the summary. The part on BAT/BEP is alraedy incorporated in the text. However expansion of the guidelines on BAT/BEP is the competence of the working group on BAT/BEP and beyond the mandate of this working group
Section 2.3.4	WCC	First sentence seems to contradict the second	Added some minor text changes
Section 2.4.1	IPEN	Replace "is of minor importance" by "efforts to reduce and eliminate HCB will also reduce"	Change is accepted
Section 2.4.1	Rae	Is there evidence that PeCB impurities can be found in the mentioned pesticides?	See risk profile, section 2.1.2. The information is originating from an USE EPA study. Reference to this study is added. The remark has been added as a note.
Section 2.4.1	Rae	Endosulfan is not, as stated, under consideration for nomination for elimination or restriction. This sentence should be deleted	Text is changed and now reflect the correct status of endosulfan
Section 2.4.1	WCC	State review endosulfan more precisely	See above
Section 2.4.1	IPEN	Replace "Endosulfan is under ….amounts of impurities" by "Actions taken to prohibit these and other relevant substances containing PeCB or reduce their impurities would help reduce and eliminate PeCB releases."	The fact that PeCB is found as an impurity in a certain pesticide is no reason for prohibiting these pesticides under the Convention. Note 1 under annex A of the Convention states: 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;
Section 2.4.1	IPEN	Add "municipal solid waste incineration, hazardous waste incineration, magnesium production, wood treatment plants" (including a reference to the risk profile). Delete "forest burning for agricultural purposes".	Change is accepted.
Section 2.4.3	IPEN	Add "or non-chemical techniques"	Change is accepted
Section 2.4.3	IPEN	Change "be a good	The Convention is not intended

		alternative" by "eliminate use of PeCB"	to prohibit the use of pesticides with trace quantities of the substance under consideration. See note 1 under annex A.
Section 3	IPEN	Delete "Natural sources forest fires .. from the Convention."	Natural sources (forest fires) is maintained, see also summary.

Responses compiled by M.P.M. Janssen following revision of the risk management evaluation