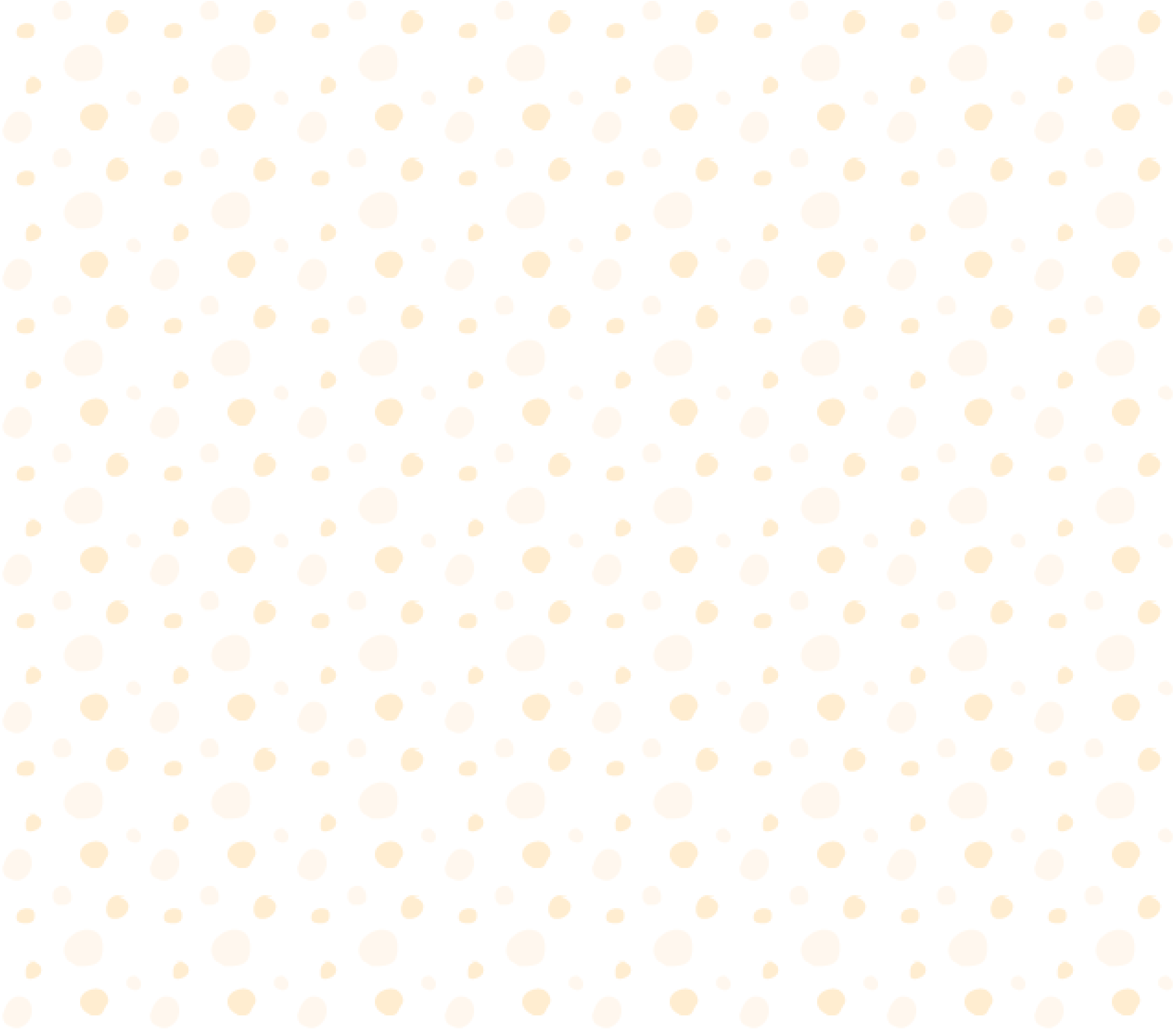
Stockholm Convention on
Persistent Organic Pollutants (POPs)

The 9 New POPs

Risk Management Evaluations

2005-2008 (POPRC1-POPRC4)



POPs Review
Committee

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Addendum

Pentabromodiphenyl ether and tetrabromodiphenyl ether (Commercial pentabromodiphenyl ether)

UNEP/POPS/POPRC.3/20/Add.1

Executive summary

1. Commercial pentabromodiphenyl ether (C-PentaBDE) is a mixture of brominated flame retardants (BFRs), mainly isomers of pentabromodiphenyl ether (PentaBDE) and tetrabromodiphenyl ether (TetraBDE). Brominated flame retardants are a group of brominated organic substances that inhibit or suppress combustion in organic material. C PentaBDE is or has been used almost exclusively in the manufacture of flexible polyurethane (PUR) foam for furniture and upholstery in homes and vehicles, packaging, and non-foamed PUR in casings and electronic equipment (EE). They are also used to some extent in specialized applications in textiles and in industry. The chemical and physical properties of TetraBDE and PentaBDE have led to their wide dispersal in the environment and in humans, and there is evidence of their toxicity. For these reasons the components of C-PentaBDE cause concern in many regions of the world.

2. There are national and international standards for fire safety for some product groups. This applies for example to electrical equipment, industrial packaging, upholstered furniture, curtains, electronic household appliances and electrical cables. These standards specify the flame-retarding properties that are required but not which flame retardants are to be used. Until now, brominated flame retardants have been considered to be the most efficient. Today, it has become common to replace these substances either with flame retardants without bromine or by changing the design of the product so that there is no need for the continued use of flame retardants.

3. High levels of the components of C-PentaBDE are detected in the environment. They have severe toxic properties and have been shown to be persistent and bioaccumulative. They thus represent a potential risk for future generations. Concentrations in wildlife and in humans have also increased significantly (RPA, 2000). Those findings have resulted in voluntary and regulatory phase-outs of C-PentaBDE in several regions in the world. Since this is a global, transboundary problem, global actions to phase out C-PentaBDE should be considered.

4. Several countries have reported that they would have problems regulating a commercial mixture of PentaBDE. Listing the individual congeners such as the major components, BDE-47 and BDE-99, or classes of tetrabrominated and pentabrominated diphenyl ethers (with specified membership of each class) would be consistent with existing national legislations for the congener PentaBDE and would facilitate the national monitoring and control of emissions, production and use. It has been suggested that consideration should also be given to listing HexaBDE, which constitutes a small proportion of the C-PentaBDE mixture. Since HexaBDE is a component of the C-OctaBDE, listing the HexaBDE would need to be considered when evaluating management options for OctaBDE.

5. Having evaluated the risk profile for commercial PentaBDE (C-PentaBDE), and having concluded that components of this mixture are likely, due to the characteristics of its components, as a result of long-range environmental transport, to lead to significant adverse effects on human health and the environment, this risk management evaluation has been prepared, as specified in Annex F of the Convention.

6. In accordance with paragraph 9 of Article 8 of the Convention the Committee recommends to the Conference of the Parties to consider listing 2,2', 4,4'- tetrabromodiphenyl ether (BDE-47, CAS No. 40088-47-9) and 2,2',4,4',5-pentabromodiphenyl ether (BDE-99, CAS No. 32534-81-9) and other tetra- and pentabromodiphenyl ethers present in C-PentaBDE, using BDE-47 and BDE-99 as markers for enforcement purposes in Annex A of the Convention, as described above.

1. Introduction

1.1 Chemical identity of the proposed substance

Background

7. In 2005 Norway nominated commercial pentabromodiphenyl ether (C-PentaBDE) to be listed as a persistent organic pollutant (POP) under Annex A of the Stockholm Convention, and Norway has been responsible for the drafting of the present Risk Management Evaluation (Annex F).

8. PentaBDE is a brominated flame retardant (BFR), one of a group of brominated organic substances that inhibit or suppress combustion in organic material. It has been used mainly in the manufacture of flexible polyurethane (PUR) foam for furniture and upholstery in homes and vehicles, packaging, and to a smaller extent non-foamed PUR in casings and electric and electronic equipment (EE). To some extent it has also been used in specialized applications in textiles

and in various other uses. Because of the chemical and toxic properties of its main components, isomers of tetrabromodiphenyl ether (TetraBDE) and pentabromodiphenyl ether (PentaBDE), and their wide spread occurrence in the environment and in humans C-PentaBDE causes concern in many regions in the world.

Chemical identity of the proposed substance

9. Commercial pentabromodiphenyl ether (C-PentaBDE) refers to mixtures of bromodiphenyl ether congeners in which the main components are 2,2', 4,4'- tetrabromodiphenyl ether (BDE-47 CAS No. 40088-47-9) and 2,2',4,4',5-pentabromodiphenyl ether (BDE-99 CAS No. 32534-81-9), which have the highest concentration by weight with respect to the other components of the mixture. Hexabrominated diphenylethers (HexaBDE) species can also comprise a significant portion of C-PentaBDE. The formulation of C-PentaBDE used in North America and Europe contains 4-12% HexaBDE.

10. The numbering system for the PBDEs is the same as that used for polychlorobiphenyls (PCBs) (Ballschmiter et al. 1993). The acronym PBDE is used for the generic term polybromodiphenyl ether, covering all congeners of the family of brominated diphenyl ethers. It is sometimes abbreviated to BDE.

1.2 Conclusions of the Review Committee of Annex E information

11. Annex E of the Stockholm Convention requires a Risk Profile to be developed to evaluate whether the chemical is likely, as a result of its long-range environmental transport, to lead to significant adverse human health and/or environmental effects, such that global action is warranted. A Risk Profile for C-PentaBDE was developed and accepted in 2006 (UNEP, 2006). The POP Review Committee concluded as follows:

12. "Pentabromodiphenyl ether (C-PentaBDE) is a synthetic mixture of anthropogenic origin with no known natural occurrence. It can be concluded therefore that the presence of components of C-PentaBDE in the environment is the result of anthropogenic activities. Long range transport must be responsible for its presence in areas such as the Arctic region, remote from sites of production and release. PentaBDE degrades slowly in the environment and can bioaccumulate and biomagnify in mammals and piscivorous birds. The phase out of C-PentaBDE production and use has led to a reduction in current use, but many materials in use, such as polyurethane foams and plastics in electronic equipment, contain PentaBDE which is slowly released to the environment. This release will be accelerated at end-of-life of such materials, especially during recovery and recycling operations. Although levels of PentaBDE in human blood and milk, and in other environmental species, are falling in Europe, they continue to increase in North America and the Arctic region.

13. Based on the information in this risk profile, C-PentaBDE, due to the characteristics of its components, is likely, as a result of long-range environmental transport and demonstrated toxicity in a range of non-human species, to cause significant adverse effects on human health and the environment, such that global action is warranted."

1.3 Any national or regional control actions taken

14. Most developed countries have taken some actions to limit the production and use of PentaBDE.

- Australia: PentaBDE is effectively banned for use in new articles. Imports of articles containing BFRs are not regulated.
- EU: placing on the market and use in concentrations higher than 0.1 % by mass is banned from 2004 (EU Directive 2003/11/EC). Use in electrical and electronic appliances was phased out from July 1st, 2006 under the EU's Restriction of Hazardous Substances in electrical and electronic equipment. Products containing more than 0.25 % PentaBDE are classified as hazardous waste when they are discarded.
- US: the industry voluntarily ceased production of C-PentaBDE from 2005, and the use is forbidden in some states. USEPA requires notification and Agency review prior to restart of manufacture for any use (see rule at 40 CFR Part 721.10000).
- Japan: use of C-PentaBDE stopped voluntarily in 1990.
- Norway and Switzerland: both countries have banned production, import, export and marketing and use of PentaBDE and mixtures containing 0.1 percent per weight or more of PentaBDE. Products containing more than 0.25 % PentaBDE are classified as hazardous waste when they are discarded. In Norway recycling and reuse of PentaBDE and materials with PentaBDE are not allowed.
- Canada: no production of PentaBDE. Regulations on manufacture, use, sale and import were proposed in 2006. Canada will be implementing virtual elimination for the tetra-, penta- and hexa-BDE homologues contained in C-PentaBDE.
- China: use of PentaBDE in electric and electronic products was banned from 1 March 2007.
- The status of the chemical under international conventions is listed in UNEP/POPS/POPRC.3/INF/23.

2. Production, use and releases

2.1 Levels and trends of production and use that will require management

Overall demand and production

15. Based on the last available market information on C-PentaBDE from Bromine Science and Environmental Forum (BSEF), total global demand has decreased from 8,500 tons in 1999 to 7,500 tons in 2001. The estimated cumulative use of C-PentaBDE since 1970 was 100 000 t in 2001 according to BSEF.

Table 1. Total global demand of C-PentaBDE by region in 2001. Metric tons and percent Source: BSEF (2001)

	Americas	Europe	Asia	Rest of the world	Total	Percent of total world usage of BFRs
Penta-mix PBDE formulation	7,100	150	150	100	7,500	4 %

16. C-PentaBDE has been produced in Israel, Japan, US and the EU (Peltola et al., 2001 and TNO-report 2005). A patent on a technical mixture containing PentaBDE was issued for China in 1999. As produced in China, the technical mixture contained a different ratio of its constituents (that is, different proportions of congeners) than C-PentaBDE produced in Europe and the US.

17. The US EPA (2007) estimates that US production and import were between 4,500 and 23,000 tons in 2002, but specific figures are confidential to the industry. The last producer of C-PentaBDE in the US, the Great Lakes Chemical Corporation (now Chemtura Corporation), voluntarily ended its production in 2004. Before the phase-out in US the majority of the C-PentaBDE formulation produced globally was used in North America (>97%). At the end of 2004, approximately 7.5% of the more than 2.1 billion pounds of flexible polyurethane foam produced each year in the US contained the C-PentaBDE formulation (Washington State 2006).

18. Results from a survey in Canada in 2000 indicated that approximately 1,300 ton of commercial products containing PBDEs were imported into Canada. Based on quantities reported, C-PentaBDE was imported in the greatest volume.

19. Production of C-PentaBDE in the former EU (15) ceased in 1997 (EU 2000). Usage in the EU (15) declined during the second half of the 1990s and was estimated to be 300 metric ton in 2000 (used solely for PUR production) (EU 2000). The use of PentaBDE was banned in the EU (25) in 2004. Use of PBDEs in electrical and electronic appliances was phased out from 1 July 2006.

20. The major producer of BFR in Israel, the Dead Sea Bromine Group, declares in a public statement on its web site that its products do not contain C-PentaBDE. This is to comply with the ban in EU, which is an important market for the company.

21. Since there should be no current production of C-PentaBDE in Europe, Japan, Canada, Australia and the US, remaining production would be located in other parts of the world. There is no information reported on the status of the production in China.

22. No information was found for Eastern European countries outside the EU or for most countries in the Asia-Pacific region. No information was available from countries in Africa or Latin America.

2.2 Use of C-PentaBDE

23. Although production and use is essentially banned in developed countries, if C-PentaBDE is not listed as a POP, there is a possibility that developing countries could begin their own production and use. According to different national and regional surveys and national submissions under the LRTAP Convention C PentaBDE is used/has been used in the following sectors (Swiss agency for the Environment 2002, Danish EPA 1999, EU 2000, Norwegian EPA 2003 and http://www.unece.org/env/popsxg/6thmeeting.htm):

- Electrical and electronic appliances (EE appliances): computers (Betts, 2006; Hazrati and Harrad, 2006), home electronics, office equipment, household appliances and others, containing printed circuit laminates, plastic outer casings and internal plastic parts, such as various small run components with rigid PUR elastomer instrument casings.
- Traffic and transport: Cars, trains, aircraft and ships, containing textile and plastic interiors and electrical components.
- Building materials: foam fillers, insulation boards, foam insulation, pipes, wall and floor panels, plastic sheeting, resins, etc.

- Furniture: Upholstered furniture, furniture covers, mattresses, flexible foam components. C-PentaBDE c an also be found in PUR-foam based packaging.
- Textiles: curtains, carpets, foam sheeting under carpets, tent, tarpaulin, working clothes and protective clothing.
- Packaging: C-PentaBDE can also be found in PUR-foam based packaging.

2.3 Global future demand for flame retardants

24. If C-PentaBDE is not banned, there are indications that its production and use – together with other brominated flame retardants – could grow. According to a market analyst consultant company, global demand for flame retardants is expected to grow by 4.4 percent per year to 2.1 million metric tons in 2009, valued at USD 4.3 billion (Fredonia Group, 2005). Growth will largely be driven by demand in developing countries in Asia (China in particular), Latin America and Eastern Europe. The growth in demand is expected for most flame retardants. Globally, growth is expected to be largest for bromine compounds, mainly due to high growth rates in China. Demand for use in electrical and electronic applications is expected to grow fastest, as electronic circuits become smaller and more densely packed, and their plastic components are subjected to higher temperatures. Higher value products will continue to make inroads as substitutes for less environmentally friendly compounds, especially in Western Europe, and as chlorine compounds begin to be replaced in China by bromine- and phosphate-based and other flame retardants (Freedonia Group, 2005).

25. Construction markets are expected to be the second fastest growing market for flame retardants globally. An exception is China, where the second fastest growth will be from motor vehicles followed by textiles, both rapidly growing industries in that country. Plastics will continue to replace other materials such as metals and glass in a wide range of products in order to lower cost and weight and to improve design and production flexibility. Their usage is widespread and growing in transportation, building products and electrical and electronic products. Plastics must be made flame retardant for many applications. As a result, 75% of all flame retardants are used in plastics (Freedonia Group 2005).

26. Environmental restrictions vary by region. In Western Europe, Japan and to a lesser extent North America, such restrictions will especially limit growth of chlorinated compounds which might be considered as in-kind replacements for PBDEs. The ban on some brominated flame retardants in Western Europe is not expected to spread substantially to other regions (Freedonia Group 2005), but it drives the development of electrical and electronic equipment without the banned substances for sale on the world market. Dozens of Asian, European, and US companies announced in 2005 that they have developed or are developing electrical and electronic equipment that does not contain C-PentaBDE. In Asia more than 90% of electronic manufacturers already make products compliant with EU regulations. Officials from electronics companies and industry consultants consider that most electric and electronic equipment sold on the world market were in compliance with the ban in EU in 2005, due to the difficulties of keeping product streams separate (Environmental International reporter 2006).

2.4 Emissions from production of C-PentaBDE and products using C-PentaBDE as input

27. The producers of C-PentaBDE have reported that the major routes of PentaBDE release to the environment during production are filter waste and material rejected because it does not meet specifications, both of which are disposed of in landfills. Waste water releases of PentaBDE may also occur from spent scrubber solutions (RPA, 2000). The emissions to air from production of C-PentaBDE is assumed to be none or negligible (RPA 2000, van der Gon et al. 2005). Modeling indicates that emissions during manufacture of products containing C-PentaBDE are minor in comparison to those associated with consumption.

2.5 Emissions from use of C-PentaBDE -containing products

28. TNO (2005) concludes that the major releases of PentaBDE to air stem from products and equipment which contain the substance as flame retardant.

Indoor equipment

29. PentaBDE has been in some studies of indoor dust, and several studies have examined the extent of human exposure (UNEP 2006). Indoor dust is considered to be one of the main sources of human exposure (UNEP 2006).

30. C-PentaBDE is used solely as an additive chemical. Although the vapor pressures of its constituents are low, some fraction can volatilize from the products during their whole life-cycle (RPA, 2000). When released, the PentaBDEs are likely to adsorb to particles. The particles (dust) may adhere to surfaces within the appliances, on other surfaces in the indoor environment or be spread to the outdoor environment (Danish EPA, 1999). Physical breakdown of products can also contribute to the presence of PentaBDE in indoor dust.

31. Several studies have detected components of C-PentaBDE in indoor air and dust stemming from products like textiles, furniture and electronic devices (Shoeib et al., 2004, Stapleton et al. 2005, and Wilford et al., 2005). Controlled chamber experiments have detected volatilization of PentaBDE from PUR-foam, used in furniture (Wilford et al. 2005). However, the work of Hale et al. (2002) indicates that physical breakdown of foam may be the major release of

PentaBDE from PUR-foam. Experimental data shows that TetraBDE and PentaBDE are released from electronic appliances, such as TV sets and computer monitors (Danish EPA, 1999). This is supported by a recent study, indicating use of C-PentaBDE in older computers (Betts 2006; Hazrati and Harrad 2006).

32. In RPA (2000) it was estimated that 3.9 % PentaBDE of the amount of C-PentaBDE present in products would be released annually through volatilization during their anticipated lifetime of 10 years, using a worst-case scenario. By 2000, the global annual releases of PentaBDE from new use of PUR-foam in articles are estimated to be 585 – 1,053 metric ton/year (see table 2.3 in UNEP/POPS/POPRC.3/INF/23).

Outdoor equipment

33. While material vaporized from outdoor equipment will be widely dispersed at low concentration in the air, particles of polymer (foam) products which contain C-PentaBDE can be released to the environment from C PentaBDE containing outdoor equipment. These particles are primarily released to the urban/industrial soil compartment (75%), but may also be released to surface waters (24.9%) or air (0.1%). PVC in which C-PentaBDE has been incorporated as flame retardant (RPA, 2000) may have been used in the following situations: car undercoating, roofing material, coil coating, fabric coating, cables and wires, and profiles and shoe soles. The emission factors for these releases are in RPA (2000) estimated to 2-10% over the lifetime of the product, with the higher factor being applied to products subject to high wear rates (such as car undercoating and shoe soles), and 2% during disposal operations. The releases in the EU region were in 2000 estimated to be 15.86 tonnes PentaBDE per year to industrial soil, 5.26 tonnes per year to surface water and 0.021 tonnes per year to air. No estimates of global releases are found in the literature.

34. According to information obtained from the bromine industry, historic uses of hydraulic fluid (in the form of a mixture) in petroleum drilling and mining can have resulted in excessive amounts released to the environment. No estimates of those releases are found in the literature.

2.6 Emissions from waste containing C-PentaBDE

35. Waste can be generated from production of C-PentaBDE, manufacturing processes of C-PentaBDE-containing products and when C-PentaBDE-containing products end up as waste. There is limited information in the literature concerning releases from C-PentaBDE- containing waste.

Waste generated from production of C-PentaBDE

36. In the production of C-PentaBDE producers have stated that the major sources of waste release were filter waste and reject material. Waste water releases of PentaBDE may also occur from spent scrubber solutions (RPA, 2000). C PentaBDE-containing waste was put on landfill (RPA, 2000). In the US this waste is disposed of in landfills that are permitted to handle hazardous chemical waste. In the EU, wastes containing more than 0.25% PentaBDE are classified and treated as hazardous waste. Waste from production of C-PentaBDE is considered negligible.

Waste generated from manufacturing processes of products containing C-PentaBDE

37. The flame retardant lost during these processes will stay in the scrap foam. Foam scrap is often recycled into carpet underlay (rebond), particularly in the United States (EU has been an exporter of scrap foam (around 40,000 tonnes/year) to the United States for this use (RPA 2000)). Other uses for scrap foam such as regrinding and subsequent use as filler in a variety of applications (e.g. car seats, addition to virgin polyol in the manufacture of slab stock foam) have been reported. It is also possible that scrap foam is deposited on landfill or incinerated in many countries.

38. During the production of printed circuit boards a substantial part of the laminate is cut off and ends up in solid waste and this is also true of production of EE appliances. C-PentaBDE is no longer used for production of printed circuit boards in most producer countries. This solid waste is put into landfills or incinerated, as is waste generated from production of building materials, textiles and furniture.

When products containing C-PentaBDE become waste

39. In the EU, wastes containing PentaBDE are covered by regulations governing plastics containing BFRs. These plastics must be separated from EE-appliances prior to recovery and recycling by December 2006. After separation from metals, the plastic fraction is disposed of or burned in municipal waste incinerators, but technologies for separation of bromine-containing and non-bromine-containing plastics are emerging, thus aiding waste management and possible recycling.

40. Vehicle hulks are stored outdoors and then dismantled in shredder plants. In some countries regulations require that components containing hazardous substances are separated before shredding. This applies, obviously, for smaller components that are easy to dismantle. For most plastic and textile components this is not done, and flame retardants in those components end up in the waste fraction from the shredder plant that is put into landfills or sometimes incinerated.

41. Other products containing C-PentaBDE are also put on landfills or incinerated when they end up as waste.

Releases from landfills and incineration

42. Polymer (foam) particles containing C-PentaBDE could leach from landfills into soil, water or groundwater. However, it is not currently possible to assess the significance of this type of process. The amount of PentaBDE put on landfill or incinerated in the EU is estimated to be 1,036 ton/year (RPA, 2000). Given the physico-chemical properties of the substance (low water solubility, high octanol-water partition coefficient) it is considered very unlikely that significant amounts of PentaBDE will leach from landfills as the substance would be expected to adsorb strongly onto soils (RPA, 2000). However, Norwegian screening studies have measured concentrations of PentaBDE of concern in the leaching water from landfills (Fjeld et al. 2003 and 2004).

43. At the operating temperatures of municipal waste incinerators almost all flame retardants will be destroyed. However, based on experience with other organic compounds, trace amounts could pass through the combustion chamber (Danish EPA, 1999). Studies of municipal waste incineration facilities have detected levels of PentaBDE in both gaseous and particulate fractions in the air in the vicinity of the facility. The levels were above background levels of PentaBDE (Agrell et al. 2004, Law 2005, ter Shure et al. 2004).

44. Potentially toxic products such as brominated dibenzo-p-dioxins and dibenzofurans may be released during incineration of waste containing C-PentaBDE (Danish EPA, 1999), just as their chlorinated analogues may be produced during combustion of wastes containing chlorinated materials. While, the technologies used in modern well-run waste incinerators to manage chlorinated dioxins and dibenzofurans emissions are believed to be adequate for controlling emissions of brominated and mixed bromo/chloro species as well (OECD 2001), these substances could be released during open burning of C-PentaBDE-containing materials or some other combustion processes (EU 2000).

2.7 Emissions from recycling and dismantling activities

Electrical and Electronic (EE) waste recycling plants

45. In EE waste recycling plants it is usually the metal that is recovered, sometimes plastic components, but never the PUR foam, which ends up in the waste fraction, that may be burned for energy recovery.

46. The analyses of dismantled FR2 printed circuit boards in electrical scrap show that about 35% of the PBDE used consists of C-PentaBDE. Based on market information it has been assumed that 25% of FR2 laminates in older appliances were treated with the commercial mixture of PentaBDE (Swiss Agency 2002).

47. Prevedouros et al. (2004) estimated production, consumption, and atmospheric emissions of PentaBDE in Europe between 1970 and 2000 based on literature data. According to their study, the flow of PentaBDE in disposed EE appliances is estimated to be in the range of 17-60 metric tons per year within the time period 2000-2005. An experimental Swiss study on substance flow in a modern recycling plant showed a much higher flow of PentaBDE than expected from the literature study. The study revealed that the majority of producers and importers have insufficient information about the content of chemical compounds in the products they market (Swiss Agency, 2002).

48. In Morf et al. (2005), the average concentration in EE-appliances was estimated to 34 mg/kg PentaBDE. The highest amount was found in the plastic fraction of EE-appliances (125 mg/kg). If a recycling process is not equipped with an efficient air pollution control device as was used in the modern plant on which the experimental study was conducted, a significant flow of dust-borne PentaBDE may be transferred into the environment. In plants with off-gas filtering, around 65% of the PentaBDE will be collected (Morf et al. 2005).

49. Studies of the working conditions in recycling plants have detected levels of PentaBDE in the indoor air, and indicate that PentaBDE also can be spread as diffuse emissions from recycling plants. The authors of a national substance flow analysis carried out for Switzerland, covering the whole life cycle of Penta-, Octa-, and DecaBDE as well as tetrabromobisphenol-A (TBBPA), concluded that EE waste equipment accounts for the largest flow of the investigated BFRs compared to other waste fractions, such as, for example, automotive shredder residues and construction waste (Swiss Agency, 2002).

Dismantling of vehicles

50. In a substance flow analysis of BFR in Switzerland, the concentrations of PentaBDE in plastics were estimated to be 0.044 g/kg in road vehicles produced in 1998 and 0.089 g/kg in road vehicles produced in 1980. These concentrations refer to the amount of C-PentaBDE in the total weight of plastics in cars exclusive of EE plastic components. Up to the end of the 1980s, 100% of all unsaturated polyester (UP) resins was treated with BFR, primarily DecaBDE but also C PentaBDE and TBBPA.

51. The first step in the recycling of vehicles is fragmentation in a shredder, where the metals are separated from other materials and recovered. The plastic parts mainly end up in a fraction called "fluff". The conditions for diffuse emissions can be assumed to be similar as for recycling plants of EE-appliances.

Dismantling of buildings and other constructions

52. In Switzerland, 5% of the PUR insulating foams produced in 1990 was used in the building industry and

contained 220 g/ kg C-PentaBDE (Swiss Agency 2000).

53. There are indications of use of C-PentaBDE in PVC plastic sheeting. In the substance flow analysis made in Switzerland, 5% of products produced in 1990 with PVC plastic sheeting were assumed to contain C-PentaBDE. The amount of C-PentaBDE was estimated to be 49 g/kg PVC sheeting. Emissions of dust-borne PentaBDE can be assumed to be released during dismantling activities. The information is too limited to quantify those emissions.

3. Summary information relevant to the risk management evaluation

3.1 Possible control measures

54. There are in principle several control measures that could be implemented to reduce the use of C-PentaBDE and/or reduce the environmental impacts associated with the use of the substance, but many of these lie outside the scope of the Stockholm Convention. These include voluntary commitments by industry; eco-labeling schemes; economic instruments; and a deposit refund system.

55. A ban/restriction on the production and use of C-PentaBDE or key components of the commercial mixture would be an effective measure if properly enforced. Some countries have already taken such actions. Standards aiming at reducing the concentrations of bromodiphenyl ethers in products would be very effective.(RPA, 2000). Standards could be used to ensure environmentally benign waste handling. Risk management would be best achieved by a global ban on production and use of C PentaBDE, brought about by listing the components of the mixture under the Stockholm Convention. Suitable, more environmentally benign alternatives exist for all use of C-PentaBDE so a ban could cover all sectors. A ban would eliminate emissions from the manufacturing of C-PentaBDE, and also eliminate release of bromodiphenyl ethers from the production and use of C-PentaBDE in new products. An important consideration is that a simple ban would not affect the emissions from C PentaBDE in products already in use. One country has reported a need for an exemption for use of C-PentaBDE in military aeroplanes, due to the lack of alternatives that meet the special demands for fire safety.

56. Various control measures at the production or waste handling facilities would ensure safe work environments and good manufacturing practice, end-of-pipe controls reducing emissions to the environment, regulations on waste handling of products etc. These measures could be applied at the production plants for C-PentaBDE, at the plants using C-PentaBDE as input in their production and at the waste handling facilities. If properly designed and enforced this could be an effective tool to reduce releases from the sources in question.

Efficacy and efficiency of possible control measures

57. The choice of control measure for the remaining use and production of C-PentaBDE must take into account that most developed countries have phased out production of C-PentaBDE. However, action is still needed for the protection of human health and the environment from emissions and releases of the components of C-PentaBDE. Further risk reduction options should be examined against the following criteria (RPA, 2000):

- Effectiveness: the measure must be targeted at the significant hazardous effects and routes of exposure identified by the risk assessment. The measure must be capable of reducing the risks that need to be limited within and over a reasonable period of time.
- Practicality: the measure should be implementable, enforceable and as simple as possible to manage. Priority should be given to commonly used measures that could be carried out within the existing infrastructure.
- Economic impact: the impact of the measure on producers, processors, users and other parties should be as low as possible.
- Monitorability: monitoring should be possible to allow the success of risk reduction to be assessed.

Waste handling

58. A ban on production and use of C-PentaBDE would not in itself affect emissions of its components of concern from waste handling, where they can present a technical and legacy problem. However, listing a substance under the Stockholm Convention implies a ban on recycling and reuse of stockpiles of C-PentaBDE itself. Article 6 in the Convention requires that wastes and stockpiles are handled in a safe, efficient and environmentally sound manner, so that the content is destroyed or irreversibly transformed, taking into account international rules, standards and guidelines. The article also bans disposal operations that lead to recovery, recycling, reclamation, direct use or alternative use of POPs material.

59. A special challenge could be to separate C-PentaBDE-containing articles from those without the substance, since most articles are not labeled telling what they contain. However, there is information about articles that have contained C PentaBDE in the past and about which articles it is used in today, like electronic articles, textiles and isolation material and casing materials. National authorities would have to make surveys to get more detailed information about C PentaBDE content in different articles becoming waste. Technically the challenge would be the separation of

bromine-containing and non-bromine-containing plastic components. Technologies on this field are emerging, thus aiding waste management and possible recycling, but they are expensive.

60. Targets for phase out of the use of existing products containing C-PentaBDE and the collection of these could be considered according to Annex A or B of the Convention. Since there are substantial stocks of products containing C PentaBDE in use, national authorities could consider some additional measures to limit releases. These measures could range from establishing collection points where people can deliver their used products to more actively promoting and encouraging people to deliver their waste products. A deposit-refund system does not seem appropriate since sales of new products containing C-PentaBDE would no longer be allowed and their presence has become a legacy problem. However, paying people a fee to deliver their products would be an option, although a source of funding for such an operation is not obvious.

61. A special challenge would be to ensure proper handling of C-PentaBDE-containing waste material/articles in developing countries. Since these countries have limited experience in handling this kind of waste, they would need practical help and information as well as financial help to ensure environmentally benign handling of this waste. The assistance could include how to dismantle C-PentaBDE-containing articles, treat the various parts and the methods of environmentally sound treatment of the final C-PentaBDE. If listed under the Stockholm Convention, guidelines on sound waste treatment of C-PentaBDE and articles containing C-PentaBDE will be developed under the Basel Convention (Article 6 para 2 of the Stockholm Convention).

3.2 Information on alternatives (products and processes)

62. With the phasing out of C-PentaBDE in important markets, manufacturers are actively identifying alternatives. Some companies, such as IKEA, have already phased out all C-PentaBDE globally. Another factor encouraging the development of alternatives is the fact that many governments and large corporations have developed green procurement guidelines that prohibit the use of PBDEs in electronic products.

63. Information on alternatives to C-PentaBDE already in use has been reported by companies, in a regional survey in US (Washington State 2006). The alternatives identified in this process are listed in Table 3.1 in UNEP/POPS/POPRC.3/INF/23. The human health or environmental impacts of these alternatives have not been investigated by the authors. For example, hexabromocyclododecane, an alternative for C-PentaBDE in coatings and adhesives, is not a preferable alternative. This compound already causes concern because of its chemical properties in several countries and regions. RPA (2000) suggests that only tetrabromobenzoate (TBBE) and chlorinated alkyl phosphate esters, tris (2 chloroisopropyl) phosphate (TCPP) in particular, followed by phosphate esters, are relevant chemical alternatives to PentaBDE. However, since that time other alternatives may have been developed and commercialized and should also be considered. Given the range of alternative flame retardants available, a wise course would be to examine the manufacturing processes, evaluate the use of synthetic materials, and give preference to those that pose least risk.

Alternatives to C-PentaBDE in PUR foam

64. The US EPA Design for the Environment completed an assessment of alternatives to C-PentaBDE in PUR which was released in September 2005 (US EPA, 2005). The agency has established a Furniture Flame Retardancy Partnership with a broad set of stakeholders to assess environmentally safer chemical alternatives to C-PentaBDE and to investigate other technologies for improving furniture fire safety. Leading US flame-retardant chemical manufacturers identified 14 chemical formulations that are viable substitutes for C-PentaBDE in large-scale production of low-density flexible polyurethane foam (see table 3.2 in UNEP/POPS/POPRC.3/INF/23). The identified alternatives are drop-in replacement chemicals for C PentaBDE, compatible with existing process equipment at foam manufacturing facilities, and therefore cost-effective. Some chemicals other than these fourteen formulations are currently used for other types of foam and in niche markets for low-density polyurethane foam. The chemicals are used to flame retard high-density, flexible polyurethane foam.

65. Three of the most commonly used chemicals that various reports have suggested may be more environmental and viable alternatives to C-PentaBDE are melamine, tris (1,3-dichloro-2-propyl) phosphate (TDCPP) (or TCPP) and ammonium polyphosphate (APP). Flame retardants based on melamine are currently used in flexible polyurethane foams, intumescent coatings (those which swell on heating and thus provide some measure of flame retardancy), polyamides and thermoplastic polyurethanes. They are used effectively in Europe in high-density flexible polyurethane foams but require 30 to 40 percent melamine per weight of the polyol. TDCPP is a chlorinated phosphate ester that is often used in polyurethane foam formulations. It is used in high-density foam and has been used in low-density foams when light scorching (discoloration) is not a primary concern. APP, an additive flame retardant, is currently used to provide flame retardancy in flexible and rigid polyurethane foams, as well as in intumescent laminations, moulding resins, sealants and glues. However, chemical manufacturers and foam manufacturing trade groups do not consider it to be an alternative for C-PentaBDE on a large scale.

Non-chemical alternatives to C-PentaBDE in PUR foam

66. Non-chemical alternatives have also been identified by the US EPA (2005). Three currently available, alternative

technologies for flame retarding furniture include barrier technologies, graphite impregnated foam and surface treatment. Graphite impregnated foam and surface treatments have limited commercial uses. Barrier technologies are predominantly used in mattress manufacturing rather than residential upholstered furniture, but may have further applications.

67. In addition, it should be noted that some furniture designs exclude the use of filling materials, and even fabric altogether. Design therefore, should be considered when evaluating alternative means for achieving flame retardancy in furniture.

Alternatives to C-PentaBDE in EE-appliances

68. As of mid-November 2005, a number of big manufacturers were phasing out all PBDEs. Manufacturing firms expects increased costs due to compliance with the EU ban on use of hazardous chemicals in EE-appliances, including C PentaBDE among a range of other substances. Among the world producers of EE-appliances 35% expect the price of their products to increase by less than 5%, another 23% of the producers expect an increase between 5 and 10%; 6% of the producers expect prices to increase by more than 10% (Environmental International Reporter, 2006). Examples of alternative flame retardants processes currently being utilized include; bromine-free circuit boards (Sony), phosphorus-based flame retardants for printed circuit boards (Hitachi), flame resistant plastic (Toshiba), halogen-free materials and low-voltage internal wires (Panasonic/Matsushita) (Norwegian EPA, 2003). Leisewitz et al. (2000) says that no problems should arise from the use of zinc borate, magnesium hydroxide or expandable graphite as alternatives to the brominated flame retardants.

Alternatives for C-PentaBDE in textiles

69. There are bromine-free flame retardant alternatives for use in textiles (see table 3.3 in UNEP/POPS/POPRC.3/INF/23). Some of them, such as antimony trioxide and borax, are not environmentally sound. There are also durable flame retardant materials, such as wool and polyester fibres. Some manufacturers claim that a ban on the use of C-PentaBDE in textiles will give poorer quality and durability of the textile.

3.3 Impacts on society of implementing possible control measures

Benefits of phasing out C-PentaBDE

70. The most obvious benefits to the global society of phasing out C-PentaBDE would be the reduced risk to human health and the environment due to reduced releases to air, water and soil of the components considered to be POPS, as well as releases in workplace settings (UNEP, 2006). The major part of the releases of PentaBDE ends up in soil and sediments, since in the environment the substance is bound to particles. PentaBDE in soil or sediments is readily incorporated into the food chain and bioaccumulates in the fatty tissues of top predators, including humans. The substance is widespread in the global environment. There have been detected levels of concern in several endangered species.

71. Levels of PentaBDE have been found in humans in all regions of the world (UNEP, 2006). Potential exposure of humans is through food, use of products containing C-PentaBDE, and contact with indoor air and dust. PentaBDE transfers from mothers to embryos and breastfed infants. UNEP (2006), in its assessment, concludes that PentaBDE is likely to cause significant adverse effects on human health or the environment, such that global action is warranted (see chapter 1.2). Continued use will entail a potentially large cost.

72. Fire prevention is important to protect human safety, and to avoid social and economic losses due to fire, but also to prevent spread in the environment of toxic materials released in fires. Using less of the flame retardant substances, or less effective agents, could therefore cause losses if fires become more frequent, but according to US EPA (2005), the available alternatives function as well as C-PentaBDE. Most of the alternatives are in themselves less hazardous to the environment than C-PentaBDE. Just a few of the substitutes are classified as dangerous for the environment, though complete information is lacking in many cases. The criteria for assessing possible candidate substances have been published by the Danish EPA (1999).

73. An estimate should be made of the reduced cost to the society from reduced damage to ecosystems and to public health, when materials like C-PentaBDE are removed from the market. The value of reduced damage to environment and health is difficult to quantify, but several methods have been suggested. The Polluter Pays Principle, under which such costs should be internalized by the producer and/or the user, is seldom applied (at least without regulatory assistance), and so no good estimates are available of the potential cost of damage avoided.

74. Given the discussion above the overall net benefit of phasing out C-PentaBDE for human health and the environment, is most likely positive.

Costs of phasing out C-PentaBDE

75. According to submitted information, production of C-PentaBDE is already phased out or is being phased out in both developed and developing countries.

76. The incremental costs for users of C-PentaBDE of replacing it with other substances in their products or re-designing the product itself to eliminate the need for additives would have to be considered. Each affected plant would have its own suite of costs incurred by the phase out of C-PentaBDE, so it is hard to make an overall assessment with any accuracy. Some manufacturers may have to invest in new production equipment, but for most users this seems not to be necessary since there are available 'drop in' replacements. In general, the costs of buying many of the alternatives seem to be similar or slightly lower than buying C-PentaBDE. However, for some alternatives there may be an increase in costs associated with a need for higher loads (RPA, 2000). However these costs should be small considering that according to submitted information most manufacturers in developed and developing countries already ceased to use C-PentaBDE. Changes in market demand, because of existing regulatory bans in other regions, and phase out C-PentaBDE, will require adjustments like those already explained in Section 2.3 for the market of electrical and electronic equipment.

77. Listing C-PentaBDE or its components in the Stockholm Convention would oblige Parties to adopt measures or guidance, as specified in the Convention, for the handling of wastes contaminated with C-PentaBDE. For those countries who have not yet adjusted their waste handling practices for C-PentaBDE, adopting such measures will involve additional costs, in both developed and developing countries. In addition to containment technology and provisions for special handling, these measures could extend, for example, to the upgrading of waste treatment plants. No data are available on the costs experienced by countries that have adopted such measures. No reliable figures for the estimated costs of phasing out C-PentaBDE are available, but most studies state that these costs are “low”. Allied to this economic analysis is the fact that most users in developed countries have phased out C PentaBDE seemingly without any great challenges.

78. Potential incremental costs of using alternative substances should be included in the analysis. Using less of the flame retardant substances, or less effective agents, could cause social and economic losses if fires become more frequent, but according to US EPA (2005), the available alternatives function as well as C-PentaBDE. It could be discussed whether the costs for producers of C-PentaBDE of closing the production and eventually switch to production of other substances should be included in a cost benefit analysis. These costs could be considered as part of an ordinary restructuring of production due to changes in market demand. No assessments of such restructuring costs for producers are found in the literature. However this cost should be small considering that most producers have already switched to production of other substances and the increased market demand of alternatives to C PentaBDE, because of the phase-out in regions with the highest demands of the substance.

79. Costs incurred by national governments related to regulation, enforcement and compliance activities (including waste management) should be included in the assessment. Some data of this type have been compiled by Canada (Environment Canada 2006). Overall costs are likely to be low in developed countries where the systems for monitoring and control activities are already in place, but the costs could be considerable for developing countries without these systems. On the other hand implementation of the Stockholm Convention would require these systems to be established, the additional cost of listing C-PentaBDE would therefore be smaller.

80. In addition society may incur some specific costs when materials such as C-PentaBDE are removed from the market and when associated wastes and contaminated sites are addressed. The Polluter Pays Principle, may be applied, but seldom is. Legacy problems such as that likely to be posed by the presence of PentaBDE in the environment often occur since the original 'polluter' in many cases cannot be identified or is no longer in business. The Polluter Pays Principle could however be an approach in those cases, but only where the original polluter can be identified and if the Party’s regulatory framework permits such action.

Comparisons of costs and benefits

81. Given the conclusions of the Risk Profile (UNEP 2006) for C-PentaBDE, its widespread global occurrence in biota and in humans, action taken or underway to phase it out in developed and developing countries and the increased demand for alternatives to C-PentaBDE, the overall consequence of a full global phase-out is most likely to be positive. Overall, the cost for developed countries of a phase out of C-PentaBDE should be small, as discussed above. However, specialized waste management and disposal related to C-PentaBDE (stockpiles and articles) could be costly for some countries and financial and technical assistance to developing countries should be considered to address this aspect as required.

4. Synthesis of information

4.1 Summary of evaluation

82. Commercial pentabromodiphenyl ether (C-PentaBDE) has been used mainly in the manufacturing of flexible polyurethane (PUR) foam for furniture and upholstery in homes and vehicles, packaging, and to a small extent in (non foamed) PUR in casings and electrical and electronic equipment (EEE). To some extent they have also been used in specialized applications in textiles and in various other uses. The risks it poses to human health and the environment have been explored in the Annex E Risk profile adopted by the POPRC in November 2006.

83. There are national and international standards for fire safety for some product groups. This applies for example to electrical material, industrial packaging, upholstered furniture, curtains, electronic household appliances and electrical cables. These standards specify the flame-retarding properties that are required. Traditionally brominated flame retardants have been considered to be the most cost-effective way of imparting ignition resistance to many types of articles. However, in some cases these are being replaced with flame retardants without bromine, or the design of the product is changed so that there is no need for the continued use of chemical flame retardants.

84. Suitable alternatives seem to exist for almost all uses of C-PentaBDE. However, some of the alternative substances are also hazardous, and the impacts of some have not been properly investigated. Still, overall benefits from phasing out the use of C-PentaBDE are assumed to be positive. Costs of phasing out C-PentaBDE are generally perceived to be "low" due to the fact that most developed countries have already phased out C-PentaBDE without meeting excessive challenges. Cost-competitive non-POP alternatives are available and have been taken up by companies as replacements for C-PentaBDE in PUR-foam and electronic equipment.

4.2 Elements of a risk management strategy

85. Since the dissemination of bromodiphenyl ethers into the environment is a global, transboundary problem, some global actions to phase out C-PentaBDE should be considered. Risk management would be best served by a global ban on production and use of C-PentaBDE covering all sectors. Listing components of C-PentaBDE under Annex A of the Stockholm Convention would be the most appropriate measure, given that most developed countries have already banned production. Eventually, some very special uses of C-PentaBDE (military airplanes, space suits etc.) where alternatives are not efficient enough and/or very costly could be exempted from the ban for a time-limited transition period. Developed countries have in place all monitoring and control capacities as well as legislative tools to enforce a ban. Thus, the main enforcement challenge would be for the developing countries to get sufficient capacities in place.

86. Several countries have reported that they would have problems regulating a commercial mixture containing unspecified bromodiphenyl ethers. Listing the individual congeners would be consistent with existing national legislation in several countries for components of C-PentaBDE and would facilitate the national monitoring and control of emissions, production and use. In addition, there is always the possibility that commercial routes might be found to one or other of the components of the mixture, thus avoiding any ban occasioned by listing C-PentaBDE. Most national regulations concern specific compounds. It will therefore be more practical, rather than listing the commercial mixture C-PentaBDE under the Convention, to list major components of the mixtures (BDE-47 and BDE-99) or to list all brominated diphenylethers with 4 or 5 bromines. All mixtures with one of the isomers of tetrabromodiphenyl ether (TetraBDE) or pentabromodiphenyl ether (PentaBDE) will then be covered by the conditions in the Convention, except when they occur as trace. The Convention could set lower limits for these listed substances, so that mixtures containing concentrations below these levels (traces, for example) would not be covered.

87. A particular reason for listing by bromination level rather than listing the commercial mixture is that the production of low brominated PBDE mixtures apart from PentaBDE, which was discontinued as a voluntary measure by the industry, could be restarted. For example, the commercial mixture "Tetrabromodiphenyl ether" which was previously used in Japan, would not be covered by the C-PentaBDE prohibition, should a manufacturer decide to produce it, but listing of specified congeners would cover the case.

88. At present C-OctaBDE and Deca-BDE do not contain TetraBDE or PentaBDE so there will be no consequences of the proposed listing of brominated flame retardants with 4 to 5 bromines (Guardia et al. 2006 and EU 2002).

89. The C-PentaBDE contains up to 12% of HexaBDE. A global risk profile for C-OctaBDE, which also contains appreciable amounts of the HexaBDE, is under consideration by the Committee. If HexaBDE is considered a POP, one option for C-PentaBDE could be listing brominated flame retardants with 4 to 6 bromines. But this would also have consequences for C OctaBDE which has yet to undergo a risk management evaluation by the POPRC.

90. The provision of guidance on criteria for the selection of alternatives to C-PentaBDE should be part of the risk management strategy for the elimination of this substance. It will be important to discourage the replacement of C PentaBDE with other environmentally harmful substances.

91. A ban would eliminate emissions from the manufacture of C-PentaBDE and products containing it. It would not affect the emissions from C-PentaBDE in products already in use. Recycling and reuse of products containing C PentaBDE would not be allowed, if it results in new use of the isomers of TetraBDE or PentaBDE as constituents of new products, since these activities are banned under Article 6 of the Convention. Recycling and recovery can occur, but only if the new product does not contain the specified isomers of TetraBDE and PentaBDE. Additional regulations might need to be considered when products are treated to recover the valuable materials such as metals that are contained in them, and the components of C-PentaBDE is inadvertently released to the environment. This would especially be important for recycling of electronic articles containing C-PentaBDE and for shredder plants handling these and other products, like vehicles. Some components in the waste fraction can be sorted out, but for most EE appliances this will not be practical. Thus, new regulations might require installation of air pollution control devices on

some incinerators and plants, and that would be costly for them. However, most developed countries already have other restrictions that require off-gas filtering of the emissions from recycling and shredder plants.

92. Consideration was given to listing of brominated diphenylethers with four or five bromines in Annex B, with targets to be set for the phase out of the use of specific existing products containing C-PentaBDE. However, collection of such products would be a major task and the likely complexity of such schemes militated against such a recommendation. However, a paragraph on endeavours to achieve this could be added for countries with management systems in place. The general rules on waste handling in the Stockholm Convention will, of course, apply to C-PentaBDE once brominated diphenylethers with 4 or 5 bromines are listed.

93. Waste fractions containing C-PentaBDE should be handled as hazardous waste. This is already done in large parts of the UN ECE region. This could impose extra costs on some countries and sectors. The solutions for waste handling should to a large extent depend on local conditions and be designed to fit into existing systems and traditions, taking the general rules of the Stockholm Convention into consideration, including the general guideline on waste handling in the Basel Convention, which includes in Annex VIII such substances as PCBs and polybromobiphenyls and 'other polybrominated analogues'.

5. Concluding statement

94. This risk management statement has been prepared in accordance with the content specified in Annex F of the Convention, and builds on the Risk Profile adopted by the POPRC in 2006 (UNEP 2006).

95. The available information on commercial pentaBDE includes laboratory studies conducted either with commercial mixtures or specific congeners and monitoring data for different combinations of congeners. In addition to the information summarized in the Risk Profile, the scientific literature offers a significant number of reviews presenting the overall toxicity of this chemical family.

96. The current level of information covers some of the tetra and pentaBDE congeners and seems to be consistent with a generic assessment (e.g., Canton et al., 2006; Huwe et al., 2007), since the properties that define POP characteristics and its associated risks are similar for those congeners investigated. Therefore, considering that:

- Existing national legislators have reported difficulties with the control of commercial mixtures and the enforcement of the regulations;
- Some studies cover all components in the mixture;
- Monitoring and bioaccumulation studies have demonstrated the presence of unknown pentaBDEs (e.g. Burreau et al., 2006);
- There is no information indicating that some congeners within the family do not share the POP characteristics observed for congeners or mixtures for which information is available; and
- The level of potential risk identified in the risk profile indicates that the concern cannot be restricted to the main components in the mixture, and therefore, listing BDE-47 and BDE-99 alone would be insufficient,

97. the Committee proposes that the best approach for listing the chemicals substances reviewed under the risk profile of commercial pentaBDE is to cover all polybrominated diphenyl ethers with four or five bromines. It should be noted that this proposal is based on a specific review of the characteristics of this particular group of chemicals, and that this approach should not be generically extrapolated to other chemical families in which large differences among the properties of closely related homologues, congeners or isomers have been found.

98. In accordance with paragraph 9 of Article 8 of the Convention the Committee recommends to the Conference of the Parties to consider listing 2,2', 4,4'- tetrabromodiphenyl ether (BDE-47, CAS No. 40088-47-9) and 2,2',4,4',5-pentabromodiphenyl ether (BDE-99, CAS No. 32534-81-9) and other tetra- and pentabromodiphenyl ethers present in C-PentaBDE, using BDE-47 and BDE-99 as markers for enforcement purposes. in Annex A of the Convention, as described above.

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Chlordecone
UNEP/POPS/POPRC.3/20/Add.2

Executive summary

99. The European Community and its Member States being Parties to the Stockholm Convention proposed Chlordecone to be listed in Annex A to the Convention in 2005. At its 2nd meeting in 2006, the POP Review Committee considered that although the information on long-range environmental transport is not fully conclusive, there is evidence suggesting the relevance of some transport pathways. The Committee concluded, in accordance with paragraph 7 (a) of Article 8 of the Convention, and taking into account that a lack of full scientific certainty should not prevent a proposal from proceeding, that Chlordecone is likely, as a result of its long-range environmental transport, to lead to significant adverse human health and environmental effects such that global action is warranted.

100. Chlordecone is an intentionally produced chemical that has been used as a pesticide. According to the available information, the main production and use of Chlordecone and related formulations had in effect ceased by the end of the eighties. It cannot, however, be excluded that Chlordecone may still be produced or used as an agricultural pesticide in some developing countries, although there are no reports of such production or use.

101. The most efficient control measure would be the prohibition of all production and uses of Chlordecone and Chlordecone containing products. As no remaining production or uses of Chlordecone have been identified, listing of Chlordecone in Annex A without any specific exemptions would be the primary control measure under the Convention. Listing of Chlordecone in Annex A would also mean 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.

102. As the production of Chlordecone has ceased some decades ago in the main producing countries, there are now alternatives available with comparative efficacy, and without cost implications. Based on this background, significant negative impact on society is not expected if Chlordecone is listed in Annex A of the Convention. No requests have been received nor particular needs identified for specific exemptions on Chlordecone.

103. A beneficial effect could be expected as any currently unidentified production and use around the world should end. In addition, management and disposal of all remaining stocks would be improved and accelerated. Finally, the possibility of re-introduction of Chlordecone in certain countries leading to increased releases and levels in the environment would be prevented on a global scale.

104. However, to completely and effectively terminate releases of Chlordecone into the environment, the issue of environmental degradation of related substances or derivates (such as Kelevan) into Chlordecone would have to be taken into consideration.

105. The Committee prepared this risk management evaluation and concluded that although Chlordecone is not known to be currently produced or used, it is important to prevent its re-introduction into commerce and use.

106. 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 of Chlordecone in Annex A. As no remaining production or uses of Chlordecone have been identified, listing of Chlordecone in Annex A without any specific exemptions is feasible. Furthermore, the Committee recommends focusing the implementation efforts in identifying and managing obsolete stockpiles and wastes containing Chlordecone and setting the proper measures for preventing future production and use of Chlordecone.

1. Introduction

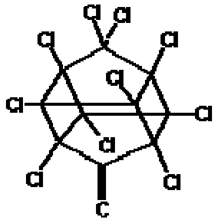
107. The European Community and its Member States being Parties to the Stockholm Convention have proposed Chlordecone to be listed in Annex A to the Convention (UNEP/POPS/POPRC.1/6).

1.1 Chemical identity, production and uses

108. Chlordecone is a synthetic chlorinated organic compound, which has mainly been used as an agricultural insecticide, miticide and fungicide.

Chemical identity

Table 2. Chemical names and registry numbers

CAS chemical name	1,1a,3,3a,4,5,5,5a,5b,6-decachloro-octahydro-1,3,4-metheno-2H-cyclobuta-[cd]-pentalen-2-one
Synonyms	decachloropentacyclo (5.2.1.0'2,6.0'3,9.0'5,8) decan-4-one Decachlorooctahydro-1,3,4-metheno-2H,5H-cyclobuta-[cd]-pentalen-2-one, Decachloroketone
Trade names	GC 1189, Kepone, Merex, ENT 16391, Curlone
CAS registry number	143-50-0
Structure	
Source	http://webbook.nist.gov, as quoted in http:// ecb.jrc.it

Production and uses

109. Based on the available information, Chlordecone is no longer produced or used. According to its Risk Profile, Chlordecone has been used in various parts of the world for the control of a wide range of pests. In particular, Chlordecone has been used extensively in the tropics for the control of banana root borer. It has been used as a fly larvicide, as a fungicide against apple scab and powdery mildew, to control the Colorado potato beetle, the rust mite on non-bearing citrus, and the potato and tobacco wireworm on gladioli and other plants. Chlordecone has also been used in household products such as ant and roach traps.

110. According to the Risk Profile on Chlordecone, the chemical was first produced in 1951 and introduced commercially in the United States in 1958. Chlordecone was produced and used in the USA until 1976. Chlordecone was also found to be present in technical grade Mirex. Between 1951 and 1975, approximately 1.6 million kg of Chlordecone were produced in the United States. Diluted technical grade Chlordecone (80% active ingredient) was exported from the USA to Europe and particularly to Germany in large quantities from 1951 to 1975 where it was converted to Kelevan which is a derivative of Chlordecone that is used for the same purposes. In the environment, Kelevan oxidizes to Chlordecone and could therefore also be considered with Chlordecone for listing in the Stockholm Convention. Approximately 90-99% of the total volume of Chlordecone produced during this period was exported to Europe, Asia, Latin America, and Africa. There is no information, indicating that Kelevan is currently being produced or used .

111. Formulated Chlordecone was marketed in France with the name Curlone, by De Laguarique from 1981 to 1993. Chlordecone for this formulation was synthesised in Brazil. The formulation was used in Martinique and Guadeloupe following the passage of hurricanes Allen in 1979 and David in 1980 which led to considerable pest infestations. The authorisation for the production and use of Curlone was withdrawn by the French Ministry of Agriculture in 1990. Use was continued until September, 1993 (Beaugendre, 2005). In Canada, no product containing Chlordecone has been registered as a pest control product since 2000.

1.2 Conclusions of the Review Committee regarding Annex D and Annex E information

112. The Committee has conducted and evaluated the risk profile in accordance with Annex E at its second meeting in Geneva 6-10 November 2006. The Committee considered that although the information on long-range environmental transport is not fully conclusive, there is evidence suggesting the relevance of some transport pathways. The Committee concluded, in accordance with paragraph 7 (a) of Article 8 of the Convention, and taking into account that a lack of full scientific certainty should not prevent a proposal from proceeding (decision POPRC-2/2), that Chlordecone is likely, as a result of its long-range environmental transport, to lead to significant adverse human health and environmental effects such that global action is warranted.

113. Furthermore, the Committee invited the drafting group on Chlordecone which prepared the risk profile to explore any further information on long-range environmental transport and risk estimations and, if appropriate, to revise the risk profile for consideration by the Committee at its third meeting.

114. The Committee decided furthermore, in accordance with paragraph 7 (a) of Article 8 of the Convention and paragraph 29 of decision SC-1/7 of the Conference of the Parties to the Stockholm Convention, to establish a drafting group to prepare a risk management evaluation that includes an analysis of possible control measures for Chlordecone

in accordance with Annex F to the Convention and invited, in accordance with paragraph 7 (a) of Article 8 of the Convention, Parties and observers to submit to the Secretariat the information specified in Annex F for Chlordecone.

1.3 Data sources

115. The draft Risk Management Evaluation is primarily based on information that has been provided by Parties to the Convention and observers. Parties and observers that provided responses regarding the information specified in Annex F of the Stockholm Convention (risk management) are listed in Table 3.

Table 3. Annex F questionnaires delivered by April 2007

Party	Institution	Date of submission
Algeria	Permanent Mission at the UNO and international organisations in Switzerland	116. 12. 01. 2007
Canada	Environment Canada	08.02.2007
Czech Republic	Ministry of Environment	06.02.2007
Germany	Federal Environmental Agency	07.02.2007
Japan	Global Environmental Division, Ministry of Foreign Affairs	09.02.2007
Mauritius	Government	117. 29. 01. 2007
Monaco	Government, Department of Environment	Not available
Switzerland	Federal Office for the Environment	06.02.2007
Thailand	Ministry of Public Health, Hazardous Substances Control Group	16.02.2005
Zambia	Environmental Council from Government of Zambia	31.01.2007
Country observer	United States Environmental Protection Agency, Office of Pesticide Programs	09.02.2007
Industry Observer	CropLife International	09.02.2007

118. In addition, France provided a report prepared for the Assemblée Nationale describing the history of production and use of Chlordecone in Martinique and Guadeloupe (Beaugendre, 2005) and a report on organochlorine pollution in the same region (Cabidoche et al., 2006).

119. Specific national and international risk management reports for Chlordecone have not been identified.

1.4 Status of the chemical under international conventions

120. Chlordecone is listed in Annex I of the Protocol to the Convention on Long-Range Transboundary Air Pollution (CLRTAP) on Persistent Organic Pollutants. The provisions of the Protocol oblige Parties to phase out all production and uses of Chlordecone. Chlordecone is also included in the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) as a substance of possible concern[1]. Under the Convention on the Protection of the Marine Environment of the Baltic Sea Area (HELCOM Convention[2]) Chlordecone is listed as selected substances for immediate priority action (Recommendation 19/5, Attachment, Appendix 3) and is scheduled for elimination (Annex I, part 2). HELCOM aims to move towards the target of the cessation of discharges, emissions and losses of hazardous substances by the year 2020.

121. In Annex VIII of the Basel Convention, off-specification or out-dated pesticides, without specific mention of Chlordecone, are classified as hazardous.

122. Chlordecone is currently not listed in the Rotterdam Convention on the Prior Informed Consent Procedure for certain hazardous Chemicals and Pesticides in international trade. Thailand has submitted a notification for Chlordecone of Final Regulatory Action for Banned or Severely Restricted Chemicals that has been verified to meet the requirements of Annex I of the Rotterdam Convention.

1.5 Any national or regional control actions taken

Regulation at European level

123. In the European Union, Chlordecone is listed in Annex I to Regulation (EC) No 850/2004 on persistent organic pollutants as scheduled for elimination and with complete prohibition of production and use.

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[1] The chemically related compound Mirex is already included in the Stockholm convention. Both Mirex and Chlordecone are included in the UNECE 1998 Aarhus Protocol on Persistent Organic Pollutants (POPs). Both are included in OSPAR as substances of possible concern.

[2] http://www.helcom.fi/environment2/hazsubs/action/en_GB/list/?u4.highlight=Chlordecone

124. The issue of Chlordecone in waste is addressed at European level in Regulation 850/2004/EC, as amended by Regulation 1195/2006/EC. According to this act, waste containing the listed POPs (including Chlordecone) above the concentration limit of 50 mg/kg has to be treated in such a manner that the POP content is destroyed.

Regulation at national level

125. At the national level, legal control actions taken have been reported by Germany, Canada, the USA, Switzerland, Thailand and Japan.

126. In Canada, production, sale, and use of Chlordecone are currently prohibited for all pesticide uses under the Pest Control Products Act (PCPA). Any stocks that existed at the time that pesticide registration was discontinued or suspended were to be sold, used or disposed of in accordance with an established timetable, after which their sale or use became a violation of the PCPA.

127. Therefore, there is no commercial reason to maintain stockpiles. In addition, Canada has established post-registration monitoring and compliance programs to ensure compliance with federal and provincial legislation. Although there is no Convention obligation to do so, federal, provincial and territorial hazardous waste programs address small quantities of retired material in the possession of consumers and have collected and safely disposed of pesticide products that are no longer registered. No further control measures are required.

128. In the USA, all uses of Chlordecone under the authority of the Federal Insecticide, Fungicide, and Rodenticide Act have been cancelled by the USEPA in 1977. Under the Resource Conservation and Recovery Act (RCRA), chlordecone is listed as a hazardous waste when it is a discarded commercial chemical product off-specification species, container residue, and spill residue thereof (EPA 1980b quoted from US ATSDR 1995). US ATSDR 1995 contains an overview of further regulations and Guidelines applicable to Chlordecone in the USA. There is no record of any Chlordecone or Chlordecone-containing products registered to the U.S. FDA.

129. In Switzerland, Chlordecone has been prohibited since 1986. In Mauritius, Chlordecone is listed as a prohibited agricultural chemical in the Dangerous Chemicals Control Act (DCCA). The law prohibits importation, manufacture, use or possession of Chlordecone.

130. In Japan, Chlordecone is included in a list of 300 substances (or group of substances) selected by the Ministry of the Environment for further investigation (environmental levels, combined effects) into the “environmental risk”.

131. In Thailand, production, importation, exportation or possession of Chlordecone for use in households and public health programmes is prohibited based on the Hazardous Substances Control Act B.E. 2535 (1992).

132. Zambia has reported that there is no documented evidence of action taken at its national level.

2 Identification of possible control measures

133. Legal prohibition of production and use of Chlordecone or Chlordecone-containing products have been stated as major control measures by all responding Parties (Annex F responses 2007).

134. In addition, Canada states the elimination of stocks and their environmental sound disposal as an additional type of control measure taken (see section 1.5.2).

135. Mauritius stressed the issue of import control to prevent uses in countries which did not produce Chlordecone.

136. Besides these control measures no further action has been reported or has been deemed necessary by contracting Parties or observers.

137. As Chlordecone is an intentionally produced pesticide, the most evident and efficient control measure would be the prohibition of all production and uses of Chlordecone and Chlordecone-containing products. Alternatively, in accordance with Article 3(1), legal and administrative measures (e.g. withdrawal or denial of pre-production and pre-marketing authorisation of pesticide products) necessary to eliminate Chlordecone would have the same impact. As no remaining uses of Chlordecone have been identified, listing of Chlordecone in Annex A without any specific exemptions could be the primary control measure under the Convention.

138. Listing of Chlordecone in Annex A would also mean 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.

2.1 Alternatives

139. Information on alternative pesticides has been reported from Canada and USA. France has provided information related to the use of Chlordecone in Guadeloupe and Martinique. It should be noted that the chemical alternatives mentioned below are not concluded as safe or recommended by the POP Review Committee.

Description of alternatives

140. According to Environment Canada, several alternatives to the pesticide uses of Chlordecone are currently

registered and in use in Canada. However, the table referred to was not provided (Annex F responses, Canada 2007).

141. In the USA, the following alternatives are registered for use to control specific pests (NPIRS, 2007, referenced in the Annex F responses, USA, 2007):

- Banana root borer: ethoprop, oxamyl.
- Tobacco wireworms: cyfluthrin, imidacloprid.
- Ants and/or cockroaches:
  azadirachtin, bifenthrin, boric acid, carbaryl, capsaicin, cypermethrin, cyfluthrin, deltamethrin, diazinon, dichlorvos, esfenvalerate, imidacloprid, lamda-cyhalothrin, malathion, permethrin, piperonyl butoxide, pyrethrins, pyriproxyfen, resmethrin, s-bioallerthrin, tetramethrin.

142. An assessment of these alternatives has not been provided by the USEPA.

143. According to a French study on the use of Chlordecone in the French Antilles (Beaugrande et al., 2005), the farmers used the following substances as substitutes after the use of Chlordecone had been stopped:

- Aldicarb
- Isophenphos
- Phenamiphos
- Cadusaphos
- Terbuphos

144. The authors concluded that exemptions for the use of Chlordecone were no longer justified as appropriate substitutes for Chlordecone were available. According to another French study on organochlorine pollution in the French Antilles (Cabidoche et al., 2006), pesticides used as Chlordecone alternatives in Guadeloupe and Martinique (such as cadusaphos) are biodegradable within several weeks.

145. Contracting Parties which reported no historical production or use did not report on alternatives.

146. Alternative pesticide products have been reviewed by the Canadian Pest Management Regulatory Agency (PMRA) and the environmental and health risks associated with their pesticide uses have been considered acceptable (Annex F responses, Canada 2007).

147. Alternatives to chlordecone also include non-chemical agro-ecological methods such as preventative pest management through appropriate fertility and field sanitation practices that reduce pest pressure; the use and habitat enhancement of natural enemies; microbial preparations such as Bacillus thuringiensis; cultural practices such as crop rotation, intercropping, and trap cropping; barrier methods, such as screens, and bagging of fruit; use of traps such as pheromone and light traps to attract and kill insects. These and other agro-ecological methods are being extensively and successfully practised in many countries, eliminating the need for Chlordecone or other chemical interventions.

148. Algeria compiled principal measures to control the impact of pesticides without specifically addressing Chlordecone as a pesticide. Measures included preventive techniques (e.g. soil aeration), mechanical control techniques (e.g. raking), burning of weeds, use of antagonistic macro-organisms (insects, parasites, predator insects), use of bio-insecticides and pesticides, and the use of composed measures such as application of precautionary principle, permitting, information and education, research and development, and environmentally sound waste management to protect environment and human health.

149. CropLife, the international association for the pesticides industry, did not provide any information but stated that a comparative evaluation of the risk of the alternatives to Chlordecone is meaningless as a risk evaluation was never performed for Chlordecone itself (Annex F responses, CropLife, 2007).

Technical feasibility

150. Alternative pesticide products are currently being utilized in Canada and the USA. Technical feasibility is a requirement for registration by Canada’s PMRA. (Annex F responses, 2007). Non-chemical agro-ecological methods are currently being used in many countries as alternatives to chemical insecticides, including Chlordecone.

Costs, including environmental and health costs

151. Information on costs of alternatives has not been provided by Parties. In Canada however, PMRA reviewed environmental and health risks from alternatives in use and considered them acceptable (Annex F responses, Canada 2007). Correspondingly, at least a slight benefit for both the environment and health could be expected. According to IPEN, there are important general points to consider when evaluating the costs of alternatives for any product (Ackerman et al., 2006) as specified in:

- Alternatives with a higher initial purchase cost may actually be more cost effective over the life of the product when durability and other factors are taken into account;
- Mass-production of alternatives can significantly lower their costs

Efficacy

152. Alternative pesticide products have been reviewed by the PMRA and have been determined to be efficacious for each registered pesticide use (Annex F responses, Canada 2007).

Availability

153. The alternative pesticide products listed in chapter 2.1.1. were readily available in the USA. In Canada, availability of all the registered alternatives listed in 2.1.1. was reported to be market dependent. (Annex F responses, 2007). Non-chemical agro-ecological alternatives are widely available throughout many countries.

Accessibility

154. The alternatives listed in chapter 2.1.1 are accessible in the USA and was reported in Canada to be market dependent. (Annex F responses, 2007)

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

Technical feasibility

155. In all Parties responding to the questionnaire, production, sale, and use of Chlordecone is prohibited. This essential phase-out of production and use of Chlordecone indicates that technically feasible alternatives have already been implemented. Also, as done in the USA in 1977, it was deemed technically feasible to cancel the registration of all uses. (Annex F responses, 2007)

Costs, including environmental and health costs

156. The phase-out of Chlordecone that has already occurred indicates that costs of alternatives have not inhibited their substitution. For the USA, there would be no additional costs to prohibit the use of Chlordecone, as USEPA cancelled these uses in 1977. In Canada, disposal of de-registered pesticides has already taken place (see 2.2.1). No specific comments have been provided by other Parties. (Annex F responses, 2007)

157. Costs could arise from elimination of unknown production and potential disposal of remaining stocks. In the case of Chlordecone, costs, however, are not expected to be important even though no information has been provided. Benefits to health and environment are expected from decreasing environmental levels when a ban of Chlordecone production and use is established at a global scale.

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

Health, including public, environmental and occupational health

158. No discernible negative impacts on society have been reported from prohibition or phase-out of Chlordecone as it is apparently not currently in production or use. 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 Chlordecone.

159. As production, sale and use of Chlordecone as a pesticide are prohibited in Canada, negative human health effects due to an ongoing pesticide use of Chlordecone are eliminated.

160. As Chlordecone has not been and is not used, no impacts in the context of pesticide use are expected from a regulation of Chlordecone under the Stockholm Convention for Germany. On a global level, a positive impact on human health can be expected from a ban of Chlordecone from the German point of view. (Annex F responses, Germany 2007)

Agriculture, including aquaculture and forestry

161. No discernible negative impacts on agriculture have been reported from prohibition or phase-out of Chlordecone due to the existence of viable alternatives.

162. There are no negative impacts on this sector in Canada as viable alternative pesticide products are available. A corresponding situation can be expected for the USA and other countries although no specific comment has been provided on this topic. No impacts in the context of pesticide-use are expected from a regulation of Chlordecone under the Stockholm Convention in countries which never used this pesticide. (Annex F responses, 2007)

Biota (biodiversity)

163. As production, sale and use of Chlordecone as a pesticide are prohibited in Canada, negative effects on biota due to an ongoing pesticide use of Chlordecone are eliminated.

164. As Chlordecone has not been and is not used, no impacts in the context of pesticide use are expected from a regulation of Chlordecone under the Stockholm Convention for Germany. On a global level, a positive impact on biota can be expected from a ban of Chlordecone from the German point of view (Annex F responses, Germany 2007).

Economic aspects

165. No negative economic impacts to Canada are apparent through the current prohibition of Chlordecone as a pesticide. As Germany does not use Chlordecone, no impacts in the context of pesticide use are expected from a regulation of Chlordecone under the Stockholm Convention. Information for other countries is not available; however cost-competitive alternatives that do not exhibit POPs characteristics have already been implemented for all uses of Chlordecone. Therefore, no negatives economic impacts from a global ban on Chlordecone are expected.

Movement towards sustainable development

166. The prohibition of Chlordecone contributes positively to sustainable development in that protection of crops through previous Chlordecone pesticide uses is still maintained by alternative methods and the risk to the environment and human health is less.

167. As the persistent, bioaccumulative and toxic properties of Chlordecone as well as its potential for a long-range transboundary transport were judged to be shown under the UNECE Protocol and by the POP Review Committee of the Stockholm Convention which concluded that Chlordecone meets the screening criteria listed in Annex D, a positive impact on a globally sustainable development from a ban/restriction of the substance is to be expected.

168. Reduction and elimination of Chlordecone is consistent with sustainable development plans that seek to reduce emissions of toxic chemicals. A relevant global plan is the Strategic Approach to International Chemicals Management (SAICM) that emerged from the World Summit on Sustainable Development[3]. The Overarching Policy Strategy calls to promote and support the development and implementation of, and further innovation in, environmentally sound and safer alternatives, including cleaner production, informed substitution of chemicals of particular concern and non-chemical alternatives. Moreover the Global Plan of Action of SAICM, listing the proposed work areas and activities contains specific measures to support risk reduction that include prioritizing safe and effective alternatives for persistent, bioaccumulative, and toxic substances.

Social costs

169. According to Canada, no negative social costs are apparent through the current prohibition of Chlordecone used as a pesticide. Since Chlordecone has already been replaced with other substances or technologies, the impact of an Annex A listing on consumers and farmers should be negligible and not incur any social costs.

Other impacts (waste and disposal implications - technical feasibility)

170. Technical feasibility of the disposal of waste Chlordecone is no longer applicable in Canada, as any stocks that existed at the time that pesticide registration was discontinued or suspended were to be sold, used or disposed of in accordance with an established timetable. Canada has established post-registration monitoring and compliance programmes to ensure compliance with federal and provincial legislation and federal, provincial and territorial hazardous waste programmes address and have collected and safely disposed of small quantities of retired pesticide products in the possession of consumers.

171. As the pesticide was not applied in Germany, no obsolete stocks of Chlordecone are expected to be found. However, the introduction of a threshold for Chlordecone in waste (Regulation 1195/2006/EC)[4] will lead to measures taken in Germany as well. At the moment no information on costs is available.

172. Further Regulations concerning the annexes of Regulation (EC) 850/2004 are expected to be elaborated for the European Union. These are related to thresholds and regulations of destruction measurements.

173. Finally, no data on existing Chlordecone stockpiles have been provided but it can be assumed that some countries may still possess obsolete stockpiles which would need to be managed as waste in accordance with Article 6 of the Convention if listed in Annex A or B. At least two regions (Sub-Saharan Africa and South East Asia / South Pacific) have identified Chlordecone as a possible substance of concern in their Regionally Based Assessment of Persistent Toxic Substances but no further information on possible obsolete stockpiles is provided in those reports. (UNEP 2002a, UNEP 2002b).

174. In a report submitted by France, the issue of soil decontamination by Chlordecone has been addressed. According to the report, common techniques of soil decontamination such as solvent extraction and incineration are cost intensive. Microbiological degradation is not promising as it shows only low degradation rates and leads to degradation

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[3] http://www.chem.unep.ch/saicm/

[4] Amending Regulation (EC) 850/2004

products with similar toxicity to Chlordecone itself. The authors of the study indicate that phyto-remediation might be an economically viable option for the decontamination of soil which is polluted with Chlordecone. Chlordecone is taken up by specific plants from the soil. However it is noted that according to the current state of knowledge, phyto-remediation requires large time scales (several centuries) to achieve similar decontamination rates as in solvent extraction (Cabidoche et al., 2006).

2.4 Other considerations

Access to information and public education

175. In Canada, the Pest Management Regulatory Agency of Health Canada (PMRA) provides a wide variety of information regarding pesticide regulation through its web site (www.pmra-arla.gc.ca) including information regarding regulatory decisions taken on pest control products. In taking regulatory decisions on registered products, the PMRA considers the availability of alternatives, and includes relevant information in its documentation. The PMRA website also provides access to a Public Registry that includes a collection of information on pesticides or the pesticide regulatory system, including all publicly available information on currently registered pesticides.

176. In the Czech Republic information on Chlordecone is part of the SC/UN ECE CRLTAP education and awareness raising campaign under the national implementation plan.

177. In Zambia access to environmental information is low, though it has improved in the recent past (ECZ 2001, State of the Environment, Lusaka, Zambia).

178. Risk Profiles and Risk Management evaluations prepared by the POPRC are made publicly available in six UN languages, which ensure access to basic information on Chlordecone.

Status of control and monitoring capacity

179. Information on control and monitoring capacity has been provided by Canada, the Czech Republic and Zambia.. Other Parties and observers did not cover this topic in their responses.

180. In Canada control and monitoring capacity of pesticide uses is managed by the Pest Management Regulatory Agency (PMRA) through compliance mechanisms in place at border crossings and entry points to prohibit importation of Chlordecone or any other chemicals not registered for use in Canada. Compliance issues within Canada may be referred to the PMRA through the following avenues:

- PMRA compliance activities;
- reporting of suspected infractions; and/or
- results reported from other government agencies.

181. In Zambia, general chemical control and monitoring capacity is handled through the Environmental Protection and Pollution Control Act which is enforced by the Environmental Council of Zambia (ECZ 2001, State of the Environment, Lusaka, Zambia).

182. The Czech Republic has reported that there is no specific control and monitoring capacity for Chlordecone.

183. In general, listing Chlordecone in Annex A will involve control measures that are straight forward to communicate and monitor and therefore should be effective and suitable, even in countries that have limited chemical regulatory infrastructure.

3. Synthesis of information

184. According to the Risk Profile on Chlordecone the main production of Chlordecone in the USA ceased in 1975 and the use of Chlordecone (or related formulations) may have largely ceased by the end of the eighties. It is assumed that Chlordecone can still be produced or used as an agricultural pesticide in some developing countries, although there are no reports of such production or use. In French overseas territories, Chlordecone was used until September 1993. If it is still used as a pesticide, it will be directly released to the environment. Moreover, due to the high persistency of the substance, contaminated sites can serve as a source of pollution for an extended period.

185. Chlordecone is already listed in Annex I of the CLRTAP POP Protocol and in the European POP Regulation (EC) No 850/2004. In addition, it is addressed under the OSPAR and HELCOM conventions. At the national level, a legal ban has been reported by Germany, Canada, the USA and Switzerland. In Japan, Chlordecone is included in a list of substances where further information on “environmental risk” is sought.

186. Chlordecone is an intentionally produced pesticide and thus the most efficient control measure would be the prohibition of all production and uses of Chlordecone and Chlordecone containing products. As no remaining production or uses of Chlordecone have been identified, listing of Chlordecone in Annex A without any specific exemptions would be the primary control measure under the Convention. Listing of Chlordecone in Annex A would

also mean 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.

187. As production of Chlordecone has ceased some decades ago in the main producing countries, availability of alternatives, efficacy and cost implications do not constitute a problem. Similarly, significant impact on society is not expected if Chlordecone is listed in Annex A of the Convention. No needs for specific exemptions have been identified.

188. A beneficial effect could be expected as currently unknown production and use in parts of the world would cease. In addition, management and disposal of any remaining stocks would be further regulated. Finally, re-introduction of Chlordecone which currently remains possible in certain countries and which would directly lead to increased releases and levels in the environment would be prevented on a global scale.

189. To effectively avoid releases of Chlordecone into the environment however, the issue of environmental degradation of related substances or derivates (such as Kelevan) into Chlordecone would have to be taken into consideration. Simple listing of Chlordecone in Annex A of the Convention would not cover this type of release, unless a supplementary provision was added in Annex A Part II.

4. Concluding statement

190. The Committee at its second meeting evaluated the risk profile for Chlordecone. While there is a convincing set of data concerning the potential for causing adverse effects, the assessment of the potential for long-range transport is based, due to lack of monitoring data, on physico-chemical properties and modelling data. However, taking into account that a lack of full scientific certainty shall not prevent a proposal from proceeding, the Committee concluded that this chemical is likely, as a result of long-range environmental transport, to lead to significant adverse human health and/or environmental effects such that global action is warranted. The Committee had requested Parties and observers to submit additional information on chlordecone that might be identified during the intersessional period. Despite this call, no new information could be detected by or at the third meeting.

191. The Committee prepared this risk management evaluation and concluded that although Chlordecone is not known to be currently produced or used, it is important to prevent its re-introduction into commerce and use.

192. 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 of Chlordecone in Annex A. As no remaining production or uses of Chlordecone have been identified, listing of Chlordecone in Annex A without any specific exemptions is feasible. Furthermore, the Committee recommends focusing the implementation efforts in identifying and managing obsolete stockpiles and wastes containing Chlordecone and setting the proper measures for preventing future production and use of Chlordecone.

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Hexabromobiphenyl
UNEP/POPS/POPRC.3/20/Add.3

Executive summary

193. The European Community and its Member States being Parties to the Stockholm Convention proposed Hexabromobiphenyl to be listed in Annex A of the Convention in 2005. At its 2nd meeting, the POP Review Committee decided, in accordance with paragraph 7 (a) of Article 8 of the Convention, given the fact that Hexabromobiphenyl is likely, as a result of its long-range environmental transport, to lead to significant adverse human health and environmental effects such that global action is warranted.

194. Hexabromobiphenyl is an intentionally produced chemical that has been used as a flame retardant. According to the available information, the production and use of the substance has been ceased already years ago but it cannot be excluded that it is still in production or in use in some developing countries. Hexabromobiphenyl has mainly been used in ABS plastics and coated cables. Based on an expected lifetime of 5-10 years for electrical and electronical products it is expected that all of the products have already been disposed of.

195. The most efficient control measure would be the prohibition of all production and uses of Hexabromobiphenyl and hexabromobiphenyl containing products and articles. As no remaining uses of Hexabromobiphenyl have been identified, listing of Hexabromobiphenyl in Annex A without any specific exemptions could be the primary control measure under the Convention. Listing of Hexabromobiphenyl in Annex A would also mean 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.

196. Concerning chemical substitutes and technical alternatives reported data (although not specifically related to Hexabromobiphenyl but as overall alternatives to brominated flame retardants) show that there are less hazardous alternatives e.g. aluminium trihydroxide. However, it cannot be disregarded that equally or more harmful substances might be among the alternatives compared to the group of brominated flame retardants as such (e.g. halogenated phosphorus and partially non-halogenated phosphorus compounds).

197. As production of Hexabromobiphenyl has ceased some decades ago, availability of alternatives, efficacy and cost implications do not constitute a problem. Based on the same background significant negative impacts of listing of Hexabromobiphenyl in Annex A on society are not expected. A beneficial effect could be expected in case of currently unknown production in any part of the world, if management and disposal of potentially remaining stocks would be further regulated and reintroduction of Hexabromobiphenyl would be prevented on a global scale.

1. Introduction

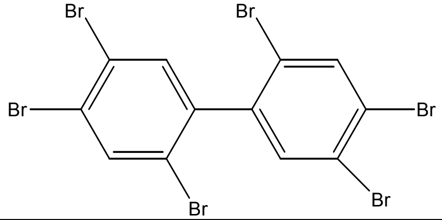
198. The European Community and its Member States being Parties to the Stockholm Convention have proposed Hexabromobiphenyl (HBB) to be listed in Annex A of the Stockholm Convention.

1.1 Chemical identity, production and uses

Chemical identity

199. Hexabromobiphenyl (HBB) belongs to a wider group of polybrominated biphenyls (PBBs). The term “polybrominated biphenyls” or “polybromobiphenyls” refers to a group of brominated hydrocarbons formed by substituting hydrogen with bromine in biphenyl. The hexabromo congeners exist as 42 possible isomeric forms, which are listed with CAS and IUPAC numbers in US ATSDR (2004) and in UNEP/POPS/POPRC.2/9 Annex B.

Table 4. Chemical name and registry numbers

CAS chemical name	hexabromo-1,1´-biphenyl
Synonyms	hexabromobiphenyl; Biphenyl, hexabromo; 1,1´- biphenyl, hexabromo -; HBB
Trade names	FireMaster(R) BP-6; FireMaster(R) FF-1; Technical grade PBBs (FireMaster$^{(R)}$) contain several PBB compounds, isomers and congeners, HBB being one of the main components. The composition of FireMaster$^{(R)}$ BP-6 changes from batch to batch, but its main constituents are 2,2',4,4',5,5'-hexabromobiphenyl (60-80%), and 2,2',3,4,4',5,5'-heptabromobiphenyl (12-25%) together with lower brominated compounds. Mixed bromochlorobiphenyls and polybrominated naphthalenes have also been observed as minor components of FireMaster$^{(R)}$ (EHC 152 (IPCS, 1994)). FireMaster FF-1 (white powder) is FireMaster BP-6 (brown flakes) to which 2% calcium silicate has been added as an anti-caking agent (EHC 152 (IPCS, 1994)). Additional data on the composition of identified PBB congeners in FireMaster$^{(R)}$ BP-6 and FireMaster(R) FF-1 is given in US ATSDR (2004).
CAS registry number	36355-01-8[5] (Common CAS number for HBB isomers) 59536-65-1 Firemaster (R) BP-6 (EHC 192 (IPCS, 1997) 67774-32-7 FireMaster(R) FF-1 (EHC 192 (IPCS, 1997)
Structural formula of 2,2',4,4',5,5' hexabromobiphenyl (Structural formula source: EHC 192 (IPCS, 1997))	

Production and uses

200. The following is a summary of the data on production and uses of HBB given in the risk profile. The commercial production of PBBs began in 1970. Approximately 6 million kg of PBBs were produced in the United States from 1970 to 1976. HBB constituted about 5.4 million kg (ca 88%) of this total. The production in the USA stopped in 1975. Re-initiation of manufacture of PBBs would require 90 days advance notification to EPA, during which time EPA would evaluate the intended use and associated activities, and could regulate the substance to prohibit or limit activities, if appropriate.

201. According to the information available, production and use of HBB has ceased in most, if not all, countries. However, it is possible that HBB is still being produced in some developing countries or in countries with economies in transition.

202. In the United States and Canada, HBB was used as a fire retardant in three main commercial products: acrylonitrile-butadiene-styrene (ABS) thermoplastics for constructing business machine housings and in industrial (e.g. motor housing), and electrical (e. g. radio and TV parts) products; as a fire retardant in coatings and lacquers; and in polyurethane foam for auto upholstery.

203. Approximately 5 million tonnes of HBB were produced in the USA from 1970 to 1976. Of the estimated 2,200 tonnes HBB produced in 1974, about 900 tonnes were used in ABS plastic products and an even larger amount in cable coatings. The exact quantity used in polyurethane foam for automobile upholstery was not published. The two larger consumers ceased using HBB (one of these in 1972) because PBBs did not decompose in the ultimate incineration of scrapped automobiles.

1.2 Conclusions of the Review Committee regarding Annex D and Annex E information

204. The Committee developed a risk profile in accordance with Annex E at its second meeting in Geneva 6-10 November 2006. Based on the risk profile, it has concluded (Decision POPRC-2/3) that, in accordance with paragraph 7 (a) of Article 8 of the Convention, HBB is likely, as a result of its long-range environmental transport, to lead to significant adverse human health and environmental effects such that global action is warranted. The Committee nevertheless requested the ad hoc working group which prepared the risk profile on HBB to refine the risk profile further by providing estimations of the risks to human health and the environment from exposure to HBB, which should

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[5] The CAS registry number 36355-01-8 is given as a generic CAS number for PBBs in the 1988 EU Export-Import Regulation and the UNEP Rotterdam Convention.

include the potential risk associated with the presence of HBB in articles and wastes. The Committee decided furthermore, in accordance with paragraph 7 (a) of Article 8 of the Convention and paragraph 29 of decision SC-1/7 of the Conference of the Parties to the Stockholm Convention, to establish an ad hoc working group to prepare a risk management evaluation that includes an analysis of possible control measures for HBB in accordance with Annex F of the Convention and invited, in accordance with paragraph 7 (a) of Article 8 of the Convention, Parties and observers to submit to the Secretariat the information specified in Annex F for HBB and further information to allow refinement of the hazard assessment and the risk profile of HBB.

1.3 Data sources

205. The Risk Management evaluation is primarily based on information that has been provided by Parties to the Convention and Observers. Responses regarding the information specified in Annex F of the Stockholm Convention (risk management) have been provided by the following countries (Table 5):

Table 5. Annex F questionnaires delivered by April 2007

Party	Institution	Date of submission
Canada	Environment Canada	08.02.2007
Czech Republic	Ministry of Environment	06.02.2007
Germany	Federal Environmental Agency	07.02.2007
Mauritius	Government	29.01.2007
Monaco	Government, Department for Environment	Not available
Thailand	Ministry of Public Health, Hazardous Substance Control Group	16.02.2005
Zambia	Environmental Council from Government of Zambia	31.01.2007
Switzerland	Federal Office for the Environment	06.02.2007
Country Observer	US EPA	09.02.2007
NGO Observer	IPEN	08.02.2007

206. Besides answers to the questionnaire major information sources used have been the following:

- (Danish EPA, 1999) Danish Environmental Protection Agency, Brominated flame retardants: Substance flow analysis and assessment of alternatives, June 1999. Available at http://www2.mst.dk/common/Udgivramme/Frame.asp?pg=http://www2.mst.dk/udgiv/Publications/1999/87-7909-416-3/html/kap08_eng.htm
- (USEPA, 2005), Environmental Profiles of Chemical Flame-Retardant Alternatives for Low-Density Polyurethane Foam. Available at http://www.epa.gov/dfe/pubs/flameret/ffr-alt.htm
- (OSPAR, 2001): OSPAR Priority Substances Series; Certain Brominated Flame Retardants – Polybrominated Diphenylethers, Polybrominated Biphenyls, Hexabromo-Cyclododecane, OSPAR Commission 2001 (2004 Update)
- (BMU, 2000): Leisewitz A, Kruse H, Schramm E, German Federal Ministry of the Environment, Nature Conservation, and Nuclear Safety, Substituting Environmentally relevant flame retardants: Assessment Fundamentals, Research Report 204 08 642 or 207 44 542, 2000

207. Specific national and international risk management reports for HBB have not been available. However, there are a number of reports such as Danish EPA (1999), OSPAR (2001), BMU (2000), UBA (2003a, 2003b), USEPA (2005), which address the issue of control and substitution of brominated flame retardants at international or national scale.

208. General aspects of management for PBBs without further specification are reported in the Draft “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)”,Version 7 April 2006, available at http://www.basel.int/techmatters/index.html.

1.4 Status of the chemical under international conventions

209. HBB is listed in Annex I of the Protocol to the Convention on Long-range Transboundary Air Pollution (CLRTAP) on Persistent Organic Pollutants. The provisions of the Protocol oblige Parties to phase out all production and uses of HBB.

210. HBB, together with other PBBs, is also included in the UNEP/FAO Rotterdam Convention on the Prior Informed Consent Procedure (PIC) for Certain Hazardous Chemicals and Pesticides in International Trade.

211. Under the OSPAR Convention for the protection of the marine environment of the North-East Atlantic, brominated flame retardants (including HBB) are enumerated as part of the List of Chemicals for Priority Action (March 2002). A background document has been prepared by Sweden. It was first published 2001 and was updated in 2004 (OSPAR, 2006). The action recommended in the updated document is to support several measures of the European Community on Polybrominated Biphenyls and to develop an OSPAR monitoring strategy for several Polybrominated Biphenyls and to review the need for further OSPAR measures to supplement the eventual measures of the European Community.

212. Under the Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area (HELCOM[6]) HBB is listed as a selected substance for immediate priority action (Recommendation 19/5, Attachment, Appendix 3) and is scheduled for elimination (Annex I, part 2). HELCOM aims to move towards the target of the cessation of discharges, emissions and losses of hazardous substances by the year 2020.

213. Under the Basel Convention, PBBs are classified as hazardous in Annex VIII without further specification.

214. Even if not being an international convention, the Strategic Approach to International Chemicals Management (SAICM) appears to be a noteworthy international action. SAICM was developed by a multi-stakeholder and multi-sectoral preparatory committee and supports the achievement of the goal agreed at the 2002 Johannesburg World Summit on Sustainable Development. SAICM does not specifically address HBB but includes POPs as a class of chemicals that might be prioritized for assessment and related studies. An objective of SAICM is to ensure by 2020 that chemicals or chemical uses that pose an unreasonable and otherwise unmanageable risk to human health and the environment (among others POPs) based on a scientific risk assessment and taking into account the costs and benefits as well as the availability of safer substitutes and their efficacy, are no longer produced or used for such uses (SAICM 2006).

1.5 Any national or regional control actions taken

215. In the European Union, HBB is listed in Annex I to Regulation (EC) No 850/2004 on persistent organic pollutants with complete prohibition of production and use in all the 27 Member States.

216. The EC Directive 2002/96/EC on Waste from Electric and Electronic Equipment (WEEE) requires that brominated flame retardants have to be removed from any separately collected WEEE prior to further treatment. EC Directive 2002/95/EC on Restrictions on Certain Hazardous Substances in Electric and Electronic Equipment (ROHS) stipulates in article 4 that electric and electronic articles may not contain polybrominated biphenyls from July 2006[7].

217. The issue of HBB in waste is addressed at the European level in Regulation 850/2004/EC. As amended by regulation 1195/2006/EC POPs such as HBB in wastes have to be destroyed if concentration limits of 50 mg/kg are exceeded.

218. The use of PBBs in textiles has been prohibited in the European Union already decades ago by means of Directive 1976/769/EEC.

219. At the national level, legal control actions taken have been reported by Canada, the USA and Australia. In Canada Polybrominated Biphenyls that have the molecular formula C12H(10-n)Brn, in which "n" is greater than 2, appear on Schedule 1 (List of Toxic Substances) of CEPA 1999, and are subject to prohibitions on their manufacture, use, sale, offer for sale and import. In addition, these substances appear on Schedule 3, Part 1 (Export Control List – Prohibited Substances) of CEPA 1999, effectively prohibiting their export, except for the purpose of their destruction.

220. In the USA, HBB is subject to a TSCA Significant New Use Rule which would require notification to EPA prior to re-initiating manufacture or import for any use (63 FR 45955, August 28, 1998; 40 CFR 721.1790).

221. In Australia the introduction (i.e. manufacture or import) or export of HBB, octabromobiphenyl and decabromobiphenyl are prohibited under the Industrial Chemicals (Notification and Assessment) Regulations 1990 unless the Director of the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) has given written permission.

2. Identification of possible control measures

222. Control measures already widely implemented are elimination of production, use, export, and import. US EPA refers to the subjection of HBB to the Toxic Substances Control Act (TSCA) and the Significant New Use Rule which would require notification to EPA prior to re-initiation of manufacture or import for any use (63 FR 45955, August 28,

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[6] Helsinki Commission - Baltic Marine Environment Protection Commission: http://www.helcom.fi/environment2/hazsubs/action/en_GB/list governing body of the Convention

[7] For use in article 5(1) a maximum concentration of 0.1% by weight in homogenous material of PBB shall be tolerated.

1998; 40 CFR 721.1790). Mauritius refers to the Dangerous Chemicals Control Act 2004 (DCCA) which subjects to control by the Dangerous Chemicals Control Board (DCCB) all importations of chemicals.

223. Exposure to HBB may occur in connection with the use of products, in the recycling of plastics containing PBBs and after disposal to landfills so that in general releases from articles in use and releases from waste should be taken into account when considering control measures. (OSPAR, 2001).

224. Measures related to stocks and articles in use, for release control and clean-up are not addressed in the responses to the Annex F questionnaire.

225. As HBB is an intentionally produced chemical, the most efficient[8] control measure would be the prohibition of all production and uses of HBB and HBB containing products and articles. Alternatively, in accordance with Article 3(1), legal and administrative measures (e.g. withdrawal or denial of pre-production and pre-marketing authorisation of chemicals) necessary to eliminate HBB would have the same impact. As no remaining uses of HBB have been identified, listing of HBB in Annex A without any specific exemptions could be the primary control measure under the Convention.

226. Listing of HBB in Annex A would also mean 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.

2.1 Alternatives

227. The HBB risk profile describes three principal commercial products that contained HBB in the USA and Canada:

- acrylonitrile-butadiene-styrene (ABS) thermoplastics used for business machine housings and electrical products such as radio and TV;
- fire retardant in cable coatings and lacquers, and
- fire retardant in polyurethane foam for auto upholstery.

228. Production and use of HBB has ceased in the USA, Canada, and probably most parts of the world. However, it is possible that HBB is still being produced and used in some developing countries or in countries with economies in transition. As most production and use has ceased, there are numerous alternatives available and in use. Since there may be some production and use still occurring, evaluation and assessment of alternatives is presented and will focus on the earlier known uses as far as information is available.

229. A number of reports on risk assessment of alternative substances and processes are available. The OSPAR priority substances Series (OSPAR, 2001) provides summary information on alternatives for brominated flame retardants. The Danish Environmental Protection Agency has described alternative halogen-free flame retardants for a variety of uses including epoxy, phenolic resins, rigid and soft polyurethane foam, textiles, and a variety of plastics including ABS (Danish EPA, 1999). Both drop-in chemical substitutes and alternative materials are listed. US EPA has described process alternatives and chemical substitutes for polyurethane foam (USEPA, 2005). The German Federal Ministry of Environment has reported on alternatives for flame retardants used in electronics, upholstery, and other sectors (BMU, 2000).

230. As brominated flame retardants only account for about 15% of the global flame retardant consumption, principally a large number of compounds may be considered as alternatives (OSPAR, 2001). Substitution can take place at three levels:

- brominated flame retardants can in some applications be replaced by another flame retardant without changing the base polymer; (major group of substitutes)
- the plastic material, i.e. the base polymer containing flame retardants and other additives, can be replaced by another plastic material; (e.g. polysulfone, polyaryletherketone and polyethersulfone)
- a different product can replace the product, e.g. the plastic material is replaced by another material (e.g. wool), or the function can be fulfilled by the use of a totally different solution.

231. Reported chemical substitutes (see indent 1) currently used in Europe comprise the group of (a) organophosphorus compounds, (b) inorganic fire retardants and (c) nitrogen containing compounds (Danish EPA, 1999).

(a) The group of organophosphorus compounds contains the following main substances divided into the groups of:

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[8] Minimised effort to achieve specific objectives (here: no current and future production and use of Hexabromobiphenyl in order to avoid environmental releases and significant adverse effects on human health and/or the environment).

halogenated organophosphorus (tris-dichloropropyl-phosphate, tris-chloropropyl-phosphate and tri-chloroethyl phosphate)
non-halogenated organophosphorus (triphenyl phosphate, tricresyl phosphate, resorcinal bis(diphenylphosphate), phosphonic acid, (2-((hydroxymethyl)carbamyl)ethyl)- dimethyl ester, phosphorus and nitrogen constituents for thermosets)
(b) The group of inorganics contains aluminium trihydroxide, magnesium hydroxide, ammonium polyphosphate, red phosphorus and zinc borate
(c) The group of nitrogen containing compounds contains melamine and melamine derivatives, e.g., melamine cyanurate and melamine polyphosphate

232. In addition USEPA 2005 provides an assessment for tribromoneopentyl alcohol, chloroalkyl phosphate, other aryl phosphates, tetrabromophthalate diol diester and reactive brominated flame retardants as potential substitutes for PeBDE. Tetrabromobisphenol-A (TBBPA) and reactive phosphorus polyols have been mentioned as potential alternatives as well.

2.1.1 Description of alternatives (substances)

Alternatives for ABS plastics

233. Organic phosphorus compounds which are available as halogenated or non-halogenated substances can serve as alternatives for use in ABS plastics.

234. Halogenated organophosphorus compounds include tris-chloropropyl-phosphate (TCPP), tris-chloroethyl-phosphate, and tris dichloropropyl phosphate (TDCPP) (BMU, 2000). According to (USEPA, 2005) TDCPP is often used in polyurethane foam in the US and abroad. However, TDCPP, TCPP and tri-chloroethyl phosphate entail moderate concern for carcinogenicity, reproductive toxicity, developmental toxicity, systemic toxicity, genotoxicity, acute and chronic ecotoxicity, and persistence. (WHO, 1998), (USEPA, 2005)

235. Tetrabromobisphenol A (TBBPA or TBBP-A) is regarded as very poisonous to water-living organisms and very persistent. This flame retardant is mainly used in printed circuit boards. Since TBBPA is chemically bound to the resin of the printed circuit board, there is no direct exposure of the aquatic environment and therefore minimal risk to aquatic organisms. For disposal and recovery purposes circuit boards however, would be classified as hazardous under the Basel Convention if containing polybrominated biphenyls to an extend, that they possess Annex III characteristics (Annex VIII, A 1180). Consequently the European Regulation No (EC) 1013/2006 on Shipment of waste would subject such wastes to export prohibition in Article 36. TBBPA and other flame retardants are released during recycling of waste electrical and electronic equipment[9].

236. Non-halogenated organic phosphorus compounds as alternative flame retardants for High Impact Polystyrene (HIPS) and polycarbonate (PC) plastics include commonly used substances such as triphenyl phosphate (TPP), tricresyl phosphate (TCP), resorcinol bis(diphenylphosphate) (RDP), and phosphonic acid (2-((hydroxymethyl) carbamyl)ethyl)-dimethyl ester (Pyrovatex®) (Danish EPA, 1999).

237. (USEPA, 2005) reports moderate overall hazard for TPP while it is considered to be environmentally hazardous in Germany due to its toxicity to aquatic organisms (BMU, 2000) TCP toxicity apparently differs according to isomer. IPCS recommends the use of purified m- and p- isomers to prevent formation of the highly toxic o-isomer (Danish EPA, 1999). RDP is usually used in combination with TPP.

238. Pyrovatex® is not well-characterized though the Danish report notes that it is a weak inhibitor of acetyl choline esterase and the microsomal enzyme system and that high concentrations induced chromosome aberrations and reverse mutations. The German report notes that Pyrovatex easily separates formaldehyde and often is used together with ethylene carbamide to help trap released formaldehyde (BMU, 2000).

239. Both the German and Danish reports comment on the insufficiency of human and environmental toxicity data for RDP. Due to the absence of toxicity information and its possible transmission to humans from use of consumer products, the reports conclude that the data is insufficient to be able to make a recommendation.

Alternatives in coatings and lacquers

240. Halogen-free rubber cables can contain aluminium trihydroxide and zinc borate as flame retardant alternatives and incorporate the ethylene vinyl acetate polymer as well.

241. Aluminum trihydroxide is the most frequently used flame retardant (Danish EPA, 1999). Due to an endothermic reaction when decomposing and other properties it is highly effective and also suppresses smoke. Its functional disadvantage is that large amounts are required (up to 50%) which can affect the properties of the material. It would be

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[9] Morf LS, Tremp J, Gloor R. Huber Y, Stengele M, Zennegg M. Brominated flame retardants in waste electrical and electronic equipment: substance flows in a recycling plant. Environ Sci Technol 39:8691-8699, 2005.

extremely unlikely for its use in consumer products to cause adverse effects. Accumulation of the substance in food chains is not detectable (Danish EPA, 1999). Also the German alternatives report describes the use of aluminum trihydroxide as a flame retardant as “unproblematic.”

242. Magnesium hydroxide has comparable effects; however the environmental effects still have to be assessed (Danish EPA, 1999).

243. Zinc borate is often combined with aluminum trihydroxide and used to substitute for antimony trioxide. The German report describes the teratogenicity of boron along with its ability to irritate the eyes, respiratory organs, and skin at high levels. It assumes that its use as a flame retardant will not result in significant additional concentrations for humans. However, it concludes that it would be important to measure the ability for boron to be released in dust before its wide use in consumer products in homes.

Alternatives for polyurethane foams

244. Ammonium polyphosphate (APP) is an additive flame retardant currently used to flame retard flexible and rigid polyurethane foams, as well as intumescent laminations, moulding resins, sealants and glues. APP formulations account for approximately 4-10% in flexible foam, and 20-45% in rigid foam (USEPA, 2005). APP is commonly used in combination with Aluminium hydroxide and Melamine. It metabolizes into ammonia and phosphate and is not thought to cause acute toxicity in humans (BMU, 2000). However, there are no analyses of long-term toxicity, teratogenicity, mutagenicity, or carcinogenicity. APP breaks down rapidly and does not accumulate in the food chain. Skin irritation is possible due to the formation of phosphoric acids.

245. Red phosphorus mainly used in polyamids is easily ignited and poorly characterized toxicologically. There is no data available for red phosphorus on ecotoxicity, carcinogenicity, mutagenicity, long-term toxicity, or toxicokinetics and no data exists on concentrations of red phosphorus in indoor or outdoor air (from sewage sludge) as a consequence of incorporating red phosphorus into products. Eye and mucous membrane irritation can result due to the formation of phosphoric acid. Ecosystem accumulation is thought to be unlikely (BMU, 2000). US government researchers have noted that high levels of toxic phosphine were observed during long-term storage of red phosphorus (Anthony et al., 2006). Information from the Danish EPA (1999) confirms the observations made, and states that “smaller producers of plastic products avoid the use of red phosphorus”.

246. Melamine and its derivatives (cyanurate, polyphosphate) are currently used in flexible polyurethane foams, intumescent coatings, polyamides and thermoplastic polyurethanes (Special Chemicals, 2004). They are used effectively in Europe in high-density flexible polyurethane foams but require 30 to 40 percent melamine per weight of the polyol. Melamine and its derivates display several toxic effects in animals (USEPA, 1985; Danish EPA, 1999). In a fire, melamine cyanurate will release toxic fumes such as hydrocyanic acid and isocyanate (BMU, 2000).

247. However the Danish report notes that based on the results of the Swedish flame retardants project (Berglind, 1995) and a study from Stevens et al. (1999) there is no data on emission from products and that melamine appears to have low acute and chronic toxicity and concludes that, “…no adverse effects are envisaged from the level of exposure expected from the use of melamine as a flame retardant.”(Danish EPA, 1999). In contrast, the German report describes the lack of data, presence in environmental samples and moderate organ toxicity of melamine and concludes it is a “problematic substance” (BMU, 2000).

248. Specific reactive phosphorus polyols as potential alternative for soft polyurethane foam were not identified in the Danish report, though polyglycol esters of methyl phosphonic acid (CAS 676-97-1) have been used for flame retardants in polyurethane foam (e.g. CAS 294675-51-7) (OPCW, 2006). Researchers at the Oak Ridge National Laboratory in the US describe methyl phosphonic acid as one of degradation products of chemical weapons with “significant persistence.” (Munro et al., 1999) Other types of toxicity information are minimal but the substance reacts violently with water (USEPA, 1985). The phosphonic acid family also includes amino-methyl phosphonic acid (AMPA), a degradation product of the herbicide, glyphosate (also known as [carboxymethylamino] methyl phosphonic acid.) (Annex F responses, 2007, IPEN).

249. The US EPA Design for Environment (DfE) report on flame retardant alternatives (USEPA, 2005) investigated the toxicological properties of 15 chemical substitutes for PentaBDE in low density foam. 12 of these substances have a moderate or high concern for persistence or would produce persistent degradation products. An additional 6 substances have a moderate concern for the ability to bioaccumulate. All substances (including triphenyl phosphate, tribromoneopentyl alcohol and proprietary aryl phosphates) raised moderate overall concern for human health and ranged from low to high hazard for the aquatic environment.

2.1.2 Description of alternatives (technologies)

250. Three currently-available alternative technologies (barrier technologies, graphite impregnated foam and surface treatment) are shortly discussed in the US EPA DfE report (USEPA 2005). Barrier technologies have the widest immediate commercial applicability and involve layers of materials that provide fire resistance. These include boric acid-treated cotton materials used in mattresses; blends of natural and synthetic fibres used in furniture and mattresses

(VISIL, Basofil, Polybenzimidazole, KEVLAR, NOMEX and fibreglass); and high performance synthetic materials used in fire-fighter uniforms and space suits. As regards barrier technologies that use cotton and boric acid potential negative effects of boron (see above; BMU 2000) should be taken into account and it would be important to measure the ability for boron to be released in dust before its wide use in consumer products in homes. More information on barrier fabrics or even eliminate the use of filling material can be found in Lowell, (2005) and in Posner, (2004) (USEPA, 2005). Graphite impregnated foam and surface treatments have limited commercial uses. Graphite impregnated foam (GIF) can be considered an "inherently flame-resistant foam" that is self-extinguishing and highly resistant to combustion. It is a relatively new technology and is largely used in niche markets such as for general aircraft seating. Surface treatments are also used in some applications and niche markets and may be appropriate for some textile and furniture manufacturing. However, surface treatments may not be viable as industry-wide replacements for use in low-density foam (USEPA 2005).

2.1.3 Technical feasibility

251. All the alternatives described above are technically feasible and have been used in commercial applications (Annex F responses, 2007, IPEN). No specific comments on this topic have been provided by other parties.

2.1.4 Costs, including environmental and health costs

252. The prices of the alternatives are in general not higher than the BFRs but higher loading is often necessary. This is in particular true with respect to the inorganic compounds aluminum trihydroxide and magnesium hydroxide. Due to the low price of aluminum trihydroxide alternative materials may not be more expensive than BFR containing materials, but magnesium containing materials will usually be significantly more expensive. (Danish EPA, 1999)

253. As concerns alternative technologies, USEPA (2005) describes the boric acid-treated cotton as "… the least expensive flame-retardant barrier materials available." However, also GIF modified foams can be priced competitively by minimizing the expense associated with flame-retardant fabric.

254. According to IPEN however, there are important points to consider when evaluating the costs of alternatives for any product as specified in Ackermann et al., (2006):

- Alternatives with a higher initial purchase cost may actually be more cost effective over the life of the product when durability and other factors are taken into account.
- Mass-production of alternatives can significantly lower their costs.
- The costs of initiatives to protect health and the environment are frequently overestimated in advance and later decline rapidly after the regulation is implemented.

2.1.5 Efficacy

255. According to IPEN none of the alternatives usually applied in the earlier known use fields of HBB are prohibited by federal or state laws for the uses described above and in this sense, they meet regulatory requirements meet US federal and state regulatory requirements. However, chemical manufacturers and foam manufacturing trade groups do not consider APP to be an alternative for brominated flame retardants on a large scale. Reasons for this are that APP is typically incorporated as a solid, it has adverse effects on foam properties and processing and it is not considered to be as effective as a fire retardant compared to other alternatives (USEPA, 2002 quoted in USEPA, 2005).

256. Melamine and TDCPP as two of the most commonly used chemicals to flame retard high-density, flexible polyurethane foam either result in scorching of the foam (an aesthetic effect unless severe) or a negative effect on the physical properties of foam if used in low-density flexible foams. Also, many formulations of these chemicals are available only as solids; making them less desirable as drop in substitutes for some brominated flame retardants (USEPA, 2005). (for risk assessment of alternative use see section 2.1.1)

2.1.6 Availability

257. The alternatives described here are available since many are already in commercial use (Annex F responses, 2007, IPEN). However, the fact that many alternatives are in commercial use does not necessarily mean they are available globally.

2.1.7 Accessibility

258. The alternatives described here are accessible since many are already in commercial use (Annex F responses, 2007, IPEN). However, the fact that many alternatives are in commercial use does not necessarily mean they are available globally.

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

2.2.1 Technical feasibility

259. The essential phase-out of global production and use of HBB indicates that technically feasible alternatives have

already been implemented (Annex F responses, 2007, IPEN).

2.2.2 Costs, including environmental and health costs

260. According to IPEN the considerable phase-out of HBB that has already occurred indicates that costs of alternatives have not inhibited their substitution.

261. No specific comments on this topic have been provided by other parties. As the phase out of HBB however, has taken place long ago already, significant costs from a global ban of the product would not be expected. Additional costs could arise from specific provisions concerning identification, collection, dismantling and disposal of remaining equipment.

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

2.3.1 Health, including public, environmental and occupational health

262. According to the German Federal Environment Agency impacts of a restriction/ban of HBB under the Stockholm Convention are expected to be rather low for the European region as HBB is already restricted for certain uses within the EU and as a critical level for water has lately been defined. On a global scale however, a positive impact on human health and on the environment can be expected from a ban of HBB (Annex F responses, 2007, Germany). Also the Czech Republic does not expect impacts of possible control measures (Annex F responses, 2007, Czech Republic). According to IPEN elimination of HBB production, use, export, and import through a listing in Annex A of the Stockholm Convention would positively impact human health and the environment by preventing use of a persistent toxic substance. No discernible negative impacts on society have been reported from prohibition or phase-out of HBB as it is apparently not currently in use. A listing in Annex A would prevent future production and integration into products.

2.3.2 Agriculture, including aquaculture and forestry

263. There are no likely economic impacts on agriculture, as HBB has not been used in that sector. The positive environmental impacts in the form of reduced pollution could also have indirect positive impact on agriculture.

2.3.3 Biota (biodiversity)

264. As the persistent, bioaccumulative and toxic properties of HBB were shown under the POPs-Protocol and under the Stockholm Convention, a positive impact on biota from a ban/restriction of the substance can be expected according to the German Federal Environment Agency.

2.3.4 Economic aspects

265. According to IPEN cost competitive alternatives that do not exhibit POPs characteristics have already been implemented by companies for all uses of HBB.

2.3.5 Movement towards sustainable development

266. As the persistent, bioaccumulative and toxic properties of HBB as well as its potential for a long-range transboundary transport were shown under the POPs-Protocol and by the POPRC of the Stockholm Convention which concluded that HBB meet the screening criteria listed in Annex D, a positive impact on a globally sustainable development from a ban/restriction of the substance is expected by the German Federal Environmental Agency (Annex F responses, 2007, Germany). According to IPEN reduction and elimination of HBB is consistent with sustainable development plans that seek to reduce emissions of toxic chemicals. A relevant global plan is the Strategic Approach to International Chemicals Management (SAICM) that emerged from the World Summit on Sustainable Development[10]. The Global Plan of Action of SAICM contains specific measures to support risk reduction that include prioritizing safe and effective alternatives for persistent, bioaccumulative, and toxic substances.

2.3.6 Social costs

267. Since HBB has already been replaced with other substances or technologies, the impact on costs for consumers of an Annex A listing should be negligible according to IPEN.

2.3.7 Other impacts (waste and disposal implications- stocks, contaminated sites)

268. Since HBB has already been largely phased-out, the impact on municipal waste and disposal according to IPEN should be minimal.

269. However, the risk profile outlines former consumer uses of HBB including ABS plastic used for business machine housings and electrical products such as radio and TV, cable coatings, and polyurethane foam. In addition there are concerns over export of electronic waste to developing countries leading to HBB releases during recycling

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[10] http://www.chem.unep.ch/saicm/

operations. Finally, burning or incineration of HBB-containing waste could lead to formation and release of brominated dibenzo-p-dioxins and -furans.

270. A listing of HBB in Annex A would subject wastes, products or articles containing the substance to Article 6 of the Stockholm Convention and require that they are disposed of in environmentally sound manner.

271. According to the US EPA approximately 11.8 million pounds (5.4 million kg) of HBB were used in commercial and consumer products in the U.S. with an estimated use life of 5-10 years. It is assumed that most of these products, such as TV cabinet and business machine housings must have been disposed of by land filling or incineration (US ATSDR, 2004). The sole U.S. producer depleted their remaining stocks in April 1975 (IARC Monographs, 1972 to present, V. 18, p. 110, quoted in TOXNET entry, http://toxnet.nlm.nih.gov)

272. There are no data on obsolete products and stocks in Zambia.

273. Against this background it can be assumed that there are hardly any products in service containing HBB because they are virtually all disposed of. Other impacts e.g. concerning stocks, waste and disposal or contaminated sites are therefore not expected.

2.4 Other considerations

2.4.1 Access to information and public education

274. As HBB is prohibited within the EU and as a critical level for water has been defined, the need for public education programmes on the impacts of HBB is low in Germany. However, information can be obtained by everybody from the official websites of the Stockholm Convention and Convention on Long-range Transboundary Air Pollution (CLRTAP) Aarhus Protocol (on the control of POPs) as well as from websites and helpdesks of national authorities dealing with chemicals (Annex F responses, 2007, Germany). In the Czech Republic the issue of hexabromobipenyl is part of the SC/UN ECE CRLTAP education and awareness campaign under the national implementation plan. In Zambia access to environmental information is low, though it has increased in the recent past (ECZ 2001, State of the environment, Lusaka, Zambia).

2.4.2 Status of control and monitoring capacity

275. According to IPEN listing HBB in Annex A will involve control measures that are straightforward to communicate and therefore should be effective and suitable, even in countries that have limited chemical regulatory infrastructure. Concerning the waste control measures, it is in practice difficult to identify HBB containing articles and waste but based on the assumption that most products containing HBB have already been disposed of, it can be expected that no further control and monitoring capacity is required.

3. Synthesis of information

276. According to the risk profile on HBB known commercial production (about 5,400 t) has mainly taken place in the USA from 1970 to 1975 by a sole producer Michigan Chemical Cooperation, St. Louis. There is no information on potential HBB production in Russia, developing countries or countries with economies in transition. According to Danish EPA (1999), PBBs may still be in production in Asia.

277. HBB has mainly been used in ABS plastics and coated cables. Based on an expected lifetime of 5-10 years for electrical and electronic products it is expected that all of the products have already been disposed of (US ATSDR, 2004).

278. HBB is already listed in Annex I of the Protocol to the Convention on Long-range Transboundary Air Pollution (CLRTAP) on Persistent Organic Pollutants (Aarhus Protocol), requiring to phase out all production and uses. HBB, together with other PBBs, is also included in the UNEP/FAO Rotterdam Convention on the Prior Informed Consent Procedure (PIC) for Certain Hazardous Chemicals and Pesticides in International Trade. OSPAR lists HBB as chemicals of priority action since 1998.

279. At the European level HBB is listed in Annex I to Regulation (EC) No 850/2004 on persistent organic pollutants with complete prohibition of production and use. In addition Directive 2002/96/EC on Waste from Electric and Electronic Equipment (WEEE) requires that brominated flame retardants have to be removed from any separately collected WEEE prior to further treatment. EC Directive 2002/95/EC on Restrictions on Certain Hazardous Substances in Electric and Electronic Equipment (ROHS) stipulates in article 4 that electric and electronic articles may not contain polybrominated biphenyls from July 2006[11].

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[11] For use in article 5(1) a maximum concentration of 0.1% by weight in homogenous material of PBB shall be tolerated.

280. The issue of hexabromobiphenyl in waste is addressed at the European level in Regulation 850/2004/EC. As amended by regulation 1195/2006/EC HBB in wastes has to be destroyed if concentration limits of 50 mg/kg are exceeded.

281. At the national level legal control actions taken have been reported by Germany, Canada, Australia and the USA.

282. Concerning chemical substitutes and technical alternatives reported data (although not specifically related to HBB but as overall alternatives to brominated flame retardants) show that there are less hazardous alternatives e.g. aluminium trihydroxide. However, it cannot be disregarded that equally or more harmful substances might be among the alternatives compared to the group of brominated flame retardants as such (e.g. halogenated phosphorus and partially non-halogenated phosphorus compounds). Providing guidance on criteria for selecting alternatives to HBB should be part of the risk management strategy for HBB elimination. This would help discourage substitution of HBB with other harmful substances. Criteria should include a non-hazardous synthetic pathway; minimum human and environmental toxicity; minimum release during product use; minimum formation of hazardous substances during incineration or burning; and the ability to be recycled or degrade into a non-hazardous substance[12].

283. As production of HBB has ceased some decades ago, availability of alternatives, efficacy and cost implications do not constitute a problem. Based on the same background significant negative impacts of listing of HBB in Annex A on society are not expected.

284. The Persistent Organic Pollutants Review Committee, has decided, in accordance with paragraph 7 (a) of Article 8 of the Convention, given the fact that HBB is likely, as a result of its long-range environmental transport, to lead to significant adverse human health and environmental effects such that global action is warranted.

285. A beneficial effect could be expected in case of currently unknown production in any part of the world, if management and disposal of potentially remaining stocks (e.g. coated cables, equipment exceeding average life time) would be further regulated and reintroduction of HBB would be prevented on a global scale.

4. Concluding statement

286. Having evaluated the risk profile corresponding to HBB, having assessed and concluded on the rationale for a class approach on all hexabrominated biphenyls as laid down in the annex to this document, 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 and/or the environment, such that global action is warranted. Although HBB is not known to be produced or used anymore, it is important to prevent future production and use of this substance.

287. 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 of HBB in Annex A. As no remaining production or uses of HBB have been identified, listing of HBB in Annex A without any specific exemptions is feasible. Furthermore, the Committee recommends focusing the implementation efforts in identifying and managing articles and wastes containing HBB and setting the proper measures for avoiding that HBB is reintroduced in the future.

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Annex

Additional rationale for the “class approach” for groups of closely-related chemicals for all hexabromo biphenyls (42 congeners)

288. The available information on hexabromobiphenyl includes laboratory studies conducted either with mixtures or specific congeners and monitoring data for different combinations of congeners. In addition to the information summarized in the risk profile on hexabromobiphenyl, the scientific literature offers a significant number of reviews presenting the overall toxicity of this chemical family.

289. It is clear that the current level of information does not cover all hexabromobiphenyl congeners. Nevertheless, the information seems to be consistent with the generic assessment. Therefore, although differences in the properties that define persistent organic pollutant characteristics and their associated risk are expected among the congeners within this family, it is not likely that these differences would be so significant that they should preclude a generic assessment. The Convention already contains lists of closly related chemicals, the polychlorinated biphenyls (PCBs), toxaphene, polychlorinated dibenzo-p-dioxins and dibenzofurans.

290. In the light of the foregoing, the Committee supports the approach for listing hexabromobiphenyl as a group including all the hexabrominated congeners as originally proposed by the European Community and its member States.

291. It should be noted that the drafting group is making the present proposal after reviewing the characteristics of this particular group of chemicals and that it should not be generically extrapolated to other chemical families in which large differences among the properties of closely related homologues, congeners and isomers have been found.

Lindane

UNEP/POPS/POPRC.3/20/Add.4

Executive summary

292. Mexico proposed that Lindane be added to Annex A of the Stockholm Convention on June 29, 2005. The POPs Review Committee evaluated Annex D information at its first meeting and concluded that "the screening criteria have been fulfilled for Lindane". The Review Committee at its second meeting evaluated the risk profile for Lindane in accordance with Annex E, and concluded that "Lindane is likely, as a result of its long range environmental transport, to lead to significant adverse human health and environmental effects such that global action is warranted".

293. International initiatives on Lindane include the Protocol on Persistent Organic Pollutants of the Convention on Long-Range Transboundary Air Pollution; the Rotterdam Convention; and the OSPAR Commission for the Protection of the Marine Environment of the Northeast Atlantic.

294. Lindane is banned for use in 52 countries, restricted or severely restricted in 33 countries, not registered in 10 countries, and registered in 17 countries. Regional actions on Lindane include: The North American Regional Action Plan on Lindane and Other Hexachlorocyclohexane Isomers between Canada, United States and Mexico under the North American Commission for Environmental Cooperation; the Great Lakes Binational Toxics Strategy between the United States and Canada; the European Water Framework Directive 2000/60/EC; the European Union Regulation 850/2004/EC and the European Council Directive 850/2004/EEC, among others.

295. Lindane control measures currently implemented in several countries include: Production, use, sale and imports prohibition, registrations and use cancellations, clean-up of contaminated sites, and public health advisories and hazard warnings issuing for pharmaceutical uses.

296. The assessment of the efficacy and efficiency of control measures is country dependent; however, all countries consider that control measures currently implemented are technically feasible. There are several chemical alternatives for Lindane for seed treatment, livestock, and veterinary uses. Alternatives that are currently in use are considered, in general, technically feasible, efficient, available and accessible by the countries that are already using them. A different scenario exists for pharmaceutical alternatives for Lindane, where alternatives are available, but failures have been reported for scabies and lice treatments producing a big concern in relation to the limited number of available alternative products on the market. Non-chemical alternatives for Lindane agricultural uses have also been reviewed. Some information has been received about the cost of replacing Lindane with alternative pesticides in agricultural applications.

297. Lindane meets several internationally accepted criteria for persistence, bioaccumulation and toxicity. Therefore, the implementation of control measures is expected to reduce the risks from exposure of humans and the environment to Lindane. Implementation of control measures is expected to have positive impacts on biota due to the ease with which Lindane accumulates in wildlife, especially in Arctic wildlife. There are potential risks identified from dietary exposure, particularly to people in Alaska and the circumpolar Arctic who depend on traditional foods such as fish and marine mammals.

298. Several countries that have already prohibited or restricted Lindane use, consider the use of existing stockpiles for a set time period as feasible, leaving a limited amount of waste for disposal. Contaminated sites of former Lindane producers, old storages and dumps have to be addressed by several countries.

299. Canada, the United States, the Czech Republic, the Republic of Zambia and Brazil have mechanisms to monitor and control Lindane. Other countries also have programs to share information concerning Lindane uses, alternatives and regulations.

300. A thorough review of existing control measures that have already been implemented in several countries, shows that risks from exposure of humans and the environment to Lindane can be reduced significantly. Control measures are also expected to support the goal agreed at the 2002 Johannesburg World Summit on Sustainable Development of ensuring that by the year 2020, chemicals are produced and used in ways that minimize significant adverse impacts on the environment and human health.

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

302. In accordance with paragraph 9 of Article 8 of the Convention, the Committee recommends that the Conference of the Parties to the Stockholm Convention considers listing Lindane in Annex A. Given submissions from Parties and

observers, the Conference of the Parties may wish to consider allowing a specific exemption for the production and use of Lindane for control of head lice and scabies as a human health pharmaceutical only. Consideration may also be given to additional reporting and reviewing requirements in collaboration with the World Health Organisation for the specific exemption mentioned above and to the following elements for additional control measures under this specific exemption:

- Limiting the package size;
- Requiring appropriate labelling;
- Use of Lindane as a second-line treatment only;
- Protecting vulnerable groups especially infants;
- Outreach and awareness programmes;
- Promoting alternative products, methods and strategies

303. Further consideration may also be given to control measures regarding the production such as prevention and sound management of generated waste.

1. Introduction

1.1 Chemical identity of the proposed substance

Lindane: gamma-hexachlorocyclohexane
Chemical formula: $C_6H_6Cl_6$
CAS number: 58-89-9
Molecular weight: 290.83
Physical and chemical properties are shown in Table 6.

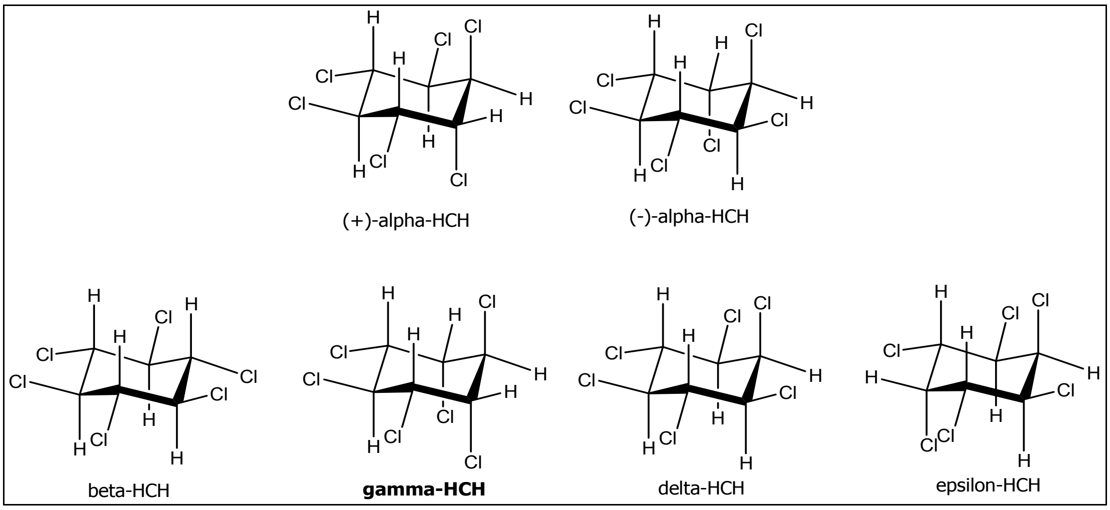
Table 6. Physico-chemical properties of Lindane

Physical state	Crystalline solid
Melting point	112.5 °C
Boiling point at 760 mmHg	323.4 °C
Vapor pressure at 20°C	4.2x10-5 mmHg
Henry's Law constant at 25°C	3.5x10-6 atm m3/mol

Source: ATSDR, 2005

304. Lindane is the common name for the gamma isomer of 1,2,3,4,5,6-hexachlorocyclohexane (HCH). Technical HCH is an isomeric mixture that contains mainly five forms differing only by the chlorine atoms orientation (axial or equatorial positions) around the cyclohexane ring (Figure 1). The five principal isomers are present in the mixture in the following proportions: alpha-hexachlorocyclohexane (53%–70%) in two enantiomeric forms ((+)alpha-HCH and (-)alpha-HCH), beta-hexachlorocyclohexane (3%–14%), gamma-hexachlorocyclohexane (11%–18%), delta-hexachlorocyclohexane (6%–10%) and epsilon-hexachlorocyclohexane (3%–5%). The gamma isomer is the only isomer showing strong insecticidal properties.

Figure 1. Structure of alpha, beta, gamma, delta and epsilon HCH isomers



Source: Modified from Buser et al, 1995.

305. The term “benzene hexachloride (BHC)” is also commonly used for HCH, but according to IUPAC rules this designation is incorrect. Nevertheless the term is used and therefore, gamma-BHC also designates Lindane. In the present risk profile document, Lindane refers to at least 99% pure gamma-HCH and the BHC term is not used.

1.2 Conclusions of the Review Committee

306. Mexico proposed that Lindane be added to Annex A of the Stockholm Convention on June 29, 2005. The Persistent Organic Pollutants (POPs) Review Committee at its first meeting evaluated Annex D information and concluded that “the screening criteria have been fulfilled for Lindane”[13], and decided to establish an ad hoc working group to prepare a risk profile.

307. The POPs Review Committee at its second meeting evaluated the risk profile for Lindane[14] in accordance with Annex E, and concluded that “Lindane is likely, as a result of its long range environmental transport, to lead to significant adverse human health and environmental effects such that global action is warranted”[15].

1.3 Data sources

308. The following Parties and observers have answered the request for information specified in Annex F of the Convention: Brazil, Canada, Czech Republic, Germany, Japan, Mauritius, Mexico, Monaco, Republic of Zambia, Sweden, Switzerland, Thailand, United States of America, CropLife International and the International POPs Elimination Network. A more elaborated summary of the submissions is provided as separate POPRC/INF document.

1.4 Status of the chemical under international conventions

309. Lindane is listed as a “substance scheduled for restrictions on use” in Annex II of the 1998 Protocol on Persistent Organic Pollutants of the Convention on Long-Range Transboundary Air Pollution. This means that products in which at least 99% of the HCH isomer is in the gamma form (i.e. Lindane) are restricted to the following uses: 1. Seed treatment. 2. Soil applications directly followed by incorporation into the topsoil surface layer. 3. Professional remedial and industrial treatment of lumber, timber and logs. 4. Public health and veterinary topical insecticide. 5. Non-aerial application to tree seedlings, small-scale lawn use, and indoor and outdoor use for nursery stock and ornamentals. 6. Indoor industrial and residential applications. All restricted uses of Lindane shall be reassessed under the Protocol no later than two years after the date of entry into force. The Protocol entered into force on October 23th, 2003. There are currently 28 Parties to this Protocol[16].

310. Lindane, as well as the mixture of HCH isomers, is listed in Annex III of the Rotterdam Convention on the Prior Informed Consent Procedure as “chemicals subject to the prior informed consent procedure”. The Rotterdam Convention entered into force 24 February 2004. There are currently 116 Parties to this Convention[17].

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[13] UNEP/POPS/POPRC.1/10

[14] UNEP/POPS/POPRC.2/10

[15] UNEP/POPS/POPRC.2/17

[16] Convention on Long-range Transboundary Air Pollution: http://www.unece.org/env/lrtap/

[17] Rotterdam Convention: http://www.pic.int.

311. Hexachlorocyclohexane isomers, including Lindane, are included in the List of Chemicals for Priority Action (Updated 2005) under the OSPAR Commission for the Protection of the Marine Environment of the Northeast Atlantic. Under this initiative, the Hazardous Substance Strategy sets the objective of preventing pollution of the maritime area by continuously reducing discharges, emissions and losses of hazardous substances, with the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances. The OSPAR Convention entered into force on 25 March 1998[18].

312. HCH (including Lindane) is listed as a Level II substance in the Great Lakes Binational Toxics Strategy between the United States and Canada, which means that one of the two countries has grounds to indicate its persistence in the environment, potential for bioaccumulation and toxicity[19].

1.5 Any national or regional control actions taken

313. Lindane is banned for use in 52 countries, restricted or severely restricted in 33 countries, not registered in 10 countries, and registered in 17 countries (CEC, 2006).

314. The three Parties (Mexico, Canada and the United States) of the North American Commission for Environmental Cooperation (CEC)[20] have recently signed a North American Regional Action Plan (NARAP) on Lindane and Other Hexachlorocyclohexane Isomers, under the Sound Management of Chemicals project. The goal of the NARAP is to reduce the risks associated with exposure of humans and the environment to these substances.

315. Lindane is also listed under the European Water Framework Directive 200/60/EC. This Directive is a piece of water legislation from the European Community. It requires all inland and coastal water bodies to reach at least “good ecological status” and “good chemical status” by 2015. Lindane is one of the listed priority hazardous substances for which quality standards and emission controls will be set at EU level to end all emissions within 20 years.

316. Lindane is listed under the European Union Regulation 850/2004/EC, that specifies Member States may allow until September 2006 professional remedial and industrial treatment of lumber, timber and logs, as well as indoor industrial and residential applications; and until December 31, 2007 the use of technical HCH as an intermediate in chemical manufacturing and the restriction of products containing at least 99% of the HCH gamma isomer for use as public health and veterinary topical insecticide (Annex F information provided by Germany, 2007).

317. HCH is listed in Annexes IB (banned substances) and Annex IV (waste regulation) of European Council Directive 850/2004/EEC. Regulation 850/2004/EC was lately amended by regulation 1195/2006/EC in order to include thresholds for POPs containing waste. Article 7 applies to waste containing >50 mg/kg of the sum of alpha, beta and gamma HCH (Annex F information provided by Germany, 2007).

2. Summary information relevant to the risk management evaluation

2.1 Identification of possible control measures

318. Lindane control measures currently implemented in several countries include: Production, use, sale and imports prohibition, use restrictions, registrations and use cancellations, clean-up of contaminated sites and public health advisories and hazard warnings issued for pharmaceutical uses.

Africa and Europe

319. Lindane is also prohibited for agricultural uses in Mauritius (Annex F information provided by Mauritius, 2007). A presentation on the socio-economic considerations at the third meeting of the POPRC highlighted the registration status and control measures taken in many African countries (UNEP/POPS/POPRC.3/INF/27). In Morocco, Lindane has been used in the past but has been withdrawn from the market in 1995 and is no longer registered in the national classification system. In the Czech Republic Lindane use was banned in 1995, and the site of former producer (Spolana Neratovice) was successfully cleaned-up (Annex F information provided by the Czech Republic, 2007). In Germany, Lindane has not been used in agriculture and forestry since 1989. In the European Union, Lindane can still be used as public health and veterinary topical insecticide until the end of 2007 (Annex F information provided by Germany, 2007). In Sweden, Lindane has not been used for scabies and lice in humans or animals since the 1980s (Annex F information provided by Sweden, 2007).

320. Lindane is severely restricted in Switzerland under the Ordinance on Risk Reduction related to Chemical Products. The only legal use is in medicinal products. Until the coming into force of the Ordinance, the only legal use of Lindane other than medicinal products was in seed dressings for agricultural purposes (Annex F information provided by Switzerland, 2007).

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[18] OSPAR Convention for the Protection of the Marine Environment of the Northeast Atlantic: http://www.ospar.org/

[19] Great Lakes Binational Toxics Strategy: http://www.epa.gov/glnpo/gls/index.html

[20] North American Commission for Environmental Cooperation: www.cec.org/Lindane

North America

321. Production, sale and use of Lindane are prohibited for all pesticide use in Canada. Stocks that existed at the time that pesticide registration was discontinued or suspended were to be sold, used or disposed of in accordance with an established timetable, after which their sale or use became a violation of the Pest Control Products Act (PCPA) (Annex F information provided by Canada, 2007).

322. In 1998 the United States Environmental Protection Agency (USEPA) cancelled the livestock uses of Lindane. In 2006, the United States announced the cancellation of the remaining agricultural uses of Lindane, effective July 1, 2007. However, the United States Food and Drug Administration (USFDA) determined that Lindane products have benefits that outweigh the risks for individual patients when used as directed as second-line treatment of scabies and lice when other treatments fail or cannot be tolerated. In 2003, USFDA issued a public health advisory, a medication guide, a boxed warning, and limited package sizes to reduce risks from the use of Lindane. (Annex F information provided by the United States of America, 2007). Morton Grove Pharmaceuticals is the sole supplier of Lindane pharmaceutical products in the United States. Lindane shampoo and lotions are sold solely for a single application in formulations of 1% concentration. In 2006, 151,600 units of Lindane lotion using 136.4 kg of Lindane and 261,440 units of Lindane shampoo using 136.4 kg of Lindane were produced. Total Lindane used (272.8kg or 600 pounds) represents 0.4% of the 150,000 pounds reported to have been used for seed treatment in the United States in 2006 (Morton Grove Pharmaceuticals, 2007).

South America

323. In Brazil, the use of Lindane as a pesticide was prohibited in 1992. As a wood preservative, a phase-out programme is in progress. Imports and formulation of Lindane were allowed until 2006. Commercialization and use of legal products containing Lindane will be allowed until December 2007.

324. In Uruguay, Lindane has never been produced. It was banned for agriculture and veterinary purposes since the ‘80s. It still has a pharmaceutical registration, even though it has not been the first choice for the last few years. Currently, it is in the process of being banned for all uses. Stockpiles should not pose a major problem because there are only small quantities identified. No specific information is available so far in relation to contaminated sites. Alternatives are being used for scabies and lice.

Asia

325. In Thailand, the use of Lindane-containing products is restricted. Lindane and Lindane-containing products are regulated by the Hazardous Substances Control Act B.E. 2535 (1992). According to the Act, registration and permission of any activities, including production, import, export or possession, are required. Only the use in household and public health programs is permitted under the supervision of the Hazardous Substances Control Group, Food and Drug Administration (Annex F information provided by Thailand, 2007).

326. In January, 1983, the State Council of China banned the production of HCH except for specified usages. Lindane can now only be used in locust control and wheat midge (Sitodi plosis mosellana Gehih) in cases of serious damage, and export. Lindane for wheat midge control is used as a soil treatment. Some of the alternative pesticides are isophenfos-methyl, parathion-methyl, phoxim and chloropyrifos for preventative treatment of wheat midge in soil. However, due to the toxicity of parathion and parathion-methyl, these pesticides were banned for agricultural use after January 1, 2007.

327. Lindane is restricted for use in agriculture in India. However, pharmaceutical uses are registered under the Drug and Cosmetics Act, 1940 that was amended in 2003.

328. Methods for the clean-up of sites contaminated with Lindane include: a) Hazardous waste incinerators and rotary kilns with Gas Phase Chemical Reduction (GPCR), b) Base-catalyzed decomposition, c) Sodium dispersion (alkali metal reduction), d) Subcritical water oxidation, e) Supercritical water oxidation, f) Mechanochemical method and g) GeoMelt. According to technical proofs conducted by the Ministry of Agriculture, Forestry and Fisheries of Japan, all the methods have destruction efficiencies greater than 99.999% (Annex F information provided by Japan, 2007).

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

329. The efficacy and efficiency of implemented control measures is country dependent.

330. The Czech Republic considers clean-up of contaminated sites feasible by application of Base-catalyzed decomposition (BCD) technology. The estimated remediation cost of a former Lindane production site is 100 000 000 € (Annex F information provided by the Czech Republic, 2007).

331. In Mauritius, Lindane is already listed as a prohibited agricultural chemical in the Dangerous Chemicals Control Act 2006. All imports of chemicals are subject to control by the Dangerous Chemicals Control Board (DCCB) under the Dangerous Chemicals Control Act 2004. The law provides that no person shall import, manufacture, use or possess Lindane (Annex F information provided by Mauritius, 2007).

332. The United States cancelled registrations and eliminated all of the remaining agricultural uses of Lindane. In 2002 Lindane was registered as a seed treatment on wheat, barley, corn, sorghum, oats and rye crops. Until 2006, there were no alternatives for use on oats and rye. However, in 2006, Imidacloprid was registered for these two uses, and currently alternatives exist for all six seed treatment uses. The scenario for pharmaceutical uses is quite different in the United States, where at this time it is not technically feasible to withdraw Lindane as a treatment for scabies and lice (Annex F information provided by the United States of America, 2007).

333. Canada has established post-registration monitoring and compliance programs for the agricultural use of Lindane to ensure compliance with federal and provincial legislation. Federal, provincial and territorial hazardous waste programs address small quantities of retired material in the possession of consumers and have collected and safely disposed of pesticide products that are no longer registered (Annex F information provided by Canada, 2007).

334. In Japan, the distribution of Lindane was banned by the Minister of Agriculture, Forestry and Fisheries in 1971. Lindane is listed as a deleterious substance under Poisonous and Deleterious Substances Control Law. Manufacturers, importers and sellers are required to register themselves to handle Lindane. There are also regulations for labelling containers and packages, and for handling and disposal of Lindane (Annex F information provided by Japan, 2007).

335. In Thailand, banning of medical use of Lindane is still in question because the current substitutes for the treatment of head lice and scabies appeared not to be as effective as Lindane. For medical purpose, Lindane is in the National List of Essential Medicines (2004). It is the second-line drug of choice for head lice or scabies treatment (Annex F information provided by Thailand, 2007).

336. Lindane is not used for human pharmaceutical uses in the South African public health care sector as the alternatives are cheaper such as 25% Benzyl Benzoate and reduce risk to vulnerable populations (UNEP/POPS/POPRC.3/INF/27).

337. Though Lindane is permitted for use for locust control in China, it was not used in fact for a long period because it's high risk to environmental and public health. Some alternatives are available, such as the organophosphorous and pyrethroid pesticides. At present, organophosphorous and pyrethroid pesticides, i.e. malathion and cypermethrin, are the dominant pesticides in locust control in China. Additionally, fipronil is applied on a limited basis. Meanwhile, biological environmentally friendly pesticides of low toxicity are being strongly promoted by the Chinese government. These include locust microsporidium, metarrhizium anisopliae and nimbin. However, based on the assessment of relevant authorities, Lindane is still the best pesticide to control Locust in the case of extensive outbreaks.

2.3 Information on alternatives (products and processes)

Description of alternatives

338. Chemical and non-chemical alternatives for the agricultural, veterinary and pharmaceutical uses of Lindane in the United States, Canada and Mexico have been reviewed in the North American Regional Action Plan on Lindane and Other HCH Isomers developed by the North American Commission for Environmental Cooperation (CEC, 2006).

339. In the United States, at least one of the following active ingredients is registered for seed treatment for corn, barley, wheat, oat, rye and sorghum: Clothianidin, Thiamethoxam, Imidacloprid, Permethrin and Tefluthrin. For uses on livestock, Amitraz, Carbaryl, Coumaphos, Cyfluthrin, Cypermethrin, Diazinon, Dichlorvos, Fenvalerate, Lambda-cyhalothrin, Malathion, Methoxychlor, Permethrin, Phosmet, Pyrethrin, Tetrachlorvinfos, and Trichlorfon are registered. Veterinary Drugs include: Eprinomectin, Ivermectin, Doramectin, Moxidectin, and Methoprene. For pharmaceutical uses, approved treatments for head lice include: Pyrethrum/Piperonyl butoxide, Permethrin, and Malathion. Lice nit combs are also recommended for use in conjunction with these treatments. For scabies, Permethrin and Crotamiton (Eurax) are approved treatments (Annex F information provided by the United States of America, 2007).

340. Canadian alternatives for pharmaceutical uses of Lindane include: Permethrin (1% cream), Bioallethrin and piperonyl butoxide, Pyrethrin and piperonyl butoxide, Permethrin (5% cream), Precipitatedisulphur 6% in petrolatum and Crotamiton 10% (Eurax). Canadian registered alternatives for agricultural uses include: for canola: Acetamiprid, Clothianidin, Thiamethoxam and Imidacloprid; for corn: Clothianidin, Imidacloprid (only for field corn grown for seed) and Tefluthrin; and for sorghum: Thiamethoxam and Imidacloprid. Alternatives for livestock treatments include: Carbaryl, Diazinon, Dichlorvos, Malathion, Phosmet, Tetrachlorvinphos, Trichlorfon, Cyfluthrin, Cypermethrin, Fenvalerate, Permethrin, Pyrethrin, Rotenone, Eprinomectin, Evermectin, Abamectin, Doramectin, Moxidectin and Phosmet (CEC, 2006).

341. Alternatives for use on canola cultivation in the Republic of Zambia include: Gaucho, Helix and Primer-Z, and for head lice treatment: Nix (Annex F information provided by the Republic of Zambia, 2007).

342. In Germany, alternatives against Atomaria linearis include: Thiamethoxam, Imidacloprid, Imidacloprid / Tefluthrin, Clothianidin, Clothianidin / Beta-Cyfluthrin, Alpha-Cypermethrin and Deltamethrin; against Elateridae: Clothianidin, Imidacloprid and Thiamethoxam; against leaf-cutting insects: Lambda-Cyhalothrin, Acadirachtin, Pyrethrin / Rapsöl, Beta-Cyfluthrin, Alpha-Cypermethrin, Lambda-Cyhalothrin, Acadirachtin, Pyrethrin / Rapsöl and

Methamidophos. Alternatives for use as a wood protection product include: 3-Iodo-2-propynyl butylcarbamate (IPBC), (E)-1-(2-Chloro-1,3-thiazol-5-ylmethyl)-3-methyl-2-nitro guanidine / Clothianidin, 1-(4-(2-Chloro-alpha,alpha,alpha-p-trifluorotolyloxy)-2-fluorophenyl)-3-(2,6-difluorobenzolyl)urea / Flufenoxuron, Cyclopropanecarboxylic acid, 3-[(1Z)-2-chloro-3,3,3-trifluoro-1-propenyl]-2,2-dimethyl-, (2-methyl[1,1'-biphenyl]-3-ylmethyl ester, (1R,3R)-rel- / Bifenthrin, 3-Phenoxybenzyl-2-(4-ethoxyphenyl)-2-methylpropylether / Etofenprox, m-Phenoxybenzyl 3-(2,2-dichlorovinyl)-2,2-dimethylcyclo propanecarboxylate / Permethrin, alpha.-cyano-3-phenoxybenzyl 3-(2,2-dichlorovinyl)-2,2-dimethylcyclo propanecarboxylate / Cypermethrin, Dazomet, Thiamethoxam and 4-Bromo-2-(4-chlorophenyl)-1-(ethoxymethyl)-5-(trifluoromethyl)-1H-pyrrole-3-carbonitrile / Chlorfenapyr. The alternative used for public health and veterinary topical insecticide is: Infectopedicul solution (Permethrin) (Annex F information provided by Germany, 2007).

343. In Thailand, alternatives for the treatment of head lice and scabies include: Permethrin, Cabaryl, Stemona root extract and benzyl benzoate. The alternatives for use on pets are: Permethrin, Flumethrin and Cypermethrin; and for termite control: Alpha-cypermethrin, Bifenthrin, Cypermethrin and Delta-methrin (Annex F information provided by Thailand, 2007).

344. Though Lindane is permitted for use for locust control in China, it was not used in fact for a long period because it's high risk to environmental and public health. Some alternatives are available, such as the organophosphorous and pyrethroid pesticides. At present, organophosphorous and pyrethroid pesticides, i.e. malathion and cypermethrin, are the dominant pesticides in locust control in China. Additionally, fipronil is applied on a limited basis. Meanwhile, biological environmentally friendly pesticides of low toxicity are being strongly promoted by the Chinese government. These include locust microsporidium, metarrhizium anisopliae and nimbin. However, based on the assessment of relevant authorities, Lindane is still the best pesticide to control Locust in the case of extensive outbreaks.

345. In Sweden, Malation, Permethrin and Disulfiram with bezylbenzoate have been used as alternatives against scabies and lice in humans. In veterinary applications, Flumethrin, Foxim, Fipronil, Ivermectin and Moxidectin have been used (Annex F information provided by Sweden, 2007).

346. Alternatives used in Brazil include: Cypermethrin for termite control in compacted wood, Cypermethrin and 3-iodo-2-propynyl butylcarbamate (IPBC) for control of insects and fungi in dry wood, Cyfluthrin for wood used in construction or furniture fabrication, Deltamethrin for control of termite and drill, Endosulfan for termite control in wood, Fipronil for termite control in manufacture of compacted agglomerated wood, and TBP for fungal control in just-sawed wood (Annex F information provided by Brazil, 2007).

347. Alternatives used in Switzerland for seed treatment are Fipronil and Thiamethoxam (Additional information provided by Switzerland, 2007)

348. Besides the chemical alternatives, there are also non-chemical alternatives to agricultural seed treatment uses of Lindane. Among cultural methods currently known to effectively prevent harm to seeds and crops are: Crop rotation (alfalfa, soybeans and clover), where small grains need to be rotated with a non-host species every year to reduce the severity of infestation and maintain low levels of pests; Site selection and monitoring in order to determine if wireworms are present; Fallowing, starving wireworms by allowing the area to fallow for a few years before planting; Re-seeding with resistant crops such as buckwheat or flax; Timing of seeding and planting, trying to plant in warm, dry conditions, usually later in the season for small grains where larvae are deeper in the soil and giving seedlings a greater chance of survival; Shallow cultivation to starve hatchlings, expose eggs for predation and damage larvae; and Soil packing to impede wireworm travel (CEC, 2006).

349. Biological methods are also considered as non-chemical alternatives to Lindane. Current research at Pacific Agri-Food Research Centre, in Canada is examining the use of Metarhizium anisopliae, an insect fungal pathogen to control wireworm. Additional biological control methods employed in Costa Rica include Trichodama spp, Piper aduncum, Trichogram wasps, and Bacillus thuringiensis (Annex F information provided by IPEN, 2007). Also, Alternatives to lindane for controlling wheat midge involve agroecological practices and integrated pest management techniques that include crop rotation, altering seeding dates to reduce vulnerability, use of farming practices that promote greater crop uniformity, use of resistant wheat varieties, and biological controls such as parasitic wasps (Manitoba, 2006).

350. There are also non-chemical methods for the treatment of head lice and scabies. Some authors argue that the use of these methods exceed the efficacy of pediculicidal treatments. For the treatment of head lice they suggest application of hot air or mechanical removal using a wet combing method. For scabies treatment some authors suggest that essential oils have shown positive effects against mites in vitro and in field studies. Tea tree oil (Melaleuca alternifolia) and a paste made from extracts of neem (Azadirachta indica) and tumeric (Curcuma longa) are considered highly effective. In a clinical trial in Nigeria, bush tea (Lippia multiflora) essential oil showed similarly high cure rates. A randomized control study in Brazil showed a commercially available repellent containing coconut oil and jojoba was highly effective (IPEN, 2007).

Technical feasibility

351. Chemical alternatives for seed and livestock treatments and approved alternatives for pharmaceutical uses in the United States are technically feasible and are currently in use. However there have been reported treatment failures for all the approved pharmaceutical alternatives for treatment of scabies and lice. Some physicians prescribe off-label oral Ivermectin for scabies even when it is not approved by USFDA for treatment for scabies. The manufacturer of oral Ivermectin does not have an approved application for its use in scabies and does not advocate its use in scabies. USFDA is currently reviewing potential new treatments for lice from a number of companies and is exploring mechanisms to encourage pharmaceutical companies to submit candidate treatments for scabies (Annex F information provided by the United States of America, 2007).

352. In Canada, alternative pesticide products are also currently being used. Technical feasibility is a requirement of registration by Canada's Pest Management Regulatory Agency (PMRA) (Annex F information provided by Canada, 2007).

353. In Sweden, alternatives are all technically feasible, available, freely accessible and effective if used as prescribed. There are no reports of major resistance problems (Annex F information provided by Sweden, 2007).

Costs, including environmental and health costs

354. Only the United States has information available regarding costs associated with alternatives. The information provided includes data from 2002 to 2006.

355. In 2006, the usage of Lindane in the United States was less than 150,000 lbs of active ingredient applied annually to about 9.7 million acres. In 2002, Lindane was used in the United States as a seed treatment on wheat, barley, oats, rye, corn, and sorghum. Imidacloprid and Thiamethoxam were the primary seed treatment alternatives to Lindane for barely, corn, sorghum and wheat. Moreover, since 2002, additional alternatives have been registered on corn and sorghum. The alternatives are as effective as Lindane but costlier to use. For wheat and barley, the estimated increase in treatment cost would be $0.36 to $1.71 per acre ($5 million for all US acreage). For corn, the estimated increase in treatment cost would be $1.82 per acre ($8.7 million dollars for all US acreage). For sorghum, the estimated increase in treatment cost would be $3.70 to $4.69 per acre (about $386,000 for all US acreage) (USEPA, 2006).

356. In 2002, there were no registered alternatives for oats and rye. If these two uses had been cancelled at that time, there would have been a major impact on growers of those crops, estimated at a 9% yield loss. The total aggregate increase in treatment costs is $14 million. Total aggregate value of yield loss on oats and rye is $354,000. By 2006, Imidacloprid was registered for use on oats and rye (Annex F information provided by the United States of America, 2007).

357. Regarding health costs associated with pharmaceutical alternatives, scabies can be a serious problem in long-term care facilities, crowded living environments and economically poor conditions in general. Scabies may be complicated by secondary bacterial infections of the lesions, and scabies has been identified as a risk factor for development of post-streptococcal glomerulonephritis. In the United States, children cannot return to school with untreated lice or scabies (Annex F information provided by the United States of America, 2007).

Efficacy, including benefits and limitations of alternatives versus nominated substance and identification of any critical uses for which there is at present no alternative

358. In the United States, resistance has been reported for all of the approved treatments for head lice. For scabies, treatment failures have been reported with all of the approved treatments, and resistance has been reported for Permethrin and oral Ivermectin although the latter is not approved for this indication (Annex F information provided by the United States of America, 2007).

359. In Thailand, current substitutes for the treatment of head lice and scabies appeared not to be as effective as Lindane (Annex F information provided by Thailand, 2007).

Risk, including information on whether the proposed alternative has bee tested/evaluated and any information on potential risks associated with untested alternatives over the life-cycle of the alternative

360. USEPA conducts risk assessments for pesticide products as a routine part of the registration process; therefore, the USEPA has conducted risk assessments for the alternative products and uses of those products (Annex F information provided by the United States of America, 2007).

361. Alternatives have been reviewed in Canada by the PMRA and their efficacy and the environmental and health risks associated with their uses have been considered acceptable (Annex F information provided by Canada, 2007).

Availability

362. Alternatives for the agricultural, livestock and pharmaceutical uses of Lindane in the United States are available and currently in use.

363. The feasibility of using alternatives in the Republic of Zambia remains undetermined. Imidacloprid (Gaucho) is readily available and easily accessible on the local market (Annex F information provided by the Republic of Zambia, 2007).

Accessibility

364. The availability and accessibility of alternatives in Canada is market dependant (Annex F information provided by Canada, 2007).

365. Alternative products in Thailand are on the market. Particularly the alternatives for use on pets or for termite control are widely used (Annex F information provided by Thailand, 2007).

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

Health, including public, environmental and occupational health

366. Considering that Lindane meets several internationally accepted criteria for persistence, bioaccumulation and toxicity, the implementation of control measures is expected to reduce the risks from exposure of humans and the environment to Lindane.

367. Lindane can be found in all environmental compartments and levels in air, water, soil sediment, aquatic and terrestrial organisms and food have been measured worldwide (WHO/ Europe 2003). Lindane can bio-accumulate easily in the food chain due to its high lipid solubility and can bio-concentrate rapidly in microorganisms, invertebrates, fish, birds and mammals. HCH isomers, including Lindane, accumulate in colder climates of the world (CEC, 2006). General population exposure to gamma-HCH can result from food intake particularly from animal origin products like milk and meat, as well as water containing the pesticide (ASTDR, 2005). There is potential dietary exposure particularly to people in Alaska and the circumpolar Arctic who depend on traditional subsistence foods such as fish and marine mammals (USEPA, 2006).

368. At high doses Lindane has been shown to be neurotoxic, hepatotoxic, immunotoxic and to have reproductive effects in laboratory animals. Human acute intoxication data show that Lindane can cause severe neurological effects and chronic data suggest possible haematological effects. Adverse health effects associated with pharmaceutical use of Lindane include seizures, dizziness, headaches, and paresthesia. Seizures and deaths have been reported following Lindane shampoo use with repeat or prolonged application, but also in rare cases following a single application according to directions. (Additional information provided by IPEN, 2007).

369. Although there is some evidence for toxicity of Lindane when used topically as a pharmaceutical, this has been generally associated with inappropriate use. Most of the side effects of Lindane have been associated with chronic inhalation by seed treatment workers (Annex F information provided by Canada, 2007). The carcinogenicity of Lindane is less clear. The International Agency for Research on Cancer (IARC) has classified Lindane as possibly carcinogenic to humans (ATSDR, 2005). USEPA reclassified Lindane in the category "suggestive evidence of carcinogenicity, but not sufficient to assess human carcinogenic potential." The US Center for Disease Control's Agency for Toxic Substances and Registry concurs with USEPA's classification. However, the Joint Meeting on Pesticide Residues (JMPR) of the World Health Organization concluded that "…Lindane is not likely to pose a carcinogenic risk to humans" (CEC, 2006).

370. The implementation of control measures applied to Lindane pharmaceutical uses has a positive impact to the environment since Lindane application as a lice treatment shampoo or topical lotion that must be washed off, end up in waste water (Annex F information provided by the United States of America, 2007). In 2002, the state of California banned the sale of Lindane for lice and scabies treatments in order to reduce the levels in drinking water supplies. In May 2000, the California Toxics Rule (CTR) established a new water quality criterion of 19 parts per trillion (ppt) for Lindane in existing or potential drinking water supplies for protection of public health based on potential cancer risk to humans. As available treatment technologies were unable to remove Lindane to meet the new California state water quality criterion, a preventive strategy to allow compliance was required. A bill was then sponsored in the California assembly, which passed without opposition, to ban the sale of all pharmaceutical Lindane in the state of California beginning in January 2002. Since the ban, Lindane concentrations in waste water have declined to almost non-detectable levels (CEC, 2006).

371. Since the California Lindane ban, four scabies outbreaks were reported by four counties to the California Department of Health Services (CDHS) Surveillance and Statistics Section. Prior to the ban, CDHS issued guidelines to all physicians to use Malathion instead of Lindane to control head lice. For scabies outbreaks CDHS developed and distributed to healthcare facilities a guideline where CDHS recommends the use of Ivermectin to treat patients with severe scabies. Although Ivermectin has not been approved by the FDA for use for scabies and it is not recommended by CDHS for typical scabies or prophylaxis, Ivermectin has been used in outbreaks in California for treatment of symptomatic cases and for mass prophylaxis because of its ease of use and probable greater compliance and efficacy compared to Permethrin (CEC, 2006).

372. On the topic of pharmaceutical uses restriction there is a general concern. In the United States, if Lindane products were not available, approved treatment options for lice and scabies would be very limited. Cases of lice and scabies could remain untreated or harmful home remedies might be used (Annex F information provided by the United States of America, 2007). A similar concern exists in Canada where it is felt that Lindane should be available for use in cases where an alternative therapy is inappropriate (Annex F information provided by Canada, 2007). In the European Union, Lindane can be used as public health and veterinary topical insecticide until end of 2007, and only a limited number of alternative products (based on Permethrin) are currently on the market (Annex F information provided by Germany, 2007). In Thailand, current substitutes for the treatment of head lice and scabies appeared not to be as effective as Lindane (Annex F information provided by Thailand, 2007).

Agriculture, including aquaculture and forestry

373. There are no impacts of implementing possible control measures reported for this sector. However, it is to be noted that information was not received from a number of countries that are known to have used Lindane in the past or are still using it.

Biota (biodiversity)

374. Due to the ease of Lindane to accumulate in wildlife, implementation of control measures is expected to have only positive impacts on biota, especially in Arctic wildlife. Several studies in the Arctic have monitored HCH levels in Steller sea lion, beluga whales, bowhead whales, and polar bears (Annex F information provided by IPEN, 2007).

Economic aspects, including costs and benefits for producers and consumers and the distribution of costs and benefits

375. Information regarding costs of implementing possible control measures and alternatives is provided in this document in sections 2.2 and 2.3 as well as UNEP/POPS/POPRC.3/INF/27.

Social costs (employment, etc.)

376. No information received.

Other impacts

377. No information received.

2.5 Other considerations

Access to information and public education

378. In Sweden, extensive information on treatment regimes for all available drugs against scabies and lice may be found on the Swedish Medical Products Agency website http://www.lakemedelsverket.se or in the list of pharmaceutical products in Sweden http://www.fass.se (Annex F information provided by Sweden, 2007).

379. The USEPA Office of Pesticide Program maintains a website with recent regulatory decisions on Lindane. http://www.epa.gov/oppsrrd1/reregistration/Lindane/. The United States government also maintains an electronic docket (www.regulations.gov). The complete docket is accessible by typing in the docket ID box: EPA-HQ-OPP-2002-0202. USFDA has a website for safety alerts for primary care providers, pharmacists and consumers http://www.fda.gov/medwatch/SAFETY/2003/safety03.htm#lindan (Annex F information provided by the United States of America, 2007).

380. Mexico developed and published in 2004 a National Diagnostic Report on Lindane. The report includes information on production, imports, exports, commercial names, prices, selling patterns, quantities used and possible alternatives. http://www.ine.gob.mx/dgicurg/download/Proyectos-2003/EL_LINDANO_EN_MEXICO.pdf (Annex F information provided by Mexico, 2007).

381. The Czech Republic has an education and awareness POPs campaign (SC/UN ECE CRLTAP) based on the Czech National Implementation Plan (Annex F information provided by the Czech Republic, 2007).

Status of control and monitoring capacity

382. In Canada, control and monitoring capacity of pesticide uses is managed by the Pest Management Regulatory Agency (PMRA) through compliance mechanisms in place at border crossings and entry points to prohibit the import of Lindane to Canada. Compliance issues within Canada may be reported by PMRA through PMRA compliance activities, reporting of suspected infractions and/or results reported from other government agencies (Annex F information provided by Canada, 2007).

383. In the United States, in December 2006 USEPA announced the cancellation of all agricultural pesticide products containing Lindane under the authority of the Federal Insecticide, Fungicide and Rodenticide Act, effective July 1, 2007. USEPA works with its federal, state and tribal regulatory partners to assure compliance with pesticide laws and

regulations in order to protect human health and the environment (Annex F information provided by the United States of America, 2007).

384. Control and monitoring institutions in the Czech Republic include: RECETOX MU for monitoring in ambient air, surface waters, sediments, soils, mosses and needles, Water Research Institute for monitoring of surface and ground waters and sediments, Central Institute for Supervising and Testing in Agriculture (CISTA), Research Institute of Amelioration and Soil Conservation (RIASC), State Veterinary Inspection and Czech Food Inspection for food control, and National Institutes of Public Health for human exposure and dietary studies (Annex F information provided by the Czech Republic, 2007).

385. The control and monitoring capacity of the Republic of Zambia is addressed through the Environmental Protection and Pollution Control Act which is enforced by the Environmental Council of Zambia (Annex F information provided by the Republic of Zambia, 2007).

386. The Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA) controls the stockpiles, the adequate destination of obsolete products and the illegal entrance of products (Annex F information provided by Brazil, 2007).

Waste and disposal implications

387. Current production of Lindane seems to be declining with only a few producing countries remaining, but former production and the inefficient production process over the years, have left an enormous amount of waste products.

388. For the United States it would be technically feasible to use agricultural and pharmaceutical existing stocks for a set time period. USEPA will allow the use of Lindane products in agriculture until October 1, 2009. Therefore it is expected that there will be minimal costs associated with disposal of unusable stocks (Annex F information provided by the United States of America, 2007).

389. In Switzerland, about 3000 contaminated sites would require remediation. Specially two sites, Bonfol (Canton Jura) and Kölliken (Canton Aargau) which served as chemical waste disposal sites contain around 114 000 and 350 000 tons respectively of special waste, probably containing POPs chemicals. The exact amount of POPs chemicals in these disposal sites is still unknown. The current estimate is that the now initiated full remediation (including on-site incineration in a high tech oven) will require about CHF 200 and 500 million for Bonfol and Kölliken, respectively (Annex F information provided by Switzerland, 2007).

390. In the Czech Republic, waste problems represent old contaminated sites of former producer Spolana Neratovice, old storages, unknown illegal stores and dumps. Spolana Neratovice is now successfully cleaned-up using the BCD technology. Plans for future remediation of other contaminated sites are under development (Annex F information provided by Czech Republic, 2007). Lindane was also produced in Romania (Vijgen, 2006)

391. In Canada there is no commercial reason to maintain stockpiles given that any stocks that existed at the time that pesticide registration was discontinued or suspended were to be sold, used or disposed of in accordance with an established timetable. Federal, provincial and territorial hazardous waste programs address small quantities of retired material in the possession of consumers and have collected and safely disposed of pesticide products that are no longer registered (Annex F information provided by Canada, 2007).

392. For Morocco, even though Lindane has been banned for use, there remain large stockpiles that have possible environmental impacts.

393. Disposal methods for Lindane as well as costs of disposal and management of HCH isomer wastes in different countries have been reviewed in the report: The legacy of Lindane HCH Isomer Production (Vijgen, 2006). The document describes chemical methods for the conversion of HCH isomers to trichlorobenzene, trichlorophenoxyacetic acid, HCl, hexachlorobenzene, sodium pentachlorophenolate and trichlorophenol. The report also includes the description of studies that have monitored biodegradation of HCH isomers and situations where landfills have been used for disposal of soil contaminated with HCH isomers (IPEN, 2007).

3. Synthesis of information

394. Published risk assessment reports on Lindane indicate that Lindane is persistent, bioaccumulative and toxic. Lindane has been found in environmental samples all over the world as well as in human blood, human breast milk and human adipose tissue in different studied populations, especially in Arctic communities that depend on subsistence foods2.

395. At high doses Lindane has been shown to be neurotoxic, hepatotoxic, immunotoxic and to have reproductive effects in laboratory animals. Human acute intoxication data show that Lindane can cause severe neurological effects, and chronic data suggest possible haematological effects. The International Agency for Research on Cancer (IARC) has classified Lindane as possibly carcinogenic to humans (ATSDR, 2005).

396. Implementation of control measures is expected to reduce the risks from exposure of humans and the environment to Lindane, especially in the Arctic where Lindane accumulates easily in the wildlife, and where communities depend on subsistence foods.

397. Lindane control measures that have shown to be technically feasible, efficient and accessible include: Production, use, sale and imports prohibition, use restrictions, registrations and use cancellations and clean-up of contaminated sites. Therefore, they may be appropriate for consideration as potential control measures to be implemented by countries. When Lindane registrations are cancelled, allowing the use of stocks for a reasonable time period is a recommended strategy in order to reduce the amount of waste generated and the costs associated with disposal.

398. Lindane chemical alternatives that have been reviewed in the present document for agricultural, livestock and veterinary uses are considered efficient, technically feasible and accessible. However, some countries have expressed their worries about the availability and efficacy of alternatives for certain pharmaceutical and agricultural uses. For these particular cases, it has been proposed to give incentives to find more environmental and health friendly alternatives. For pharmaceutical uses, consideration should be given to establishing a date for phase out of these uses when listing the chemical. Issuing public health advisories would also be recommended to control Lindane use patterns and reduce risks associated.

4. Concluding statement

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

400. A thorough review of existing control measures that have already been implemented in several countries, shows that risks from exposure of humans and the environment to Lindane can be reduced significantly. Control measures are also expected to support the goal agreed at the 2002 Johannesburg World Summit on Sustainable Development of ensuring that by the year 2020, chemicals are produced and used in ways that minimize significant adverse impacts on the environment and human health.

401. In accordance with paragraph 9 of Article 8 of the Convention, the Committee recommends that the Conference of the Parties to the Stockholm Convention considers listing Lindane in Annex A.

402. Given submissions from Parties and observers, the Conference of the Parties may wish to consider allowing a specific exemption for the production and use of Lindane for control of head lice and scabies as a human health pharmaceutical only. Consideration may also be given to additional reporting and reviewing requirements in collaboration with the World Health Organisation for the specific exemption mentioned above and to the following elements for additional control measures under this specific exemption:

- Limiting the package size;
- Requiring appropriate labelling;
- Use of Lindane as a second-line treatment only;
- Protecting vulnerable groups especially infants;
- Outreach and awareness programmes;
- Promoting alternative products, methods and strategies
- Further consideration may also be given to control measures regarding the production of Lindane such as prevention and sound management of generated waste.

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Perfluorooctane sulfonate
UNEP/POPS/POPRC.3/20/Add.5

Executive summary

403. PFOS and 96 PFOS-related substances were proposed as a POPs candidate by Sweden in 2005. The 2nd meeting of the POPs Review Committee decided that PFOS is likely, as a result of its long-range environmental transport, to lead to significant adverse human health and environmental effects, such that global action is warranted.

404. PFOS is both an intentionally produced substance and an unintended degradation product of related anthropogenic chemicals. Under the Convention, the most adequate control measures include listing in Annex A or B. To allow for certain critical uses of PFOS and PFOS-related substances, which may ultimately degrade to PFOS, an acceptable purpose/specific exemption for use of PFOS and certain PFOS-related chemicals and production of PFOS and certain PFOS-related chemicals as an intermediate, only as required to produce other chemical substances designated for these critical uses, could be given together with a detailed description of the conditions for these uses in a new Part III to Annex A or B. Stockpiles and waste containing PFOS or PFOS-related substances would be subject to the provisions in Article 6.

1. Introduction

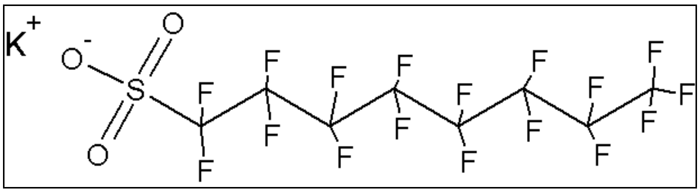
1.1 Chemical identity of the proposed substance

405. On July 14, 2005, the government of Sweden made a proposal for listing perfluorooctane sulfonate (PFOS) and 96 PFOS-related substances in Annex A of the Stockholm Convention on Persistent Organic Pollutants (POPs).

1.1.1 PFOS

Chemical name: Perfluorooctane Sulfonate (PFOS)
Molecular formula: C8F17SO3-
PFOS, as an anion, does not have a specific CAS number. The parent sulfonic acid has a recognised CAS number (CAS No. 1763-23-1). Some examples of its commercially important salts are listed below:
Potassium salt (CAS No. 2795-39-3)
Diethanolamine salt (CAS No. 70225-14-8)
Ammonium salt (CAS No. 29081-56-9)
Lithium salt (CAS No. 29457-72-5)
Perfluorooctane sulfonic acid may be produced commercially from perfluorooctane sulfonyl fluoride (PFOSF) by alkaline hydrolysis. It can also be formed from PFOSF in water at room temperature, although at rates too slow for industrial purposes (Lehmler, 2005). PFOSF was one of the PFOS-related substances include in the proposal by Sweden.

Figure 2. Structural formula of PFOS shown as its potassium salt



1.1.2 Issues regarding PFOS-related substances

406. PFOS is a fully fluorinated anion, which is commonly used as a salt or incorporated into larger polymers. PFOS and its closely related compounds, which may contain PFOS impurities or substances which can give rise to PFOS, are members of the large family of perfluoroalkyl sulfonate substances. In its regulatory measures on PFOS, the European Union (EU) has addressed all molecules having the following molecular formula: $C_8F_{17}SO_2X$ (X= OH, Metal salt (O-M^+), halide, amide and other derivatives including polymers) (European Union, 2006).

407. PFOS can be formed (by environmental microbial degradation or by metabolism in larger organisms) from PFOS-related substances, i.e., molecules containing the PFOS-moiety. Although the ultimate net contribution of individual PFOS-related substances to the environmental loadings of PFOS cannot be predicted readily, there is a potential that any molecule containing the PFOS moiety could be a precursor to PFOS. This is further supported by modelling the fate of perfluorinated chemicals (PFCs) in the environment (Dimitrov et al. 2004).

408. The majority of PFOS-related substances are polymers of high molecular weights in which PFOS is only a fraction of the polymer and final product (OECD, 2002). PFOS-related substances have been defined somewhat differently in different contexts and there are currently a number of lists of PFOS-related substances containing varying numbers of PFOS-related substances that are thought to have the potential to break down to PFOS.

409. The Organisation for Economic Co-operation and Development (OECD), within the framework of the Inter-Organisation Programme for the Sound Management of Chemicals (IOMC) has published “Risk Management Series No.21: Preliminary lists of PFOS, PFAS, PFOA and related compounds, and chemicals that may degrade to PFCA (ENV/JM/MONO(2006)15)”. Annexes I and II contain Lists of Perfluorooctane Sulfonate (PFOS) and Related Compounds and Perfluoroalkyl Sulfonate (PFAS) and Related Compounds. These lists are currently being updated and the updated lists are due to be published shortly.

410. DEFRA in the United Kingdom (RPA and BRE, 2004) has recently proposed a list of 96 PFOS-related substances. However, the properties of the 96 substances have not generally been determined. According to 3M (submission to the secretariat of Stockholm Convention (SC), 2006), they may have very different environmental characteristics such as solubility, stability and ability to be absorbed or metabolised. Nevertheless, the document by the United Kingdom infers that all of these substances would give rise to PFOS as their final degradation product (RPA and BRE, 2004).

411. Environment Canada’s ecological risk assessment defines PFOS precursors as substances containing the perfluorooctylsulfonyl ($C_8F_{17}SO_2$, $C_8F_{17}SO_3$, or $C_8F_{17}SO_2N$) moiety that have the potential to transform or degrade to PFOS (Canada, 2007). The term “precursor” applies to, but is not limited to, some 51 substances identified in the ecological assessment. However, this list is not considered exhaustive, as there may be other perfluorinated alkyl compounds that are also PFOS precursors. This information was compiled based on a survey to Canadian industry, expert judgement and CATABOL modelling, in which 256 perfluorinated alkyl compounds were examined to determine whether non-fluorinated components of each substance were expected to degrade chemically and/or biochemically and whether the final perfluorinated degradation product was predicted to be PFOS. While the assessment did not consider the additive effects of PFOS and its precursors, it is recognized that the precursors to PFOS contribute to the ultimate environmental loading of PFOS. Precursors may also play a key role in the long-range transport and subsequent degradation to PFOS in remote areas, such as the Canadian Arctic.

412. A preliminary substance flow analysis for Switzerland in 2005 based on the international literature estimated remaining PFOS-related substances in products after the retreat of 3M products to be approximately 230 kilogram /a. (Switzerland, 2007)

413. The historical use of PFOS-related substances in the following applications has been confirmed in the US, Canada and the EU.

- Fire fighting foams
- Carpets
- Leather/apparel
- Textiles/upholstery
- Paper and packaging
- Coatings and coating additives
- Industrial and household cleaning products
- Pesticides and insecticides

414. It is presently unclear whether these uses of PFOS-related substances still occur in some parts of the world. Besides these uses, China also uses PFOS in the petroleum industry and for nano-material processing.

1.2 Conclusions of the Review Committee Annex E information

415. The POPs Review Committee has developed and adopted the risk profile for perfluorooctane sulfonate contained in document UNEP/POPS/POPRC/17/Add.5, in accordance with Annex E of the Convention. The Committee concluded, in accordance with paragraph 7 (a) of Article 8 of the Convention, that perfluorooctane sulfonate is likely, as a result of its long-range environmental transport, to lead to significant adverse human health and environmental effects such that global action is warranted (Decision POPRC-2/5). The Committee also concluded (item 3 of the Decision) that issues related to the inclusion of potential perfluorooctane sulfonate precursors should be dealt with in developing the draft risk management evaluation for perfluorooctane sulfonate.

1.3 Data sources

416. Data relating to Annex F were submitted by the following Parties: Algeria; Armenia; Australia; Brazil; Canada; Czech Republic; European Commission; Former Yugoslav Republic of Macedonia; Germany; Japan; Mauritius;

Monaco; Switzerland, and the following observers: European Photo and Imaging Association; European Electronic Component Manufacturers Association; International Imaging Industry Association; European Semiconductor Industry Association (EECA-ESIA); International Indian Treaty Council (IITC)- Indigenous Environmental Network (IEN); International POPs Elimination Network (IPEN); Japan Electronics and Information Technology Industries Association –Japan Semiconductor Industry Association (JEITA-JSIA); Photo Sensitized Materials Manufacturers' Association; Semiconductor Industry Association (SIA); Semiconductor Equipment and Materials International (SEMI) and United States of America

1.4 Status of the chemical under international conventions

417. PFOS is undergoing risk management evaluation under the UNECE Convention on Long-Range Trans-Boundary Air Pollution (LRTAP) Protocol on POPs. The POPs Task Force met in Vienna in June 2007 to explore possible risk management options for PFOS. The evaluation produced by the Task Force will be submitted to the Working Group on Strategies and Review in September 2007 and the Executive Body in December 2007 for further consideration.

1.5 Any national or regional control actions taken

418. Australia has produced three Alerts concerning PFOS through its National Industrial Chemicals Notification and Assessment Scheme (NICNAS). PFOS- based chemicals are not currently manufactured in Australia; however products containing these chemicals have been made and are used in Australia.

419. The first Alert indicated the phasing-out of water, oil, soil and grease repellent products containing PFOS by September 2002. As well, the use of PFOS for leather products was to be phased out by March 2003. Stocks of PFOS fire fighting foams are being held at some sites in Australia. These will be replaced as they run past the expiry date or when stocks run out. NICNAS is looking at developing a strategy to phase out use of PFOS in Australia.

420. The second Alert makes recommendations regarding PFOS, perfluorosulfonates (PFAS) and perfluorooctanic acid (PFOA). These recommendations include:

- that PFOS (and PFAS-based chemicals) be used only for essential uses for which there is no suitable alternative, such as certain class B fire fighting foams, but not for use in fire training exercises; and
- that caution be used in selecting PFOA as an alternative for PFOS since PFOA may show the same environmental and health concerns as PFOS.
- The third Alert published in February 2007 updates the uses of PFOS and related substances in Australia. The recommendations in this Alert include:
- PFOS (and PFAS-based chemicals) be used only for essential uses for which there is no suitable alternative.
- The existing PFOS-based fire fighting foam not be used for fire training purposes to limit environmental release.
- PFOS not be replaced by PFOA as an alternative, as PFOA may have the same environmental and health concerns as PFOS.

421. Canada has proposed regulations to prohibit the production and use of PFOS and its salts and substances that contain on of the following groups: C8F17SO2, C8F17SO3 or C8F17SO2N (Canada Gazette, vol. 140, No 50, December 16, 2006).

422. The proposed regulations for PFOS would:

- prohibit the manufacture, use, sale, offer for sale and import of PFOS or products containing these substances;
- exempt the use of PFOS-based aqueous film-forming foam, sometimes also referred to as aqueous fire fighting foam (AFFF), manufactured or imported before the coming into force of the proposed Regulations for a period of five years after the coming into force of the proposed Regulations (but this AFFF may not be used for training or testing purposes);
- exempt the use of PFOS-based fume suppressants, and sale, offer for sale and import for that use, for a period of five years after the coming into force of the Regulations for chromium electroplating, chromium anodizing, reverse etching, electrolysis nickel-polytetrafluoroethylene plating and etching of plastic substrates prior to their metallization;
- exempt the use, sale, offer for sale and import of the following manufactured items: semiconductor or similar components of electronic or other miniaturized devices and photographic films, papers and printing plates;
- exempt the use, sale and offer for sale of manufactured items, that were manufactured or imported before the coming into force of the proposed Regulations; and

- provide standard exemptions for laboratories, scientific research and laboratory analytical standards.

423. Importers of PFOS-based fume suppressants will be required to submit annual reports detailing types, quantities, sales and end uses for the substances that are imported.

424. The European Union has adopted Directive 2006/122/EC of the European Parliament and the Council Directive 76/769/EEC of the Council of 12 December 2006 on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use and preparations of perfluorooctane sulfonates and related substances. The restrictions include the following:

- PFOS and related substances will be banned as substances or constituents of preparations in concentrations equal to or higher than 0.005%, in semi-finished products and articles at a level of 0.1% except for textiles or coated materials in which the restricted amount of PFOS will be 1 µg/m2.
- Exemptions were provided for the following PFOS uses, as well as for the substances and preparations needed to produce them: photoresists or anti-reflective coatings for photolithography processes, industrial photographic coating, mist suppressants for chromium plating and other electroplating applications, as well as aviation hydraulic fluids; in addition, stocks of PFOS-based AFFF supplied on or before the date 12 months before the legislation comes into force may be used for a period of 54 months.

425. The United States Environmental Protection Agency (US EPA) has adopted federal Significant New Use Rules (SNURs) for 88 PFOS substances which apply to new manufacture and new uses of these substances. Further, a final SNUR for 183 additional perfluoroalkyl sulfonate substances was issued in October 2007 (72 FR 57222, October 9, 2007).The SNURs require manufacturers and importers to notify the US EPA at least 90 days before manufacture or import of these substances for any use other than certain narrow, ongoing uses. This provides the US EPA with the necessary time to evaluate the intended new use and prohibit or limit the new activity, if necessary. While the SNURs do not require current manufacturers to stop manufacturing or selling the substances, the primary manufacturer in the United States voluntarily discontinued production between 2000 and 2002. Therefore, once the SNURs pertaining to the substances became effective, they essentially restricted all manufacture and importation of PFOS other than manufacture and importation other than for certain specific uses, excluded from the SNURs. Those uses include:

- Use as an anti-erosion additive in fire-resistant phosphate ester aviation hydraulic fluids.
- Use as a component of a photoresist substance, including a photo acid generator or surfactant, or as a component of an anti- reflective coating, used in a photomicrolithography process to produce semiconductors or similar components of electronic or other miniaturized devices.
- Use in coating for surface tension, static discharge, and adhesion control for analog and digital imaging films, papers, and printing plates, or as a surfactant in mixtures used to process imaging films.
- Use of: 1-Pentanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,5-undecafluoro-, potassium salt (CAS No. 3872-25-1); Glycine, N-ethyl-N-[(tridecafluorohexyl)sulfonyl]-, potassium salt (CAS No. 67584-53-6); Glycine, N-ethyl-N-[(pentadecafluoroheptyl)sulfonyl]-, potassium salt (CAS No. 67584-62-7); 1-Heptanesulfonic acid,1,1,2,2,3,3,4,4,5,5,6,6,7,7,7-pentadecafluoro-, ammonium salt (CAS No. 68259-07-4); 1-Heptanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,7-pentadecafluoro- (CAS No. 68957-62-0); Poly(oxy-1,2-ethanediyl), .alpha.-[2-[ethyl[(pentadecafluoroheptyl)sulfonyl]amino]ethyl]-.omega.-methoxy- (CAS No. 68958-60-1); or 1-Hexanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,6-tridecafluoro-, compd. with 2,2'-iminobis[ethanol] (1:1) (CAS No. 70225-16-0) as a component of an etchant, including a surfactant or fume suppressant, used in the plating process to produce electronic devices.
- Use of tetraethylammonium perfluorooctanesulfonate (CAS No. 56773-42-3) as a fume/mist suppressant in metal finishing and plating baths. Examples of such metal finishing and plating baths include: Hard chrome plating; decorative chromium plating; chromic acid anodizing; nickel, cadmium, or lead plating; metal plating on plastics; and alkaline zinc plating.
- Use as an intermediate only to produce other chemical substances to be used solely for the uses listed in the first 3 bullets above.

426. The US EPA also negotiated a phase-out of PFOS-related pesticide products containing sulfluramid, a substance that is manufactured using a PFOS derivative and will degrade to PFOS, or the lithium salt of PFOS (LPOS), concurrently with the 2002 publication of the final SNUR on 88 PFOS substances. Sulfluramid and LPOS were formulated in bait stations for use in the control of ants, cockroaches, termites, wasps, and hornets, and in one granular broadcast bait for use in the control of leaf cutter ants in pine reforestation areas. The registrants associated with those products agreed to voluntarily cancel some of their products and to phase out the remaining products under an agreed-upon timeline. The continuing products being phased out were produced using stocks of sulfluramid produced before the completion of the PFOS production phase-out in the US in 2002.

2. Summary information relevant to the risk management evaluation

2.1 Identification of possible control measures

427. The objective of the Stockholm Convention (Article 1) is to protect human health and the environment from persistent organic pollutants. When assessing control measures under the Convention, consideration should be given to the potential for all PFOS-related substances to degrade to PFOS and thus contribute to the total environmental load. When assessing whether specific exemptions would be appropriate, among other considerations identified in Annex F to the Convention, factors such as exposure; production volume; and societal costs and the ubiquitous contamination of humans, the environment and possible impact on future generations should be considered.

428. Under the convention this may be achieved in different ways.

- PFOS and/or PFOS-related substances may be listed in Annex A, with or without specific exemptions, or accompanied with a new Part III that details actions for each or groups of PFOS-related substances or uses of such substances; or
- PFOS and/or PFOS-related substances may be listed in Annex B, with acceptable purposes/specific exemptions or a Part III of Annex B that details actions for each or groups of PFOS-related substances or uses of such substances; or
- PFOS may be listed in Annex C as an unintentional POP to capture all PFOS-related substances that may give rise to PFOS when released into the environment; or
- PFOS may be listed in Annex A or B, as described above, and at the same time also be listed in Annex C.

429. In the Annex F process, some certain uses have been identified by Parties and observers. They may be grouped into three subgroups.

A. Based on the information submitted to the Secretariat, technically feasible alternatives may not be available for certain uses. These uses are: photo imaging, photo mask; semi-conductor; aviation hydraulic fluids; radio-opaque catheters, such as catheters for angiography and indwelling needle catheters; and manufacture of ant baits for leaf-cutting ants.

B. Based on the information submitted to the Secretariat, the uses for which alternative substances or technologies are or may be available but would need to be phased in. These uses are: metal plating; electric and electronic parts; and fire fighting foam.

C. Based on the information submitted to the Secretariat, uses for which there are alternatives in developed countries include: fire fighting foams, carpets, leather/apparel, textiles/upholstery, paper and packaging, coatings and coating additives, industrial and household cleaning products, and pesticides and insecticides.

430. It should be noted that due to the complexity of the use and the many sectors of society involved in the use of PFOS and PFOS-related substances, several countries, developed and developing, have declared that there might be other uses of PFOS and PFOS-related substances that they are not presently aware of. Other uses than those listed below may therefore in the future need to be added to the different categories.

431. These uses and the potential substitutes will be further described in section 2.3 below.

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

432. The phase-out and regulation in the US successfully reduced the volume of these chemicals produced and/or used in the U.S. from approximately 2,900 tonnes in 2000 to less than 8 tonnes in 2006.

433. Canada has provided a national cost-benefit analysis for the proposed Canadian regulation of PFOS and PFOS-related substances. The key assumptions used in the cost-benefit analysis included:

- Time frame: The proposed control measures could come into force in 2009, with the exemption for AFFF and the metal plating sector expiring 5 years later in 2014;
- Time span for analysis: A time frame of 25 years is selected to account for the life span of PFOS containing AFFF as well as the service life of metal plating equipment. Thus, the analysis time frame is 2008 to 2032;
- Cost and benefit perspective: costs and benefits which directly or indirectly affect human health and the environment are included in the analysis to the extent possible;
- Discount rate: A discount rate of 5.5%, and all monetized costs and benefits are expressed in 2006 € or US$.

434. For Canada the net benefits of the proposed regulations were estimated at US$337 000. It should be noted that this does not include benefits to the ecosystem as these could not be quantified due to data limitations and uncertainties (Canada, 2006). It should be noted that the analyses done by Canada may not be relevant to the situation in other countries, in particular developing countries and countries with economies in transition, however there is no available

information on this point. It has been suggested by China that use in the petroleum industry and for nano-material processing might also fall into these categories.

2.3 Information on alternatives (products and processes), where relevant

435. The POPRC has agreed that PFOS is likely a POP due to its long-range environmental transport and significant adverse human health and environmental effects such that global action is warranted. The target or aim of any risk reduction strategy for PFOS should be to reduce or eliminate emissions and releases taking into consideration the indicative list in Annex F including technical feasibility of possible control measures and alternatives, the risk and benefits of the substances and their continued production and use. In considering any strategy for a reduction in such risks, it is important to consider the availability of substitutes in the sectors of concern. In this regard, the replacement of a PFOS-related substance by another chemical or an alternative system needs to take account factors such as:

- Technical feasibility
- Costs, including environmental and health costs
- Efficacy
- Risk
- Availability and accessibility

436. A discussion of the availability and suitability of substitutes for the 'continuing uses' of PFOS-related substances is provided below. The discussion focuses on continuing uses; in the absence of information to the contrary, substitution is considered to already have taken place in the other sectors.

437. A significant proportion of previous users of PFOS-related substances have moved to other fluorochemical products (telomers and related products). These telomers are not related to PFOS but under certain circumstances may degrade to perfluorooctanoic acid (PFOA) or related perfluorinated carboxylic acids. It is important to note that, while there is little information currently available to assess the environmental and health impacts of telomers, extensive work is currently on-going in the U.S. and other countries where there is some concern over the fate and behaviour of these substances. Until these studies are concluded, it will not be possible to draw any firm conclusions concerning the environmental/human health advantages of telomers and related products over the PFOS-related substances for which they have been substituted.

438. The manufacture of PFOS has been phased out in several countries, including the U.S., as indicated in Section 1.5 above. There is no manufacture of PFOS in Canada or Australia. Manufacture of PFOS and PFOS-related substances occurs in certain countries as noted in the survey conducted by the Organization for Economic Cooperation and Development in 2006 (OECD, 2006).

A. Uses for which at present, according to responses received, no technically feasible alternatives are available

439. In addition to the below, China noted that there is continuing use of PFOS-related substances in the petroleum industry and in nano-material processing for which at present they do not have alternatives available.

Photo imaging

440. According to the photographic industry, chemicals or classes of chemicals that may be considered alternatives to PFOS or PFOS-related substances on an industry-wide basis (or even a company-wide basis) are reported as not currently being available. Successful alternatives to PFOS materials have included non-perfluorinated chemicals such as hydrocarbon surfactants, chemicals with short perfluorinated chains (C3 - C4), silicones, telomers. In very few cases, it has been possible to reformulate coatings so that they are inherently less sensitive to static build-up.

441. According to the industry, the imaging products/applications where there are currently no identified alternatives to PFOS-related substances and which represent critical uses are as follows:

- Surfactants for mixtures used in coatings applied to films, papers, and printing plates; PFOS chemicals are critical for creating coatings of high complexity in a highly consistent manner, thus avoiding the creation of large amounts of waste due to irregularities in coating thickness;
- Electrostatic charge control agents for mixtures used in coatings applied to films, papers, and printing plates. The antistatic properties of PFOS materials also provide important safety features by controlling the build-up and discharge of static electricity, thus preventing injuries to employees and users, damage to operating equipment and products, and fire and explosion hazards;
- Friction control and dirt repellent agents for mixtures used in coatings applied to films, papers, and printing plates; and

- Adhesion control agents for mixtures used in coatings. Adhesion control is a property imparted to film coatings as a result of the use of PFOS materials as coating aids.

442. Estimates of releases from the photo imaging industry, as developed by UK DEFRA, are 1.02 kilogram into waste water and 0.051 kilogram into air from manufacturing uses in the EU. The industry estimates a total of less than 2 kilogram worldwide, by extrapolation.

443. Most consumer and professional imaging papers do not contain PFOS-related substances. For papers that do contain the substances, the coatings contain concentrations in the range of 0.1-0.8 µg/cm2. Most of this material will not be on the surface of the coating as the PFOS-related substance is contained within a matrix and is bound to coating matrices.

444. The cost, so far, for replacement of PFOS materials is estimated to be in the range of € 20-40 M for the full range of imaging products. These costs are based on the estimated cost of achieving the current reduction of 83% in the use of PFOS-related substances. The cost to be incurred from further work on replacements (for the remaining 17%) is expected to be significantly higher than the above figure as the replacement work is increasingly more difficult.

445. Based on the previous cost estimates of US$20-40 M for reduction that took place between 2000 and 2004, i.e., a reduction of roughly 15 tonnes, the average cost is US$2 M per tonne. Further reductions are estimated to cost more than twice as much, up to US$5 M per tonne. The cost of substituting the remaining 10 tonnes would be US$50 M. Since only 2 kilogram is estimated to be released into the environment the cost of reducing the release to zero, using these estimates would be US$25 M per kilogram. This calculation indicates the level of magnitude of the costs of reducing the release.

Photoresist and Semi-conductor

446. According to the semi-conductor industry, the operation of PFOS based photo acid generators (PAGs) is critical to the semiconductor industry in the photolithography process. ESIA, JSIA, SIA and SEMI indicate that there are currently no substitutes known that give the same level of critical functionality to cause effective, efficient transformation in leading edge photoresists and which can be used in volume manufacturing.

447. For anti-reflective coatings used in combination with photoresists, ESIA indicates that there is also no alternative available that fulfils the specific technical requirements necessary (ESIA, 2003). The industry is also evaluating one additional specialized application for which PFOS use may have no current substitute -- use in liquid etchant in the photo mask rendering process.

448. The semiconductor industry indicates that the industry and its suppliers continue to search for alternatives for these critical uses. The nature of semiconductor production is such that if alternatives to PFOS are eventually identified at the fundamental research stage, critical adjustment to the chemistry of inputs such as PFOS use in the photolithography process will trigger far-reaching adjustments throughout the manufacturing process and supply chain to ensure that the chemical processes throughout the production process remain aligned. Thus, the semiconductor industry believes it could take an additional ten years to design, operationalize and integrate the new technology, once it has been identified, into the semiconductor manufacturing process. According to the industry, the delay is a necessary function of the semiconductor technology development cycle: technological innovations generally require 10 years of further development before they can be reflected in high volume manufacturing (ESIA, JSIA, SIA, SEMI 2007).

449. It should also be noted that during the chemical formulation of photolithography products, worker exposure potential is very low because the process occurs under highly automated, largely closed system conditions. The same process for electronics fabrication is similarly automated, with a low volume of PFOS used, and use of protective equipment. Chemical isolation is also an intrinsic part of quality control procedures.

450. Environmental release potentials are deemed to be low. Due to the low vapour pressure of PFOS, and the nature of the process, no emissions to air are expected. However, waste products, including 93% of the resist formulation (PAGs and surfactants) are incinerated. Releases to water are also considered to be negligible. Furthermore, there is no residual PFOS compound present in manufactured microprocessors and therefore no consumer exposure or concern about releases from electronic waste disposal or recycling.

451. PFOS releases from photolithography uses are small compared with PFOS use in other industry sectors. In 2002 for the whole of Europe, an estimated 43 kilogram of PFOS were released in the effluent from photolithography uses, on the order of only 0.45 percent of all PFOS releases at that time in Europe. Mass balance data for Europe in 2004 indicates an estimated 54 kilogram of these releases. It has been estimated that a similarly small proportion of releases in the United States and Japan is attributable to the photolithography uses, based on recent past use patterns.

452. It is difficult to quantify the costs that will ultimately be involved in replacing PFOS use in the photolithography industry with alternative substances, given that such alternatives are not currently available. The requirements for innovation and the limits of technical feasibility are the main factors that currently limit access to alternatives. If those hurdles can eventually be overcome, however, there will be substantial costs associated with the transition to the use of alternative substances in the photolithography process. For example, there are likely to be extensive introduction costs

associated with bringing a new system into high volume production, including re-qualification costs and possible loss of revenues associated with much lower yield as new systems are brought on line. Many resists are specifically tailored to one individual company's process, which means that a valid replacement for one cannot necessarily be applied industry-wide. Given those uncertainties, the estimate below, derived for this evaluation, is only an indication of the order of magnitude of the costs involved.

453. Replacing existing resists systems would require extensive R&D followed by a time-consuming manufacturing process re-qualification. The development cost of one completely new photoresists system for the industry has been estimated at US$192M for 193nm resist, US$287M for 157nm, and US$218M for EUV resist. The cost for 157nm resist development is the highest, because it has more novel requirements than either 193nm or EUV resists.

454. Development costs of a new photoresist system would be US$700M. Assuming that variable costs are the same as in the present system, it takes 5 years to develop the new system and the time span for the analysis is 25 years. This would imply that the reduction in release of PFOS related substances is equal to 20 years of releases (50 kilogram per year), i.e. a total of 1000 kilogram. Costs would be US$0.7M per kilogram PFOS. This calculation indicates the level of magnitude of the costs of reducing the release. By comparison, the semiconductor industry had global sales of $248 billion in 2006[21].

455. The semiconductor industry recently signed an agreement to curtail the use of PFOS-based chemicals at the global level. Under the agreement, members of the World Semiconductor Council, which comprises the trade associations representing the microchip industries of most of the world's leading semiconductor-producing countries (including SIA, ESIA and trade associations in Asia), and SEMI have committed to the following actions: (i) ending non-critical uses for PFOS by specific dates; (ii) working to identify substitutes for PFOS in critical uses for which no other materials are presently available; (iii) destroying solvent wastes from critical uses; and (iv) taking other steps to mitigate the potential environmental impacts of PFOS use in these critical applications.

Photo masks in the Semiconductor and Liquid Crystal Display (LCD) Industries

456. Photo masks are an essential part of the photolithography process of semiconductor and LCD production. Photo mask production is mainly outsourced from semiconductor or LCD producers to other companies.

457. Three major photo mask producers in Japan report that a wet process is used in the production of most photo masks. PFOS and PFOS-related substances are contained in etchants for semiconductor and Thin Film Transistor (TFT) panels, because these products require very fine patterning. In the case of photo masks for semiconductors, a dry process is also used for some specific cases. All TFT photo masks are produced using a wet process because of their large size.

458. The total amount of PFOS (including PFOS moiety in PFOS-related substance) use for this purpose in Japan is estimated at approximately 70 kilogram per year. It is estimated that Japanese companies play a major role in photo mask production, and have more than a 70% share of the worldwide market. Thus it is estimated that total use of PFOS and PFOS-related substances for this use in the world is approximately 100 kilogram.

459. Because of strong acid of etchants, non-fluoro surfactant is not stable in etchants, thus it is not applicable for this process. Furthermore, other fluoro-surfactants such as shorter chain PFAS are not suitable because their ability to lower surface tension is not sufficient.

460. A dry etching process is applied to high-end ultra-fine patterns of semiconductor photo masks. However, the yield and productivity of the dry etching process is much (15 to 20 times) lower than the wet process. Furthermore, the dry process is not useable for LCD panels because of their large size (more than 1m by 1m).

Aviation hydraulic fluids

461. According to information received from one of the major producers of hydraulic fluids, there are no alternatives to the PFOS substances currently being used in aircraft systems and there is no known alternative chemistry that will provide adequate protection to aircraft.

462.

The process of qualifying a new fluid for use in commercial aircraft has historically taken about 10 years from concept to actual commercial manufacture. There are no current alternatives to PFOS substances currently being used in aircraft systems and there is no information on costs or environmental/human health attributes of alternatives.

Certain medical devices

463. The medical device industry has been using many raw materials containing PFOS for a very long time. For example, PFOS is used as an effective dispersant when contrast agents are incorporated into an ethylene tetrafluoroethylene copolymer (ETFE) layer. PFOS plays an essential role in radio-opaque ETFE production, allowing

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[21] http://www.sia-online.org/pre_facts.cfm

the achievement of the levels of accuracy and precision required in medical devices (e.g., radioopaque catheters, such as catheters for angiography and indwelling needle catheters).

464. Since about 2000, when the effects of PFOS on the environment were identified as a problem, radio-opaque ETFE manufacturers have been working with chemical material suppliers to find alternatives.

465. The 2006 OECD survey identified use of perfluorobutane sulfonate (PFBS) as surfactant in coating products. In some cases, this substance can be used as a dispersant for inorganic contrast agent when it is mixed into ETFE. For many other medical devices, alternatives that allow the achievement of the same standard, however, remain to be found. It is expected that, due to its unique properties, PFOS will continue to be used for a variety of medical devices..

B. Uses for which alternative substances or technologies may be available but would need to be phased in

Metal plating

466. PFOS-related substances are used in the following main applications:

- decorative chromium plating; and
- hard chromium plating.

467. Other important uses are: pre-treatment agent for plastic plating, PTFE powder plating treatment agent, pre-treatment agent for printed circuit board plating; chromic acid anodizing; nickel cadmium, or lead plating; alkaline zinc plating; stainless steel electric grinding agent; and chemical abrasive agent for copper alloy.

468. The 2006 OECD survey identified use of perfluorobutane sulfonate (C4 PFAS) as mist suppressants. Other information indicates that there are currently no known effective alternative chemical mist suppressants to PFOS-related substance for these applications (Japan, 2007; US, 2007)).

469. However, information received from a number of industry and regulatory authorities indicates that the substitution of Cr (VI) or hexavalent chromium with the less hazardous Cr (III) in decorative plating applications would eliminate the need for the use of PFOS-related substances in this application. Such substitution has potentially significant cost savings and health and safety and environmental benefits for the metal plating sector.

470. The higher costs of using Cr (III) are more than offset by the savings from reduced waste treatment costs, reduced air monitoring costs, record keeping, and the reduced reject rate. The major benefit, however, relates to the significantly reduced risk of employee ill health induced by working with hexavalent chromium. The progress of substitution is different due to the quality requirements of the different markets e.g. in Japan only 40-50 of about 1000 companies have changed their process. In such cases, PFOS mist control agents are still needed to protect workers' health

471. For hard chromium plating, information received indicates that the direct substitution of Cr (VI) with Cr (III) is not currently a viable option. While industry has indicated that substitute processes for Cr (VI) hard chrome plating have been developed for certain small applications, currently there are no technologies that are available on a large, commercial scale to replace the majority of Cr (VI) plating applications. In Japan alternatives for uses other than hard chromium plating are not yet identified partially because of the requirements for high reliability e.g. for automobile pumping parts.

472. The cost of improved ventilation with extraction, which is the recommended substitute for PFOS-based mist suppressants, has been calculated to be €3400 per year in each production unit where the investment period is 15 years (RPA 2004). Assuming a few hundred units in the EU the total cost would be one or two million euros. In Japan it has been estimated that the cost would be US$40 000 for each 1000 litre bath (Japan, 2007).

473. The anticipated costs of the proposed Canadian regulations (See Section 1.5) by firm size are US$0.65 M for 34 small firms, US$2.6 M for 52 medium firms and US$0.68 M for 14 large firms. The total estimated compliance costs for Canadian facilities using PFOS fume suppressants to comply with the proposed regulations is approximately US$3.9 M (discounted at 5.5% over 25 years). This would result in a reduction in PFOS releases of approximately 86 tonnes over the 2013 to 2032 period (Canada, 2006)). Based on these Canadian calculations, the cost of reduction is US$46 per kilogram of PFOS reduced.

Fire fighting foam

474. A number of alternatives to the use of PFOS-based fluorosurfactants in fire fighting foams are now available/under development. These alternatives include: non-PFOS-based fluoro-surfactants; silicone based surfactants; hydrocarbon based surfactants; fluorine-free fire fighting foams; and other developing fire fighting foam technologies that avoid the use of fluorine. The efficacy of alternatives would need to be considered.

475. Fluorine-free foams are approximately 5-10% more expensive than the fluorosurfactant-based foams (including those PFOS-based foams marketed previously). The manufacturers, however, indicate that prices for fluorine-free foams would reduce if the market size increased. It is, therefore, assumed that prices are broadly comparable.

476. As the transition from PFOS-based products has already taken place for most uses in many countries, there are only limited developmental or operational costs associated with the substitution of PFOS-based foams by foam manufacturers or users. The main costs for phasing out PFOS-based foams are related to managing stockpiles and waste containing such foams.

477. With regard to the toxicological and ecotoxicological suitability of non-PFOS based fluorosurfactants, data are limited. Whether telomers represent a significant concern for human health and the environment is under review elsewhere and conclusions are awaited.

478. With regard to fluorine-free foams, current information indicates that compared to PFOS based foams, they do not persist or bio-accumulate in the environment (due to the absence of fluorine). With regard to acute toxicity, fluorine-free foams appear to have a slightly lower acute toxicity, although the information provided to date is not conclusive.

479. For Canada, it is estimated that the proposed regulations would reduce the release of PFOS based AFFF into the environment in the order of 2.83 tonnes over the 2008 to 2032 period. The present value of the disposal and replacement costs experienced by airports, military facilities and refineries would be in the order of approximately US$0.64 M (in 2006 $) discounted at 5.5% over the 25-year time period (Canada, 2006). Based on these Canadian calculations the cost of reduction is US$226 per kilogram of PFOS reduced.

480. For the EU, costs of replacement and destruction of foam have been estimated at €6000 per tonne. The stocks in the EU are 122 tonnes (RPA 2004). Based on the RPA's calculations, the cost of reduction is €6 per kilogram of PFOS reduced. Once the foam has been renewed, the cost of destruction may be as low as €1 per kilogram.

481. In Japan, it has been estimated that 86 tonnes of PFOS equivalent exist in AFFF products on the market. Based on this information, the estimated total amount of PFOS in the market is less than 200 tonnes in fire fighting foam concentrate. The market has stockpiled some 21,000 tons of PFOS fire fighting foam concentrate, and some 11,400 tons of fire fighting foam contains PFOS itself, the rest 9,600 tones contains PFOS derivatives. The majority of market stock is fire fighting foam for water-immiscible liquids such as oil, naphtha and hydrocarbon-fuels, and non-PFOS alternatives are already marketed for this use. It is estimated that replacement will take about15 years based on present production capacity. On the other hand, some 2,000 tones of market stock, fire fighting foam for water miscible liquid such as alcohols glycols and acetone is more indispensable before long for biological fuels (bio-ethanol etc.). The foam for water miscible liquid is required to fulfil government standards and a non-PFOS alternative is not yet developed due to technical difficulties and technical feasibility. It is estimated that the alternative development will take several years and that replacement will take also about 15 years. Furthermore, fire fighting foam containing PFOS is also stored at airports (Japan, 2007).

482. The SNUR regulations in the U.S. restrict only new manufacture or importation of PFOS chemicals and PFOS-containing products. The U.S. regulations do not impose any restriction on the use of existing stocks of PFOS-based AFFF manufactured or imported into the U.S. prior to the effective date of the regulations, and no mandatory phase out of those existing stocks is either in place or contemplated.

Electric and electronic parts

483. PFOS is widely used in the production of electric and electronic parts. Major uses are as sealing agents and adhesives. For these uses, alternatives are available or are under development, and PFOS will be replaced relatively quickly. However, several uses have been identified for which alternatives will not soon be available. One such use is in the intermediate transfer belt of colour copiers/multi-function printers.

484. The intermediate transfer belt is an essential part of colour printers and colour copying machines. According to information provided to the Japanese government, the largest manufacturer (which supplies more than 60% of polyimide intermediate transfer belts) uses PFOS to ensure the required properties. Intermediate transfer belts of this manufacturer contain up to 100 ppm of PFOS. The part is used by 12 colour copier/multi-function printer manufacturers that dominate the global market; it is also supplied worldwide as a spare part. The properties of the intermediate transfer belt determine the design of the copier/multi–function printer. Due to the long life of copiers/multi-function printers, if supplies of this part are stopped, millions of copiers/multi-function printers might be discarded before the end of their product life, leading to unnecessary potential environmental damage.

485. Similar to intermediate transfer belts, PFA rollers and belts in fixing units contain PFOS for the same reason. The largest manufacturer of these units has reported that PFOS in the amount of 8×10-4 ppm is contained in an additive used in producing the units, and that additive is used in the amount of 3µg/cm2. The production volume is 300,000 units per month, and annual consumption of PFOS is less than 3 g.

486. Furthermore, PFOS is used in various kinds of additives, such as grease additives for mechanical slides and micrometers, as a component of an etchant used in the plating process to produce electronic devices, as well as a wider range of other uses in electric and electronic industries. However, due to the very low concentrations involved, as

mentioned above, and the complex supply chain, use in this area was only recognized very recently, and thus further study is needed.

487. It is not clear what the impact of using alternatives to PFOS would be with regards to product performance.

488. According to information from Japan, PFOS is used in an etching process of the piezoelectric ceramic filter which is used as a bandpass filter at intermediate frequency in two-way radios for police radio, FM radios, TV, Remote Keyless Entry for Cars, etc. Annual PFOS usage is about 20 kg. The possibility of PFOS environmental discharge is estimated to be low. PFOS alternatives are under consideration by industries.

489. Etching of high-frequency compound semiconductors is a processing method to produce semiconductor transistors used for satellite communications and various radar systems. To fabricate fine patterns by etching, use of surfactant containing PFOS is currently necessary, according to information from Japan. Alternate technology is being developed and is estimated to be completed by November, 2014

Use of PFOS derivative in production of ant baits for control of leaf-cutting ants

490. Sulfluramid (1-octanesulphonamide-N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro; CAS: 4151-50-2), is manufactured using a PFOS-related derivative (perfluorooctyl sulfonyl fluoride (PFOSF), CAS No 307-35-7). Sulfluramid is the active ingredient in the manufacture of ant baits in ready-to-use formulations and is known to degrade to PFOS. It is estimated that the production of sulfluramid in Brazil is about 30 tonnes per annum. Sulfluramid is used at a 0.3% concentration, resulting in a production of around 10,000 tonnes of ant baits/year. In 2006, around 400 tonnes of ant baits (sulfluramid 0.3%) were exported to 13 countries in South and Central America. Sulfluramid cannot be manufactured without the use of PFOS-related derivatives. Since 10 % of sulfluramid is degraded to PFOS its use represents a direct release of PFOS to the environment.

491. Several mechanical, cultural, biological and chemical methods, including different formulations, have been studied for controlling leaf-cutting ants. Granulated baits represent the most widely used method for leaf-cutting ant control, consisting of a mixture of an attractant (usually orange pulp and vegetable oil) and an active ingredient (insecticide), presented in the form of pellets. This method features some significant advantages over other methods. It is a low-cost method, delivering high efficiency with reduced health hazards to humans and the environment during application and being specific to the pest target. Its formulation is developed with low concentrations of active ingredients, and its localized application does not require application equipment. The utilization of ready-to-use formulations should reduce or impede releases to humans but the release of 30 tonnes of sulfluramid annually to the environment will eventually result in a significant part of it being degraded to PFOS.

492. Currently, the active ingredients used in ant baits are: sulfluramid, fipronil and chlorpyrifos. Fipronil and chlorpyrifos are more acutely toxic to mammals, water organisms, fish and bees than sulfluramid. Comparative studies demonstrate low efficiency of ant baits with chlorpyrifos and fipronil. According to the Brazilian Annex F information, sulfluramid cannot presently be efficiently replaced in Brazil by other registered products commercialized for the same purpose. In the EU, PFOS-related substances are not used in the manufacture of pesticides (RPA 2004). Ant baits containing S-methoprene and pyriproxifen are registered in New Zealand for the control of exotic ants by aerial and ground applications (ERMANZ, 2007).

493. Limited information provided on associated worker exposure to PFOS from the manufacture of sulfuramid baits indicates low exposure to the workers. There was no information on the exposure of the local community and environment from the use of sulfluramid baits.

494. The ant pesticides S-methoprene and pyriproxifen are registered for exotic ants, not for leaf-cutting ants, according to Brazilian information. According to additional Brazilian information, toxicological assessments and environmental hazard assessments of both Sulfluramid and Sulfluramid-based baits have been conducted before registration.

Medical devices

495. According to information from Japan, PFOS was used related to the CCD Color Filters. The product is a CCD color filter used as a replacement part for CCD color filters to repair video endoscopes that were manufactured in the past. It is technically possible to manufacture PFOS-free CCDs, but PFOS-free CCDs are not suitable for use in the repair of video endoscopes with CCDs that contain PFOS. To make all CCDs in video endoscope PFOS-free would require replacing the whole video endoscope systems. Presently there is no production of CCDs with color filters containing PFOS in Japan, but these CCDs are available for replacement purposes.

496. The CCDs are contained inside the insertion sections of video endoscopes so the possibility of PFOS leakage and the risk of environmental contamination are small when recovered and appropriately incinerated (when replaced). According to submitted data, one CCD contains 150 ng of PFOS.

Chemically driven oil production

497. According to information from China, PFOS is used for chemically driven oil production in old oil fields where

surfactants are used to recover oils trapped in smaller pores between rock particles. A small amount of fluoro-surfactants are used to effectively lower interfacial tensions. The concrete situation including the amount used in this sector would require further investigation.

C. Uses for which alternatives are available in developed countries

498. For the following uses which have been historical ones in the US, Canada and the EU, alternatives are available and in use: fire fighting foams; carpets; leather/apparel; textiles/upholstery; paper and packaging; coatings and coating additives; industrial and household cleaning products; and pesticides and insecticides.

499. It is presently unclear whether these uses of PFOS-related substances still occur in some parts of the world. However, in China PFOS and/or PFOS-related substances are still used in clothing manufacturing and for surface coating.

500. Based on available information, China reports that PFOS is still used in a number of areas where alternatives are available in developed countries. These applications include: textiles, pesticides, fire fighting foams, cleaning products, rubber and plastics, leather, coating and coating additives, paper and packaging. Of the national production of PFOSF, about 100 tonnes are used nationally.

Use of PFOS derivative in production of pest control

501. According to additional information from China, Sulfluramid using a PFOS-related derivative is also used against cockroaches, white ants and fire ants in China. There are three Chinese companies using about 3 tonnes of PFOS for pest control. Estimating the cost and the efficiency of alternatives would require further investigation.

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

2.4.1 Health, including public, environmental and occupational health

502. A positive impact on human health and on the environment can be expected from reduction or elimination control measures on PFOS on a global scale. The establishment of further control measures for those uses of PFOS for which no substitution is yet possible, will presumably contribute positively to human health and the environment, especially concerning reprotoxicity and blood values.

503. A major, positive impact may be for vulnerable groups such as pregnant women, embryos and infants due to the reproductive toxicity of PFOS. Positive impacts would also be particularly beneficial to Arctic indigenous peoples who depend on traditional native foods and therefore are at much greater risk of PFOS exposure than other communities, given the widespread PFOS contamination of the Arctic food chain. The particular risks posed by POPs to Arctic ecosystems and indigenous communities are acknowledged in the preamble to the Convention.

504. If PFOS production and use is not managed, and were to continue or increase, then levels in the environment including in humans and animals will likely rise, even in locations distant from production and use. Industry has noted that no negative impact is anticipated to result from the ongoing small number of critical uses e.g. the imaging industry and the semi-conductor industry.

2.4.2 Agriculture, including aquaculture and forestry

505. The immediate elimination of PFOS could adversely affect Brazilian agriculture through its impact on the production of sulfluramid ant baits for the control of leaf-cutting ants in agricultural or forest undertakings. Specific exemptions could permit the continued use of PFOS in the production of sulfluramid ant baits until a planned phase-out program is established.

506. According to additional information from Brazil, baits with Sulfluramid represent more than 95% of the baits used in Brazil.

2.4.3 Biota (biodiversity)

507. As the persistent, bioaccumulative and toxic properties of PFOS were shown under the LRTAP-POPs-Protocol and under the Stockholm Convention, a positive impact on biota from a ban/restriction of the substance can be expected.

508. The scientific literature has identified that at current exposure levels, PFOS could harm certain wildlife organisms (e.g. polar bear, fish-eating birds), including those found in remote locations such as in the Canadian Arctic. The effects include growth inhibition of birds and aquatic invertebrates; liver and thyroid effects in mammals; lethality to fish (US EPA OPPT AR226-0097, OECD 2002) and saltwater invertebrates (US EPA OPPT AR226-0101); and changes in biodiversity (Boudreau et al. 2003a, Sanderson et al. 2002) (Canada, 2007).

509. Although polar bear and ringed seal sample data from 2005 have shown the first decline in levels since the reduction in worldwide production that began in 2000, more sample data must be collected in future years before it can be confirmed if the reductions are indeed the start of a long term downward trend in PFOS levels (Canada, 2007).

2.4.4 Economic aspects, including costs and benefits for producers and consumers and the distribution of costs and benefits

510. The potential benefit from avoided alternate water supply expenditure attributable to the proposed Canadian regulations (prohibiting production, marketing and use of PFOS and PFOS-related substances) is estimated to result in an average annual net benefit of US$0.49 M per year. It is recognized that this benefit is uncertain; however, the value can be used to approximate the benefits to be derived as a result of the proposed regulations. Total benefits to Canadians are estimated to be approximately $5.57 M. (Canada, 2006) It is recognized that this benefit is uncertain and that only a fraction of the benefits have been monetarized. There are no data available from other countries for the risk management evaluation.

511. The semiconductor industry in China mainly uses PFOS for photoresists, anti-reflective coating, de-gluing agent and developing agent amounting annually to 30-40 kilograms. The total sales amount of this industry reached 100 billion Yuan in 2007.

Photo-imaging

512. According to industry, restrictions on the remaining uses of PFOS-related substances would have a severe impact on the photo imaging industry’s ability to manufacture a number of imaging products using current processes, including diagnostic medical products, industrial X-ray (non destructive testing), graphic printing (printing mask) and would impose a significant cost, not only on the manufacturers of photo imaging products, by requiring substantial investment in research and development, but also on users, by compelling them to replace their current systems with new systems, such as alternative digital systems.

Photoresists and semi-conductors

513. 2005 global sales were US$228 billion, with initial estimates for 2006 well above US$260 billion. The semiconductor industry employed 226,000 people in the United States and 87,000 in Europe. Global employment in the industry was approximately 500,000 in 2003, but this figure has certainly increased.

514. However, the semi-conductor industry considers that implementation of control measures that effectively precluded the use of PFOS in critical applications for semiconductor manufacturing would likely shut down high volume production semiconductor manufacturing for a considerable time. The industry believes that this action could have a drastic effect on the global economy.

Metal plating

515. The cost of improved ventilation with extraction, which is the recommended substitute for PFOS-based mist suppressants, has been calculated to be €3400 per year in each production unit where the investment period is 15 years in the EU (RPA 2004). Assuming a few hundred units in the EU the total cost would be one or two million euros. In Japan it has been estimated that the cost would be US$40 000 for each 1000 litre bath which would affect more than 1,000 plating companies, which are mainly SMEs (Japan, 2007). Based on the Canadian calculations the cost of reduction is US$46 per kilogram of PFOS reduced.

516. Annually, about 25 tonnes of PFOS-containing chromium fog inhibitor are used in the Chinese chrome plating industry, with the value of 30 billion Yuan. A phase-out of the fluoro-containing inhibitor could worsen the health of 100,000 Chinese workers.

Fire fighting foam

517. For the EU, costs of replacement and destruction of foam have been estimated at €6000 per tonne. The stocks in the EU are 122 tonnes (RPA 2004). Based on the RPA's calculations, the cost of reduction is €6 per kilogram of PFOS reduced. Once the foam has been renewed, the cost of destruction may be as low as €1 per kilogram. Based on the Canadian calculations, the cost of reduction is US$226 per kilogram of PFOS reduced. In Japan, the cost of PFOS FFF incineration is estimated at approximately US$1,000/t and incineration capacity is limited. Thus, it is difficult to estimate the time necessary for destruction (Japan, 2007).

518. More than 50 companies in China are producing Aqueous Film Forming Foam (AFFF), consuming more than 100 tons of PFOS per year. AFFF was phased in as alternative technology for halon, an ozone depleting substance.

Medical devices

519. According to the Japanese submission, at least 7500 catheters for angiography and 48 million in-dwelling needle catheters are produced annually in Japan, for which PFOS is required as part of the production process. Currently, alternatives for these medical devices have not been found yet in Japan. In order to identify appropriate alternatives, medical device manufacturers need to conduct numerous studies over several years covering such areas as feasibility, leachability, and safety and need approval by regulatory authorities. Therefore, at this stage it is very difficult to predict when alternatives will be available for use.

520. According to the Japanese additional submission, around 70% of the video endoscopes worldwide contain a CCD colour filter that contains PFOS. Replacement with PFOS-free endoscope systems instead of replacing the colour filter would impose a huge cost on medical institutions throughout the world and there would be a social impact.

Electric and electronic parts

521. According to the information from Japan the demand for piezoelectric ceramic filters is nearly 100,000,000 pieces per month. PFOS use prohibition would have a significant economic and social impact on the supply of piezoelectric ceramic filters, while the amounts used are small.

Ant baits

522. According to additional information from Brazil, damages corresponding to losses of up to 14,5% of trees per hectare have been estimated without the use of ant pesticide. The cost of an attack of leaf-cutting ants is estimated to US$ 6.7 billion in wood.

523. Considering that the sugar cane planted area in Brazil is of approximately 6 millions of hectares, the cost in this sector is estimated to US$ 1,82 billion/year. Other affected agricutural products likely to be affected at high costs are soybean and maize. Also the capacity of supporting livestocks heads / hectare is likely to be reduced if forage for grazing is reduced by ants.

Cost comparisons

524. Rough calculations based on limited existing data and estimations indicate that the differences in costs for reduction of PFOS-related substances are very large. The cost per kilogram has been estimated at US$25 M (€ 18.6 M) for photo imaging, US$0.7 M (€ 0.52 M) for semi-conductors, US$184 (€137) for destruction of fire fighting foam and US$46 (€ 40) for metal plating. Lack of data has made it impossible to do similar estimates for photo masks, aviation hydraulic fluids, medical devices, electric and electronic parts and ant baits. These uses can be judged to have costs between the two uses that are expensive to reduce and the two that are relatively cheap to reduce.

2.4.5 Movement towards sustainable development

525. As the persistent, bioaccumulative and toxic properties of PFOS as well as its potential for a long-range transboundary transport were shown under the LRTAP Convention POPs-Protocol and in the risk profile agreed by the POPRC of the Stockholm Convention, a positive impact on a globally sustainable development from a elimination/restriction of the substance is be expected.

2.4.6 Other impacts

526. Although PFOS is no longer used for the manufacturing of fire fighting foams, there are still stocks of about 122 tonnes in the EU (Germany, 2007).

527. Existing stocks of PFOS-based AFFF continue to be used in the U.S., although no new PFOS-based AFFF is being manufactured or imported into the U.S. The Fire-Fighting Foam Coalition, an industry group, estimated in 2004 that the total inventory of fluorine-containing AFFF products in the U.S. consisted of approximately 9.9 million gallons of concentrate, with approximately 4.6 million gallons being 3% and 6% PFOS-based AFFF concentrates, and the remaining 5.3 million gallons being telomer-based materials.

528. The large use of PFOS in consumer products has implications for municipal waste and disposal along with attention to production stockpiles. A listing of PFOS in Annex A or B would subject wastes, products or articles containing the substance to Article 6 of the Stockholm Convention and require that they be disposed, "…in a safe, efficient and environmentally sound manner". Waste management and disposal related to PFOS could be a problem for developing countries and financial and technical assistance to support in this task should be considered. In addition, developing countries may need financial and technical assistance to develop or change over to alternatives.

2.5 Other considerations

2.5.1 Access to information and public education

529. For more information on industry innovations regarding PFOS alternatives, please see the following websites:

- SIA: http://www.sia-online.org/home.cfm
- EECA-ESIA: http://www.eeca.org/esia.htm
- SEMI: http://www.semi.org/
- (Semiconductor)

530. Access to information on the U.S. regulation of these chemicals and the industry response is available through the online dockets for the U.S. EPA rulemaking proceedings. Information on those proceedings and dockets is available on the EPA website at http://www.epa.gov/opptintr/pfoa/pubs/related.htm .

531. Additional material on PFOS and related perfluorinated compounds is publicly available in a non-regulatory data repository maintained by the EPA Docket Office as Administrative Record AR-226. AR-226 is not available online, but an index to the documents can be requested by email from oppt.ncic@epa.gov, and documents in AR-226 are available on CD-ROM (USA, 2007).

532. Information on future needs relating to access to information and public education is not currently available.

2.5.2 Status of control and monitoring capacity

533. The worldwide semi-conductor industry associations will collect and make available aggregated industry information every 2 years to provide a transparent communication of member company progress, including:

- The results of PFOS wastewater treatment evaluations including any wastewater measurement data;
- A description of the current relevant research and development activities and any conclusions including the results of collaboration with equipment and chemical suppliers;
- Industry phase-out schedules that are known for critical and non-critical uses in semiconductor manufacturing and processing; and
- The results of the PFOS mass balance model (SIA, 2007).

3. Synthesis of information

3.1 Summary of risk profile information

534. Perfluorooctane sulfonate (PFOS) is a fully fluorinated anion, which is commonly used as a salt in some applications or incorporated into larger polymers. Due to its surface-active properties, it has historically been used in a wide variety of applications, typically including fire fighting foams and surface resistance/repellency to oil, water, grease or soil. PFOS can be formed by degradation from a large group of related substances, referred to as PFOS-related substances (see definition in section 1.1.2). The quantities of different PFOS derivatives vary widely, from less than one tonne to hundreds of tonnes.

535. PFOS and PFOS-related substances can be released to the environment during their manufacture, use in industrial and consumer applications, and from disposal of the chemicals or of products or articles containing them after their use.

536. The rate and the extent of the formation of PFOS from its related chemicals are largely unknown and may differ between individual substances. Lack of data makes it very difficult to estimate the net contribution of the transformation of each of the PFOS-related substances to the environmental loadings of PFOS. However, based on its extreme stability, it is expected that PFOS is likely to be the final degradation product of all PFOS-related substances.

537. PFOS is extremely persistent. It has not shown any degradation in tests of hydrolysis, photolysis or biodegradation in any environmental condition tested. The only known condition whereby PFOS is degraded is through high temperature incineration under controlled conditions.

538. With regard to bioaccumulation potential, PFOS meets the Annex D criteria given the highly elevated concentrations that have been found in top predators such as the polar bear, seal, bald eagle and mink. Most notable are the high concentrations of PFOS that have been found in Arctic animals, far from anthropogenic sources. PFOS has been detected in higher trophic level biota and predators such as fish, piscivorous birds, mink, and Arctic biota. Also, predator species, such as eagles, have been shown to accumulate higher PFOS concentrations than birds from lower trophic levels. Even with reductions in manufacturing of PFOS by some manufacturers, wildlife, such as birds, can continue to be exposed to persistent and bioaccumulative substances such as PFOS simply by virtue of its persistence and long-term accumulation.

539. According to available data, PFOS meets the criteria for the potential for long-range transport. This is evident through monitoring data showing highly elevated levels of PFOS in various parts of the northern hemisphere. It is especially evident in the Arctic biota, far from anthropogenic sources. PFOS also fulfils the specific criteria for atmospheric half-life.

540. PFOS fulfils the criteria for adverse effects. It has demonstrated toxicity towards mammals in sub-chronic repeated dose studies at low concentrations, as well as rat reproductive toxicity with mortality of pups occurring shortly after birth. PFOS is toxic to aquatic organisms with mysid shrimp and Chironomus tentans being the most sensitive organisms.

541. The voluntary phase out of PFOS production by the major producer in the USA, along with government regulatory actions, has led to a reduction in the current production and use of PFOS-related substances. However, PFOS or PFOS-related substances are still produced in some countries and it continues to be used in many countries. Given the inherent properties of PFOS, together with demonstrated or potential environmental concentrations that may

approach or exceed the effect levels for certain higher trophic level biota such as piscivorous birds and mammals; and given the widespread occurrence of PFOS in biota, including in remote areas; and given that PFOS precursors may contribute to the overall presence of PFOS in the environment, POPRC2 concluded that PFOS is likely, as a result of its long-range environmental transport, to lead to significant adverse human health and environmental effects, such that global action is warranted.

3.2 Suggested risk management measures

542. Consistent with Article 1 of the Convention, PFOS should be managed with the objective of protecting human health and the environment from POPs. Consideration should also be given to the potential for all PFOS-related substances to degrade to PFOS and thus contribute to the total environmental load.

543. Listing of PFOS acid, its salts and PFOSF under the Convention is able to address various aspects of substance life-cycles, including manufacture, use, import and export as well as prescribing emissions measures e.g. BAT/BEP or others to reduce releases with the aim of eliminating them. Listing of PFOS and/or PFOS-related substances under the Convention would also make it subject to the provisions on stockpiles and waste in Article 6.

544. Given the complexity of the PFOS issue and the large number of related substances that might contribute to the total environmental load of PFOS, there are several possibilities for what to list in the Convention. The original Swedish nomination included 96 substances in addition to the perfluorooctane sulfonate anion. The anion itself should not be listed since it never occurs in isolation but always with a counter cation. POPRC-1 agreed that the nomination included the anion, the acid and its salts. One option could thus to list the acid and its salts. This would be based on the reasonable assumption that all salts are ionized and dissociate in the environment to liberate the anion. Even for very insoluble salts there would be an equilibrium concentration of free PFOS anion that could be attached to more soluble cation and be available for biota. Given the extreme persistence of PFOS it can be judged that all salts would be dissociated to PFOS in such a time frame as to add to the total environmental load of PFOS.

545. Most of the PFOS in the technosphere appears in the form of derivatives of PFOS. It could be argued again that given the extreme persistence of PFOS, all PFOS-related substances would degrade to PFOS in a time frame that would contribute to the total environmental load. This line of reasoning has some support from physicochemical considerations and modelling. On the other hand there is limited experimental data to confirm this approach and it would be very time and resource-consuming to provide the experimental support that each and every individual derivative of PFOS degrades to contribute to the total environmental load of PFOS.

546. One of the 96 substances included in the Swedish nomination, the sulfonyl fluoride of PFOS, 1-Octanesulphonyl fluoride, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro (CAS-No: 307-35-7) (PFOSF), occupies a central position in the manufacture of the PFOS derivatives (Lehmler, 2005). It is the most common starting material for the synthesis of the different types of PFOS-related substances presently used. The probability for this substance to degrade to PFOS is sufficiently high to make it clear beyond doubt that it would contribute to the total environmental load of PFOS. Thus PFOSF is a clear precursor of PFOS in the environment. By controlling/listing PFOSF together with PFOS acid and its salts all possible derivatives of PFOS would be covered. Such a listing would therefore be very effective in reducing all releases of PFOS to the environment.

547. Listing of PFOS acid, its salts and PFOSF in Annex A of the Convention would prohibit the manufacture, use, import and export of PFOS acid, its salts and PFOSF (except as allowed under the treaty for environmentally sound disposal) and could be linked with specific exemptions that specify deadlines for the eventual elimination of remaining PFOS manufacturing and use. Such listing could also be coupled with a Part III of Annex A that would describe in more detail the critical uses of PFOS and/or PFOS-related substances and appropriate conditions for their manufacturing and use, including time limits.

548. Listing of PFOS acid, its salts and PFOSF in Annex B of the Convention would prohibit the manufacture, use, import and export of PFOS acid, its salts and PFOSF except for specified acceptable purposes/specific exemptions such as those mentioned above for which at present no alternatives are available. The listing could be accompanied by a Part III to Annex B, which would describe in more detail the critical uses of PFOS and/or PFOS-related substances and appropriate conditions for their use, including timelines for review and revision, as appropriate.

549. The suggested options for control measures for PFOS are as follows:

- PFOS may be listed in Annex A, with or without specific exemptions, and accompanied with a new Part III of Annex A that details actions for each or groups of PFOS acid, its salts and PFOSF or uses of such substances; or
- PFOS may be listed in Annex B, with specified acceptable purposes or specific exemptions, and accompanied with a new Part III of Annex B that details actions for each or groups of PFOS acid, its salts and PFOSF or uses of such substances

550. These options are further described below.

Option 1. Listing of PFOS acid, its salts and PFOSF in Annex A

551. Listing of PFOS acid, its salts and PFOSF in Annex A would be consistent with the POPs properties of this intentionally produced substance. Such a listing would send a clear signal that production and use of PFOS must be phased out. Such a listing may also have implications for countries joining the Convention for this substance, in light of ongoing uses for which no alternatives have been developed.

552. To allow for use of PFOS acid, its salts and PFOSF in critical applications, an exemption for production and use could be given, e.g.. "as required to produce other chemicals substances to be used solely in accordance with Part III of this Annex". Specific exemptions for certain critical uses, where there are no available alternatives, could be difficult to develop or apply, however, given the general time limit of five years, with a possible extension applicable to specific exemptions, among other reasons.

553. This option could be exercised by all Parties, in which case they would not need to register the exemption. This would also imply that any restrictions with regard to time would appear in the new Part III of Annex A. The information that has been supplied indicates that for some uses, such deadlines could be difficult to determine at present.

Option 2. Listing of PFOS acid, its salts and PFOSF in Annex B

554. Listing of PFOS acid, its salts and PFOSF in Annex B would be consistent with the POPs properties of this intentionally produced substance. This would allow for some specified acceptable purposes/specific exemptions due to the present uncertainty surrounding the availability of alternatives for several critical uses over the next five-ten years.

555. To allow for the use of PFOS-related substances in critical applications, an acceptable purpose for production of PFOS acid, its salts and PFOSF could be given, e.g., "as required to produce other chemical substances to be used solely in accordance with Part III of this Annex".

556. According to additional information received from China, many developing countries including China lack competency and related standards of inspection and enforcement systems on PFOS risk management.

557. The adverse effects and potential risks of PFOS have not been fully recognized, and most industries have not yet given attention to its substitution and phase-out.

558. Most of the PFOS auxiliary products used by Chinese industries (for textile-treatment or for semi-conductor products production) are imported mainly from the developed countries. Because the PFOS content of the products is not clearly labeled, China currently cannot implement appropriate risk management. China will urge exporters to provide related information from the perspective of the Convention.

559. The fields of application of PFOS in developing countries are generally lacking product/technology alternatives that are technologically and economically feasible and environmentally friendly. Due to lack of detailed information about alternative technologies, it can neither be assessed whether they are environmentally friendly nor whether they are feasible for developing countries in terms of technology and economy. It is therefore necessary to encourage Parties to the Convention to provide relevant information and to promote technical assistance and transfer of technology.

3.3 Conclusions

560. Ultimately the decision between Annex A or B is a political issue in this case. There appears to be no technical basis on which to choose one over the other. Both annexes may be adjusted to specify the appropriate control measures. Some considerations for the control measures are given below.

Elements of a risk reduction strategy

561. For the following uses which have been used historically in the US, Canada and the EU, alternatives are available and in use: fire fighting foams; carpets; leather/apparel; textiles/upholstery; paper and packaging; coatings and coating additives; industrial and household cleaning products; and pesticides and insecticides

562. Based on the information supplied to the Committee, the availability of alternatives is uncertain for some specific uses. Therefore, there is a need for certain critical uses over the foreseeable future. To allow for this, one could, based on the feasibility of substitution for such use and the time frame of substitution, introduce specific exemptions and/or acceptable purposes for production as required to produce other chemical substances only for the uses as described below and except for the production of PFOS acid, its salts and PFOSF as an intermediate to produce other chemical substances for those uses. One could also introduce specific exemptions or acceptable purposes for uses for which alternatives may be available. Based on the risk management evaluation critical uses would include the following: photoresists or anti reflective coatings for photolithography processes; photo mask rendering process; photo imaging; hydraulic fluids in aviation; and, certain medical devices. Other uses for which alternatives may be available include: ant baits for control of leaf-cutting ants; metal plating; fire fighting foam; and electric and electronic parts. The conditions for the use of PFOS-related substances could be further described in a new Part III to Annex A or B. Elements in such a Part III could include:

- That each Party should with regard to the ultimate elimination of the use of the substance for the critical uses take action in accordance with the set priorities e.g.:
- Phasing out as a priority the uses for which alternatives may be available but would need to be phased in; i.e. Metal plating, fire fighting foams, electric and electronic parts and the use of the substance for the production of ant baits for the control of leaf-cutting ants;
- Each Party using the substance developing and implementing an action plan as part of the implementation plan specified in Article 7, which could include development of regulatory and other mechanisms to ensure that substance use is restricted to the specific exemptions listed above and implementation of suitable alternative products, methods and strategies for all exempted uses;
- Each Party using the substance providing a report every five years on progress in its elimination and submitting it to the Conference of the Parties pursuant to Article 15;
- These reports could be considered by the Conference of the Parties in its reviews relating to progress towards elimination of the substance at five year intervals;
- The Conference of the Parties could also, as soon as new information on safer alternative substances or technologies become available review the specific exemptions or acceptable purposes to ensure that the uses of the substance are phased out as soon as the use of safer alternatives is technically and economically feasible;
- The Parties could, within their capabilities, promote research and development of safe alternative chemical and non-chemical products, methods and strategies for Parties using the substance.
- Parties that use the substance could be requested to take into account, as appropriate, the relevant parts of the general guidance on BAT and BEP given in Part V of Annex C.

563. Consideration should also be given to distinguishing between those uses which do pose a risk of wide dispersion to the environment and those that do not.

4. Concluding statement

564. 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 Perfluorooctane sulfonic acid (CAS No: 1763-23-1), its salts and 1-Octanesulphonyl fluoride, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro (CAS-No: 307-35-7) in Annex A or B as described above.

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Hexabromodiphenyl ether and heptabromodiphenyl ether (Commercial octabromodiphenyl ether)

UNEP/POPS/POPRC.4/15/Add.1

Executive Summary

565. The term "C-OctaBDE" designates a commercial mixture containing polybrominated diphenyl ethers, typically consisting of penta- to deca-bromodiphenyl ether congeners. C-OctaBDE has been used as an additive flame retardant mainly in the plastics industry for polymers used for housings of equipment containing electronics. The estimated annual world-wide production of C-OctaBDE in 1994 was 6,000 tonnes which decreased to 3,800 tonnes by 2001. Globally 70% of C-OctaBDE has been used in acrylonitrilebutadiene styrene (ABS). Other minor uses include high impact polystyrene (HIPS), polybutylene terephthalate (PBT) and polyamide polymers.

566. Production was phased out in the EU, Norway, Switzerland, Canada and the USA in the early to mid 2000's. In Japan, C-OctaBDE has never been produced; its import and sales were voluntarily phased out by 2005. There is no information available that indicates whether it is still being produced in developing countries. It has been reported that it is essentially impossible to buy C-OctaBDE at present, at the global level. Therefore, releases from production, handling and processing in these countries or regions should have already ceased or they are probably close to zero. Releases from use, disposal and recycling of products are due to volatile and particulate losses. The volatile loss over a ten year lifetime of a product containing C-OctaBDE was estimated to be 0.54% of its C-OctaBDE content. The corresponding estimate for particulate loss is 2%. These releases enter industrial or urban soil and dust (~75%), air (~0.1%) and surface water (~24.9%). Releases during the service life of products, particularly at their disposal contribute the most significant share to the total releases. Releases after disposal may be considered to be low. However, possible long-term increases in levels resulting from releases at waste sites might need to be considered further.

567. In light of the ban and phase-out of C-OctaBDE, the availability of practicable and economically viable substitutes for all its uses has already been demonstrated in practice. The potentially milder human health or environmental impacts of these alternatives have rendered them preferable over C-OctaBDE.

568. Levels of certain components of C-OctaBDE are detected in the environment. These have toxic properties and have been shown to be persistent and bioaccumulative. They thus represent a potential risk for future generations. Those findings have resulted in voluntary and regulatory phase-outs of C-OctaBDE in several regions of the world. Since this is a global, transboundary problem, global actions to phase out C-OctaBDE and include it in Annex A of the Stockholm Convention on Persistent Organic Pollutants should be considered.

569. Several countries have reported that they would have problems regulating a commercial mixture of OctaBDE. Listing the polybrominated diphenylethers (PBDE) congeners having POP characteristics would be consistent with existing national legislations and would facilitate the national monitoring and control of emissions, production and use.

Conclusion and recommendation

570. Having evaluated the risk profile for C-OctaBDE, and having concluded that components of this mixture are likely, due to the characteristics of its components, as a result of long-range environmental transport, to lead to significant adverse effects on human health and the environment, this risk management evaluation has been prepared, as specified in Annex F of the Convention.

571. The Stockholm Convention, through the Persistent Organic Pollutants Review Committee aims at protecting human health and the environment from POPs, while being mindful of the Precautionary Approach as set forth in Principle 15 of the Rio Declaration on Environment and Development. It seeks to adopt measures to eliminate releases from intentional POP production and use, to reduce or eliminate releases from unintentional POP production, and to reduce or eliminate POP releases from its stockpiles and wastes in an appropriate, environmentally sound manner.

572. Therefore, in accordance with paragraph 9 of Article 8 of the Convention the Committee recommends to the Conference of the Parties to consider listing and specifying the related control measures of hexa- and hepta-, bromodiphenyl ether congeners in Annex A of the Convention, as described above and using as markers for enforcement purposes: BDE153/154 (hexaBDE) and BDE175/183 (heptaBDE);

1. Introduction

1.1 Chemical identity

Background

573. The European Union and its Member States, which are Parties to the Stockholm Convention, submitted a proposal in July 2006 for listing commercial octabromodiphenyl ether (C-OctaBDE) in Annex A of the Stockholm Convention.

Chemical identity of the proposed substance

574. The term “C-OctaBDE” designates a commercial mixture containing polybrominated diphenyl ethers (PBDEs) with varying degrees of bromination, typically consisting of penta- to deca-bromodiphenyl ether isomers and containing approximately 79% (by weight) organically bound bromine. This bromine content corresponds to a true OctaBDE molecule and so the commercial products were often called “OctaBDE” even though the product contained a range of PBDEs.

575. These synthetic brominated compounds have been used mainly as flame retardants principally in the plastics industry for flame-retarded polymer products, typically the housings of office and other equipment containing electronics. According to the required flame retardancy, the finished products contain typically 5 to 30% C-OctaBDE by weight. The main use of C-OctaBDE is in ABS polymers with 12 to 18% weight loadings. Minor uses concern HIPS, PBT and polyamide polymers, at typical loadings of 12 to 15% weight in the final product.

576. PBDEs are flame retardants of the additive type, i.e. they are physically combined with the material being treated. This means that the flame retardant can diffuse out, to some extent, of the treated material and it is assumed that the total emission of C-OctaBDE to the environment is dominated by volatile losses from polymers over their service life.

577. Because of the chemical and toxic properties of its components, in particular isomers of hexabromodiphenyl ether (HexaBDE) and heptabromodiphenyl ether (HeptaBDE), and their wide spread occurrence in the environment and in humans C-OctaBDE causes concern in many regions in the world.

578. There are several components in the commercial product and so any assessment of the commercial product needs to include an assessment of the individual components. The commercially supplied OctaBDE (CAS Number: 32536-52-0) is a complex mixture. Table 7 shows typical composition of C-OctaBDE flame retardants (UK, 2007). The congener composition of widely-used commercial octaBDE mixtures, DE-79 and Bromkal 79-8DE was recently determined (LaGuardia *et al*., 2006). DE-79 was found to contain 15 PBDE congeners with major constituents including HexaBDE (BDE153, 8.7%), HeptaBDE (BDE175/183, 42%), OctaBDE (BDE197, 22%; BDE196, 10.5%; BDE203, 4.4%), and NonaBDE (BDE207, 11.5%). The DE-79 commercial octaBDE mixture has also been found to contain polybrominated dibenzofurans (Hanari *et al*., 2006). Bromkal 79-8DE contained 13 PBDE congeners with major constituents including HeptaBDE (BDE175/183, 13%), OctaBDE (BDE197, 10.5%; BDE196, 3.1%; BDE203, 8.1%), NonaBDE (BDE206, 7.7%, BDE207, 11.2%), and surprisingly DecaBDE in large quantities (BDE209, 50%).

Table 7. Typical composition of C-OctaBDE flame retardants (% by weight)

Main components	Up to 1994[a]	1997[c]	2000[d]	2001[e]	2006[f]	2006[g]
PentaBDE	10.5-12.0[b]		1.4-12.0[b]	≤0.5		
HexaBDE		5.5		≤12	10.5	0.3
HeptaBDE	43.7-44.5	42.3	43.0-58.0	≤45	45.5	12.8
OctaBDE	31.3-35.3	36.1	26.0-35.0	≤33	37.9	21.8
NonaBDE	9.5-11.3	13.9	8.0-14.0	≤10	13.1	18.9
DecaBDE	0-0.7	2.1	0-3.0	≤0.7	1.3	49.6

Note:
a) 1994 data are taken from WHO (1994).
b) This value is for the total amount of PentaBDE + HexaBDE.
c) 1997 data are from a composite sample from three suppliers to the EU (Stenzel and Nixon, 1997).
d) 2000 data are taken from RPA (2001) and represent the composition reported to the OECD under a Voluntary Industry Commitment.
e) 2001 data from the Great Lakes Chemical Corporation represent the upper bound composition based on random sampling of selected production lots from August 2000 to August 2001.
f) Data for DE-79 manufactured by Great Lakes Chemical Corporation, USA (LaGuardia et al., 2006).
g) Data for Bromkal 79-8DE manufactured by Chemische Fabrik Kalk, Germany (LaGuardia et al., 2006).

1.2 Conclusions of the Review Committee regarding Annex E information

579. Annex E of the Stockholm Convention requires a Risk Profile to be developed to evaluate whether the chemical is likely, as a result of its long-range environmental transport, to lead to significant adverse human health and/or environmental effects, such that global action is warranted.

580. A Risk Profile for C-OctaBDE was developed and accepted in 2007 (UNEP, 2007b). In decision POPRC-3/6, the POP Review Committee concluded as follows (UNEP, 2007a):

581. "Taking into account the high potential of the components of commercial octabromodiphenyl ether to persist in the environment, to bioaccumulate and biomagnify and to represent a hazard for humans and wildlife at very low levels, The Persistent Organic Pollutants Review Committee:

- Invites the intersessional working group on commercial octabromodiphenyl ether which prepared the risk profile to explore any further information on including octabromodiphenyl ether and nonabromodiphenyl ether related to risk estimations and bioaccumulation, including the environmental and health relevance of de-bromination, and, if appropriate, to revise the risk profile for consideration by the Committee at its fourth meeting.
- Decides, in accordance with paragraph 7 (a) of Article 8 of the Convention, that the hexa- and hepta bromodiphenyl ether components of the commercial octabromodiphenyl ether are likely, as a result of long-range environmental transport, to lead to significant adverse human health and/or environmental effects such that global action is warranted;
- Decides, in accordance with paragraph 7 (a) of Article 8 of the Convention, and taking into account that a lack of full scientific certainty should not prevent a proposal to list a chemical in the annexes of the Convention from proceeding, that the octa- and nona bromodiphenyl ether components of the commercial octabromodiphenyl ether are likely, as a result of long-range environmental transport, to lead to significant adverse human health and/or environmental effects such that global action is warranted. "

1.3 Data sources

582. Most developed countries have taken some actions to limit the production and use of C-OctaBDE. Until 2004, production occurred in the Netherlands, France, USA, UK and Israel (UNEP 2008, BSEF 2006) but C-OctaBDE is no longer produced in the EU and USA. Information about production in developing countries is sparse e.g. there is no production or uses in Armenia (UNEP 2008, Armenia). In addition, a number of international measures have also been taken related to C-OctaBDE.

European Union

583. Within the European Union, two producers of C-OctaBDE are reported in the EU IUCLID database in 1994. However, both companies stopped production within the EU (1996/1998).

584. The amount imported into the EU in 1999 was estimated to be 450 tonnes/year as the substance itself, with around 1,350 tonnes/year imported in finished articles (European Commission, 2003a). Due to legislative restrictions in place in the EU, import of C-OctaBDE as substance or in articles is prohibited, since "import" is considered as "placing on the market" in the EU legislation.

585. In the EU, C-OctaBDE was identified as a priority substance for risk assessment under Regulation 793/93/EEC. There are two areas where a definite need for risk reduction measures has been identified in the draft risk assessments for human health and the environment (subject to any further changes).

586. Based on the risk assessment, UK prepared a Risk Reduction Strategy and analysis of advantages and drawbacks of possible measures (RPA, 2002).

587. As a result of the European Union Risk Assessment process, Directive 2003/11/EC was adopted in 2003 (European Union, 2003) which prohibits the placing on the market and use of OctaBDE as a substance or as a constituent of substances or of preparations in concentration higher than 0.1% by mass. Articles may not be placed on the market if they, or flame-retarded parts thereof, contain OctaBDE in concentrations higher than 0.1% by mass. Member States were obliged to implement the prohibition by February 15, 2004 and apply the measures from August 15, 2004.

588. The European Union banned the use of PBDE in new electronics and electronic products as of July 1, 2006 pursuant to the Directive on restrictions on hazardous substances (RoHS) (European Union, 2002a).

589. To control and minimise environmental impacts from products containing PBDEs that are already in use, Directive 2002/96/EC on waste electrical and electronic equipment (WEEE) sets specific requirements with respect to collection, recovery, permitting of treatment installations, treatment standards and separation (European Union, 2002b). The Directive obliges Member States to adopt appropriate measures to minimise disposal of products containing PBDEs as unsorted waste and to achieve a high level of separate collection of WEEE. Since August 13, 2005 collection systems

from households and take-back obligations were required. By December 31, 2006, separate collection of at least four kilograms of WEEE per inhabitant per year from private households was to be achieved. Treatment is only allowed in authorised installations complying with minimum technical requirements. In addition minimum treatment requirements were specified and specific targets are set as recovery rates per appliance (by weight).

590. Brominated diphenylethers are mentioned as hazardous substances in the list of priority substances for water policy purposes, with the aim of progressively reducing pollution from these substances (European Union, 2000).

591. Prior to the Community level control measures on C-OctaBDE, several EU Member States had already introduced voluntary measures or national restrictions to phase out C-OctaBDE.

Switzerland

592. The Ordinance on Risk Reduction (ORR) related to the use of certain particularly dangerous substances, preparations and articles (Switzerland, 2005) severely restricts marketing and use of C-OctaBDE in Switzerland. It prohibits to place on the market and to use C-OctaBDE or substances and preparations with an C-OctaBDE content equal to or greater than 0.1% by mass, except for analysis and research purposes. It also prohibits introduction of new articles in the market if they have parts that are treated with flame retardants containing C-OctaBDE exceeding 0.1% by mass. The prohibition in the ORRChem is the application of the EU Directive (European Union, 2003).

Norway

593. In Norway the use of C-OctaBDE is banned since July , 2004. From January 1, 2004, products containing more than 0.25 % C-OctaBDE are classified as hazardous waste if discarded (UNEP, 2007c Norway).

United States of America

594. In the USA C-OctaBDE is subject to EPA’s Toxic Substances Control Act (TSCA) Inventory Update Reporting Rule, under which production and import information is periodically collected. For the 2002 reporting year, U.S. production of C-OctaBDE was estimated in the range of 450 to 4,500 tonnes, and none reported for the 2006 reporting year (UNEP 2007, USA).

595. A voluntary phase out of production of C-OctaBDE went into effect January 1, 2005, followed by TSCA Significant New Use Rule (US EPA, 2006) to require notification upon any restart of production or import, for any use.

596. Several American States have passed legislation restricting or banning C-OctaBDE in the USA:

597. The status of the chemical under American States legislation is listed in UNEP/POPS/POPRC.4/INF/10 .

Canada

598. c-Octa BDE has never been produced in Canada (UNECE survey 2007, Canada). Results from a recent survey conducted for year 2000 confirmed that C-OctaBDE is not manufactured in Canada. However, approximately 1300 tonnes of PBDEs (including C-OctaBDE) were imported into Canada in that year (UNEP, 2007c Canada).

599. Canada published a scientific screening assessment on PBDEs on July 1, 2006. This assessment indicates that PBDEs, including all BDE congeners contained in C-OctaBDE, are toxic under section 64(a) of the Canadian *Environmental Protection Act*, *1999* (CEPA 1999). The report also recommends the implementation of virtual elimination for tetra-, penta- and hexaBDEs which were found to be persistent, bioaccumulative, and present in the environment primarily due to human activity. PBDEs were added to Schedule 1 (List of Toxic Substances) of CEPA 1999 in December 2006 (Canada Gazette, 2006b). In Fall 2006, Canada publicly released a proposed risk management strategy for addressing the identified risks posed by the use and/or release of PBDEs.

600. On July 9, 2008, Canada published the final *Polybrominated Diphenyl Ethers Regulations*. These Regulations prohibit the manufacture of seven PBDEs (tetraBDE, pentaBDE, hexaBDE, heptaBDE, octaBDE, nonaBDE and decaBDE) in Canada. The Regulations also prohibit the use, sale, offer for sale and import of tetraBDE, pentaBDE, hexaBDE and mixtures, polymers and resins containing these substances, and prohibit the manufacture of these mixtures, polymers and resins.

601. In addition to the *Polybrominated Diphenyl Ethers Regulations*, Canada is working on several other risk management actions, including: (i) a regulation to control PBDEs in domestic and imported manufactured products; (ii) a Performance Agreement with industry to minimize releases to the environment from the use of the DecaBDE commercial mixture in Canadian manufacturing operations; (iii) a detailed review of newly published science on the bioaccumulation and environmental transformation of decaBDE in order to determine whether further controls on this form of PBDE are warranted; (iv) development of a management strategy for PBDE-containing products at end-of-life, and; (v) monitoring Canadians’ exposure to PBDEs.

Asia-Pacific

602. C-OctaBDE has never been produced in Japan; it was imported. However, import and stock sales were voluntarily phased out by 2005.

603. C-OctaBDE was removed from the Australian Inventory of Chemical Substances (AICS) in February 2007.

604. By February 2006, China promulgated a law similar to the EU RoHS Directive. Targeted substances are the same as those targeted in the EU RoHS. When fully implemented, it will prohibit c-PentaBDE and C-OctaBDE use in new electric and electronic equipment. Implementation of phase 1 of the law (marking and disclosure only) came into effect March 1, 2007; implementation schedule for Phase 2 (full restriction) is currently unclear.

1.4 Status of the chemical under international conventions

The UNECE Convention on Long-range Transboundary Air Pollution

605. In 2005, C-OctaBDE was nominated as a new POP to the Convention and considered by the Executive Body of the Convention to meet the screening criteria for POPs. In 2006, management options for C-OctaBDE were assessed to give a basis for later negotiations on restrictions.

OSPAR Commission[22]

606. Brominated flame retardants were given priority in the 1992 OSPAR Action Plan and were included in the OSPAR List of Chemicals for Priority Action in 1998. c-Octa-BDE is part of the list of substances of possible concern (OSPAR, 2004). There are no specific OSPAR measures targeting releases of brominated flame retardants. OSPAR has promoted activities in the EC on use restrictions for PBDEs, risk-reduction strategies for octaBDE, decaBDE and HCBD and waste legislation. Environmental monitoring data indicate that discharges/releases of pentaBDE and octaBDE are decreasing. However, some diffuse releases may remain due to illegal occurrence in imported products (plastics etc.) (OSPAR, 2008).

Helsinki Commission (HELCOM)

607. The Baltic Marine Environment Protection Commission (HELCOM) has included OctaBDE on its list of substances and substance-groups suspected to be highly relevant to the Baltic Sea and subjected to data and information collection from Contracting Parties.

1.5 Any national or regional control actions taken

OECD (Organisation for Economic Cooperation and Development)[23]

608. Following the 1994 publication of a risk management monograph on brominated flame retardants--substances added to synthetic fibers and plastics to prevent fires and smoke--OECD Member countries and the manufacturers of these substances held discussions on possible actions that could further reduce risks. In 1995, OECD Member countries agreed to oversee a voluntary industry commitment (VIC) by the global manufacturers of brominated flame retardants to take certain risk management actions. (Overview of VIC, US/European VIC, Japan VIC) Compliance with the VIC is on-going. In parallel to this work, OECD conducted an investigation of the waste management practices in Member countries with respect to products containing Brominated Flame Retardants. The results of this investigation are documented in the Report on the Incineration of Products Containing Brominated Flame Retardants. In 2004 the first Hazard/Risk Information Sheets for five Brominated Flame Retardants were posted on the OECD site. The Information Sheets were updated in 2005[24].

2. Summary information relevant to the risk management evaluation

2.1 Identification of possible control measures

609. There are in principle several control measures that could be implemented to reduce the use of C-OctaBDE and/or to reduce the environmental impacts associated with the use of this substance, but some of these go beyond the scope of the Stockholm Convention. These include voluntary commitments by industry, eco-labelling schemes, economic instruments and a deposit refund system.

610. A ban/restriction on the production and use of C-OctaBDE and/or the components of the commercial mixture would be an effective measure if properly enforced. Some countries have already taken such actions. Standards aimed at reducing the concentrations of PBDEs in products would be very effective (RPA, 2001). However, the possibility that

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[22] The 1992 OSPAR Convention is the current instrument guiding international cooperation on the protection of the marine environment of the North-East Atlantic. It combined and up-dated the 1972 Oslo Convention on dumping waste at sea and the 1974 Paris Convention on land-based sources of marine pollution.

[23] http://www.oecd.org/document/63/0,3343,en_2649_34375_2403647_1_1_1_1,00.html

[24] http://www.oecd.org/dataoecd/44/46/36423809.pdf

a reduction of concentrations of PBDEs could lead to lack of effectiveness may limit the scope of this strategy. Standards could be used to ensure environmentally benign waste handling. Risk management would be best achieved by a global ban on production and use of C-OctaBDE, brought about by listing the components of the mixture under the Stockholm Convention. Suitable, more environmentally benign alternatives exist for all uses of C-OctaBDE so a ban could cover all sectors. A ban would eliminate emissions from the manufacturing of C-OctaBDE, and also eliminate release of bromodiphenyl ethers from the production and use of C-OctaBDE in new products. An important consideration is that a simple ban would not affect the emissions from C-OctaBDE in products already in use.

611. A ban on the production and use of C-OctaBDE would also affect waste issues. Listing a substance under the Stockholm Convention implies a ban on recycling and reuse of stockpiles and to treat contaminated sites. Article 6 of the Convention requires that wastes and stockpiles are handled in a safe, efficient and environmentally sound manner, so that the content is destroyed or irreversibly transformed. The article also bans disposal operations that lead to recovery, recycling, reclamation, direct use or alternative use of the POPs material.

612. Various control measures at the production or waste handling facilities would ensure safe work environments and regulations on waste handling of products etc. These measures could be applied at waste handling facilities. If properly designed and enforced this could be an effective tool to reduce releases from the sources in question.

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

613. The choice of control measure for the remaining use and production of C-OctaBDE must take into account that most developed countries have phased out production of C-OctaBDE. However, action is still needed for the protection of human health and the environment from emissions and releases of the components of C-OctaBDE. Further risk reduction options should be examined against the following criteria (RPA, 2001):

- Effectiveness: the measure must be targeted at the significant hazardous effects and routes of exposure identified by the risk assessment. The measure must be capable of reducing the risks that need to be limited within and over a reasonable period of time.
- Practicality: the measure should be implementable, enforceable and as simple as possible to manage. Priority should be given to commonly used measures that could be carried out within the existing infrastructure.
- Economic impact: the impact of the measure on producers, processors, users and other parties should be as low as possible.
- Monitorability: monitoring should be possible to allow the success of risk reduction to be assessed.

Waste handling

614. A ban on production and use of C-OctaBDE would not in itself affect emissions of its components of concern from waste handling, where they can present a technical and legacy problem. However, listing a substance under the Stockholm Convention implies a ban on recycling and reuse of stockpiles of C-OctaBDE itself. Article 6 in the Convention requires that wastes and stockpiles are handled in a safe, efficient and environmentally sound manner, so that the content is destroyed or irreversibly transformed, taking into account international rules, standards and guidelines. The article also bans disposal operations that lead to recovery, recycling, reclamation, direct use or alternative use of POPs material.

615. A special challenge could be to separate C-OctaBDE containing articles from those without the substance, since most articles are not labelled telling what they contain. However, there is information about articles that have contained C-OctaBDE in the past and about which articles it is used in today, like electronic articles, textiles and isolation material and casing materials. National authorities would have to conduct surveys to get more detailed information about C-OctaBDE content in different articles becoming waste. Technically the challenge would be the separation of bromine-containing and non-bromine-containing plastic components. Technologies on this field are emerging, thus aiding waste management and possible recycling, but they are expensive.

616. Targets for phase out of the use of existing products containing C-OctaBDE and the collection of these could be considered according to Annex A or B of the Convention. Since there are substantial stocks of products containing C-OctaBDE in use, national authorities could consider some additional measures to limit releases. These measures could range from establishing collection points where people can deliver their used products to more actively promoting and encouraging people to deliver their waste products. A deposit-refund system does not seem appropriate since sales of new products containing C-OctaBDE would no longer be allowed and their presence has become a legacy problem. However, paying people a fee to deliver their products would be an option, although a source of funding for such an operation is not obvious.

617. A special challenge would be to ensure proper handling of C-OctaBDE-containing waste material/articles in developing countries. Since these countries have limited experience in handling this kind of waste, they would need practical help and information as well as financial help to ensure environmentally sound handling of this waste. The assistance could include how to dismantle C-OctaBDE-containing articles, treat the various parts and the methods of

environmentally sound treatment of the final C-OctaBDE. If listed under the Stockholm Convention, guidelines on sound waste treatment of C-OctaBDE and articles containing C-OctaBDE will be developed under the Basel Convention (Article 6 para 2 of the Stockholm Convention).

Measures to reduce emissions

618. The UNECE survey 2007 indicated the lack of information on emission control techniques which are already applied or which may be applied in the near future, such as alternative production processes and technologies, alternative operating practices and/or other pollution prevention techniques to reduce the release of C-OctaBDE to the environment. No specific studies on C-OctaBDE emission control techniques have been identified.

619. The main remaining releases of C-OctaBDE occur during the service life and particularly at disposal of products containing C-OctaBDE. Controlling emissions caused by volatile losses from polymers over their service life is very difficult. The use of reactive type flame retarding compounds could be recommended as one potential measure.

620. Concerning emission control at disposal, several measures can be taken to reduce possible emissions. They are briefly discussed in this section.

621. A ban would eliminate emissions from the production, manufacturing and use of C-OctaBDE in new products. It would not affect the emissions from products already in use. Additional regulations could therefore be considered. This would for example be relevant for recycling and dismantling of electronic articles containing C-OctaBDE. Within the EU specific requirements concerning collection, recovery, permitting of treatment installations, treatment standards and separation are already established for plastics containing PBDEs (European Union, 2002).

622. Specific measures concerning the handling of waste at disposal and recycling/recovery could include separating articles containing C-OctaBDE from those without the substance (it is problematic to identify such articles) and sending them to controlled disposal processes (e.g. treatment as hazardous waste) or setting targets for the phase out of the use of existing products containing C-OctaBDE and implementing collection of these products. XRF guns are portable and can detect Bromine in articles with an automatic readout to indicate a pass or fail for ROHS or other regulatory standards. US federal agencies use this technology routinely. For example see http://www.innovxsys.com/en/products/eb/defender.

623. There are also concerns over export of electronic waste to developing countries leading to C-OctaBDE releases during recycling operations. In addition, burning or incineration of C-OctaBDE-containing waste could lead to formation and release of brominated dibenzo-*p*-dioxins and furans (Leisewitz *et al*., 2000).

624. During the use of C-OctaBDE, there are a number of measures that plastics compounders and processors could take to reduce their environmental emissions of C-OctaBDE. For example, in relation to losses to waste water and air via settling out of dust and subsequent release through washing, companies could modify their practices such that the dust is collected and disposed of as controlled waste. In relation to volatile losses, companies could ensure that all processes are totally closed, preventing losses to the environment, or they could install abatement technology at the site to ensure that any potential emissions are captured (RPA 2002).

625. In general measures identified to reduce environmental emissions at compounders and processors could also be applied to disposal, recycling/recovery and facility-dismantling. These should aim at minimising dust and air emissions and at avoiding input to waste water. In particular, measures could be suggested to reduce releases at disposal by applying BAT/BEP (Best Available Techniques/Best Environmental Practice) at disposal and recycling/dismantling/reuse. A source for possible measures is the BREF[25] on waste treatment, despite specific measures for recycling/recovery and dismantling have not been identified in it (European Commission, 2006). Other possible measures include simple technical and organisational measures and end-of-pipe controls to reduce releases to the environment, such as:

- Considering generic techniques applied to waste storage (e.g. controlled run-off from storage places; using polymer sheeting to cover open solids storage facilities that may generate particulates);
- Considering techniques to reduce water use and prevent water contamination (e.g. by vacuuming and dust collection in preference to hosing down);
- Minimising dust input to waste water and dust collection and disposal as controlled waste (incineration or landfill);
- Applying appropriate waste water treatment processes;
- Using local exhaust ventilation to control dust and volatile emissions;
- Shredding in closed systems, including dust separation and thermal treatment of exhaust air.

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[25] BREF = Best available techniques REFerence document.

2.3 Information on alternatives (products and processes) where relevant

626. The phase out of C-OctaBDE is already advanced: production has stopped in the EU, USA and Canada. Voluntary phase out by industry is underway in Japan. In light of the ban and phase out of C-OctaBDE in 2004 in the European Union and an already increasing use of alternatives, the availability of practicable and economically viable substitutes has already been demonstrated in practice (see INF document related to this paper).

627. Design changes can eliminate the need for flame retardants by using alternative materials or designs that remove the need for chemical flame retardants (see INF document related to this paper).

Chemical substitutes for C-OctaBDE in ABS plastic

628. The report "Risk Reduction Strategy and Analysis of Advantages and Drawbacks for Octabromodiphenyl Ether" (RPA, 2002) preceding the EU level control measures contains an analysis on the suitability of various alternatives to C-OctaBDE in terms of technical performance, health and environmental risks and cost implications. Potential alternatives identified include tetrabromobisphenol-A, 1,2-bis(pentabromophenoxy) ethane, 1,2-bis(tribromophenoxy) ethane, triphenyl phosphate, resourcinol bis (diphenylphosphate) and brominated polystyrene.

629. In ABS, TBBPA and brominated epoxy oligomers are used as additive flame retardants meaning that they are not bound to the polymer and therefore have a greater tendency to be released to the environment. TBBPA is a cytotoxicant, immunotoxicant, and thyroid hormone agonist with the potential to disrupt estrogen signaling (Birnbaum and Staskal, 2004). TBBPA is classified as very toxic to aquatic organisms and is on the OSPAR Commission's List of Chemicals for Priority Action due to its persistence and toxicity (RPA, 2002; OSPAR, 2005) . To avoid their use in ABS applications, poly (phenylene oxide) / high impact polystyrene (PPO / HIPS) blends flame retarded with resorcinol diphosphate (RDP) have been proposed (Morose, 2006).

630. Bisphosphate and its derivatives include RDP and are used in "Blue Angel" printers and PCs with PC / ABS casings (Leisewitz et al., 2000). The US EPA DfE report lists triaryl phosphate and an isopropylated derivative as having moderate bioaccumulation properties based on structure activity relationships (US EPA, 2005). Bis (tribromophenoxy) ethane is poorly characterized. Studies by its manufacturer indicate low toxicity, but the substance tends to persist and bioaccumulate (Washington State, 2005).

Chemical substitutes for C-OctaBDE in synthetic textiles

631. Reactive-type flame retardants are usually used in thermosetting material (e.g. polyester resins, epoxy resins, polyurethanes). Chemical substitutes for C-OctaBDE in textiles include reactive phosphorous constituents and hexabromocyclododecane. Specific reactive phosphorous constituents were not identified in a Danish report though polyglycol esters of methyl phosphonic acid (CAS 676-97-1) have been used for flame retardants in polyurethane foam (e.g. CAS 294675-51-7) (Danish Environmental Protection Agency, 1999). Methyl phosphonic acid has attracted attention of those working on chemical weapons since it is a degradation product of VX, sarin, and soman (OPCW, 2006). Researchers at the Oak Ridge National Laboratory in the US describe methyl phosphonic acid as one of degradation products of chemical weapons with "significant persistence"(Munro *et al.* 1999a), However, methyl phosphonic acid does not appear to be bioaccumulative (Munro *et al.* 1999b). Other types of reported toxicity are minimal, but the substance reacts violently with water (US EPA, 1985). The phosphonic acid family also includes amino-methyl phosphonic acid, a degradation product of the herbicide glyphosate (also known as [carboxymethylamino] methyl phosphonic acid.)

632. Hexabromocyclododecane (HBCD) is used as an additive flame retardant indicating that it is not bound to the polymer and therefore has a greater tendency to be released to the environment. HBCD is bioaccumulative, persistent, and causes neurobehavioral alterations in vitro (Birnbaum and Staskal, 2004),

Chemical substitutes for C-OctaBDE in thermoplastic elastomers

633. Additive-type flame retardants are usually used in thermoplastic material (e.g. Polypropylen, Polyethylen, Ethylen-Vinylacetate, PVC).

634. Chemical substitutes for C-OctaBDE in thermoplastic elastomers include bis (tribromophenoxy) ethane and tribromophenyl allyl ether (Danish Environmental Protection Agency, 1999). Bis (tribromophenoxy) ethane is discussed above under alternatives for C-OctaBDE in ABS plastic. Very little information was available for tribromophenyl allyl ether, though it is on a list of flame retardants considered "deferred" for testing by the interagency testing committee of US EPA (IPCS, 1997).

Chemical substitutes for C-OctaBDE in polyolefins

635. Chemical substitutes for C-OctaBDE in polyolefins include polypropylene-dibromostyrene, dibromostyrene, and tetrabromobisphenol A (TBBPA) (Danish Environmental Protection Agency, 1999). TBBPA is described above in chemical substitute alternatives for C-OctaBDE in ABS plastic. Few data are available for dibromostyrene and polypropylene-dibromostyrene. For dibromostyrene, an EU assessment found insufficient information on toxicity, no

bioaccumulation based on a low BCF value, and overall persistence of 49 days based on modelling (Pakalin et al., 2007).

Technical feasibility

636. All above described alternatives to C-OctaBDE are technically feasible and have been used in commercial applications.

637. The EU RPA concludes, "Based on consultation with industry, it is evident that most companies have already replaced octabromodiphenyl ether in their products with other flame retardants and some companies utilise design measures, rather than flame retardants, for certain types of products. Overall, there does not appear to be any major technical obstacle to replacement of the substance, although some of the flame retardant/polymer combinations considered in this section may have inferior technical performance in certain applications" (RPA, 2002).

638. Many high profile companies have already implemented alternatives to C-OctaBDE. For example, Dell (#1 in US PC sales) eliminated all halogenated flame-retardants in all desktop, notebook and server chassis plastic parts in 2004 and has recently expanded these restrictions to include all products designed after June 2006 (Greiner et al., 2006). Lenovo (#6 in US PC sales) has eliminated PBDEs including C-OctaBDE in all of their products (Pierce, 2006). LG Electronics (#8 in US TV sales) plans to eliminate all brominated flame retardants by 2010 (Clean Production Action, 2006). A comparison of computer, TV, and game manufacturers on their BFR phase-out timelines and BFR-free products has also been assembled by Greenpeace and is updated every three months (Greenpeace International, 2007).

639. Additional companies that have phased out PBDEs in all their products include: IBM, Ericsson, Apple, Matsushita (including Panasonic), Intel, and B&O (Lassen et al., 2006).

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

Benefits of phasing out C-OctaBDE

640. The most obvious benefit to global society of phasing out C-OctaBDE would be reduced risk to human health and the environment due to reduced releases to air, water and soil of the components considered to be POPs, as well as their releases in workplace settings (UNEP, 2007b). Some components of C-OctaBDE enter into the food chain and bioaccumulate in fatty tissues of top predators, including humans. They have been detected in several endangered species.

641. Levels of some C-OctaBDE components have been found in humans in all regions of the world (UNEP, 2007b). Potential exposure of humans is through food and use of products containing C-OctaBDE. C-OctaBDE transfers from mothers to embryos and breastfed infants. UNEP (UNEP, 2007b) concludes that C-OctaBDE is likely to cause significant adverse effects on human health or the environment, such that global action is warranted. Its continued use could entail a potentially large cost.

642. Fire prevention is important for protecting human safety, and avoiding social and economic losses due to fire, and also for preventing the spread of toxic materials released by fires into the environment. Using less quantity of flame retardant substances, or less effective retardant agents, could therefore cause greater losses if fires become more frequent. However, according to European Commission (European Commission, 2005), the available alternatives function as well as C-OctaBDE and most of them are less hazardous to the environment than C-OctaBDE.

643. An estimate should be made of cost reduction to society from reduced damage to ecosystems and public health, when materials like C-OctaBDE are removed from the market. The value of reduced damage to environment and health is difficult to quantify, but several methods have been suggested. The Polluter Pays Principle, under which such costs should be internalized by the producer and/or the user, is seldom applied (at least without regulatory assistance); so, no good estimates are available of the potential cost of damage avoided. Anyhow, overall net benefits of phasing out C-OctaBDE for human health and the environment are most likely positive.

Cost implications for industry

644. Production was recently phased out in the EU, Norway, Switzerland, Canada, Japan and the USA. No information has been found indicating whether it is being produced in developing countries. Processing of C-OctaBDE is considered nonexistent in the EU and Canada. Appropriate substitutes for C-OctaBDE are available and mass-production of alternatives can significantly lower their costs (Ackerman and Massey , 2006).

645. Canada expects null cost impacts on industry due to substitution of C-OctaBDE (Canada Gazette, 2006a). Because of the complete ban and phase out of C-OctaBDE a similar conclusion can be made for Europe. Taking account of the voluntary phase out of C-OctaBDE in the USA, additional costs are also not expected for USA industries.

646. Canada considers that it is not possible to quantify and monetise the preventative (health and environment) benefits of the proposed regulations because PBDE use by industry has been discontinued and future demand for this substance cannot be estimated. However, costs to industry and government of the proposed regulations have been

estimated considering the economic criterion of cost to industry due to reformulating away from C-OctaBDE. This cost was deemed to be nil (zero) as substitutes are available, their price dropped, and C-OctaBDE is no longer being manufactured, imported or used in Canada. Therefore, the industry is not expected to experience any incremental costs as a result of the regulatory requirements. Costs to government were also considered as part of the economic analysis, which included compliance promotion and enforcement activities; these costs were calculated over a 25-year time frame and estimated to be in the order of $439,646 (discounted at 5.5%). Overall, the Regulations were estimated to result in a negative net benefit of $439,646 (net present value discounted at 5.5%) over a 25-year time frame (UNEP, 2008 Canada).

647. Also if a ban of C-OctaBDE comes into force it would be reasonable to implement BAT/BEP (Best Available Techniques/Best Environmental Practices) in order to reduce releases from products containing C-OctaBDE at disposal and recycling/recovery facilities. Additional costs could particularly arise from technical measures applied at disposal, recycling/recovery and dismantling facilities. Possible technical measures are related to BAT/BEP and require economically reasonable operational and/or investment costs. By definition, costs due to the application of BAT are economically viable, as this term designates economically and technically available techniques. The BEPs are usually linked to BAT and its effective and efficient operation.

648. Installing end-of-pipe control technologies could be costly, but in most countries, particularly in developed ones, end-of-pipe measures already exist for disposal and recycling/reclamation plants (e.g. for off-gas cleaning in incineration plants and emission control in shredding plants). Therefore, expected cost implications are limited to those countries.

649. Within the EU, the European Commission and the UK have prepared a Risk Reduction Strategy and an analysis of advantages and drawbacks of possible measures to reduce the risks identified for the environment through the European Union Risk Assessment procedure (RPA, 2002). In light of the ban and phase out of C-OctaBDE such analysis is no longer up-to-date, in particular regarding the economic assessment.

Cost implications for consumers

650. In the RPA cost assessment it has been indicated that increased costs would be passed on to the consumer (RPA, 2002). As there will be no further increases in cost to industry, no increased cost for consumers are expected. However, even though C-OctaBDE may no longer be used in production of consumer items, there will be a considerable bank of products in the community which do contain C-OctaBDE. There will clearly be costs to consumers if jurisdictions pass on them the costs of environmentally sound disposal (ESD) methods.

Cost implications for state budgets

651. In the EU no incremental costs for state budgets are expected due to the ban and phase out of C-OctaBDE as a consequence of the proposed option. Additional budgets for enforcement and compliance are not required.

652. Canada has performed a regulatory impact analysis for the costs incurred by the federal government as a result of enforcement and compliance promotion activities related to the *Polybrominated Diphenyl Ethers Regulations*. Published on July 9, 2008 (prohibition of the manufacturing of seven PBDEs (tetraBDE, pentaBDE, hexaBDE, heptaBDE, octaBDE, nonaBDE and decaBDE); prohibition of the use, sale, offer for sale and import of tetraBDE, pentaBDE, hexaBDE and mixtures, polymers and resins containing these substances, and prohibition of the manufacture of these mixtures, polymers and resins)

653. Key assumptions used for the analysis include the following:

- Time frame for analysis: costs and benefits are assessed over a 25-year time frame (2007 to 2032).
- Accounting stance: the costs and benefits assessed are those that directly or indirectly affect Canada or Canadians. All costs and benefits are in 2006 Canadian dollars[26].
- Discount rate: where possible, impacts are reported as net present values and a real social discount rate of 5.5% is used.
- Risk and uncertainty testing: the key sources of uncertainty were identified and are considered in the analysis.

654. Total enforcement and compliance promotion costs for the Canadian Government over the 25-year time frame were reported to be in the order of $327,420 Canadian dollars which can be split up as follows:

- With respect to enforcement costs, for the first year following the enforcement of the Regulations, a one-time amount of $75,000 will be required for the training of enforcement officers.

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[26] 1€ = 1.53 Canadian dollars

- In addition, for years one through five following the delivery of the training, the enforcement costs are estimated to require an annual budget of $22,633 broken down as follows: $7,475 for inspections (which includes operations and maintenance costs, transportation and sampling costs), $14,330 for investigations and $828 for measures to deal with alleged violations (including environmental protection compliance orders and injunctions).
- For the subsequent years (6 through 25), the enforcement costs are estimated to require a total budget of $47,582 broken down as follows: $13,500 for inspections (which includes operations and maintenance costs, transportation and sampling costs), $14,330 for investigations and injunctions, $1,656 for measures to deal with alleged violations and $18,096 for prosecutions.
- Compliance promotion activities are intended to encourage the regulated community to achieve compliance with the Regulations. Compliance promotion costs would require an annual budget of $118,000 during the first year of coming into force of the Regulations. Compliance promotion activities could include mailing out of the final Regulations, developing and distributing promotional materials (i.e. a fact sheet, Web material), the development of an advertising campaign in specialized trade publications, attendance at association conferences and workshops/information sessions to explain the Regulations. This could also include responding to and tracking inquiries in addition to contributing to the compliance promotion database.
- In the four years that follow, compliance promotion activities could decrease in intensity and focus on sending letters, advertising in specialized trade magazines, attending association conferences, responding to and tracking inquiries, and contributing to the compliance promotion database. This would require a budget of $36,800. Note that a higher level of effort for compliance promotion may be required if enforcement activities of the Regulations are insufficient. For subsequent years, no additional compliance promotion activity is expected, and therefore, total compliance promotion costs are estimated at $154,800.

655. To conclude, Canada expected no incremental costs for state budgets in light of the regulations on PBDE. Additional budgets for enforcement and compliance are not required.

656. No information has been provided by developing countries concerning the impact of the possible restriction of c-octaBDE. However, as some of these countries use or have used this substance, its listing to the Convention could have some incremental costs on their state budgets. In this regard, it may be necessary to ensure technical and financial assistance for these countries to allow them to respect their obligations under the Stockholm Convention.

Comparisons of costs and benefits

657. Given the conclusions of the Risk Profile (UNEP 2007) for C-OctaBDE, its widespread global occurrence in biota and in humans, action taken or underway to phase it out in developed and developing countries and the increased demand for alternatives to C-OctaBDE, the overall consequence of a full global phase-out is most likely to be positive. Overall, the cost for developed countries of a phase out of C-OctaBDE should be small, as discussed above. However, specialized waste management and disposal related to C-OctaBDE (stockpiles and articles) could be costly for some countries and financial and technical assistance to developing countries should be considered to address this aspect as required.

2.5 Other considerations

Possible management options

658. The objective of the Stockholm Convention is to protect human health and the environment from POPs while being mindful of the Precautionary Approach as set forth in Principle 15 of the Rio Declaration on Environment and Development. In practice this means adopting measures to eliminate releases from intentional production and use such as prohibition of production, use, import, and export; setting measures to reduce the releases from unintentionally-produced POPs with the goal of continuing minimization and ultimate elimination; and devising measures to manage stockpiles and wastes in an appropriate environmentally sound manner.

659. The main remaining emissions of C-OctaBDE occur during the service life and particularly at disposal and recycling/reclamation of products containing C-OctaBDE; however, re-introduction of a product or similar products is currently possible.

660. Possible management options are to restrict or eliminate production and use of C-OctaBDE and/or its congeners having POP characteristics. Listing C-OctaBDE but naming the individual congeners as markers for enforcement purposes could facilitate the monitoring and control of emissions, production and use. This would also be consistent with existing national legislations. All mixtures containing congeners having POP characteristics would then be covered by the Convention, except when they occur as traces.

661. Options for the regulation of C-OctaBDE have also been discussed in the risk management evaluation of c-PentaBDE (UNEP, 2007d). It was suggested that, if a decision is taken to list the bromodiphenyl ethers with four or five bromines, consideration should be given to also listing HexaBDE, which constitutes a small proportion of the c-

PentaBDE mixture. While this has some obvious advantages, the earlier information on c-PentaBDE (including the Annex D Risk profile statement) has not included much information about the HexaBDE. Also, since HexaBDE is a component of the C-OctaBDE, listing the HexaBDE would need to be considered when evaluating management options for C-OctaBDE.

662. In agreement with a risk management evaluation for c-PentaBDE, the Persistent Organic Pollutants Review Committee decided, in accordance with paragraph 9 of Article 8 of the Convention, to recommend to the Conference of the Parties that it consider listing in Annex A of the Stockholm Convention 2,2', 4,4'- tetrabromodiphenyl ether (BDE-47, CAS No. 40088-47-9) and 2,2',4,4',5-pentabromodiphenyl ether (BDE-99, CAS No. 32534-81-9) and other tetra- and pentabromodiphenyl ethers present in commercial pentabromodiphenyl ether, using BDE-47 and BDE-99 as markers for enforcement purposes (UNEP 2007a).

Discussion of options

663. C-OctaBDE can be released from production, handling, compounding and conversion (processing), use of products, disposal, recycling and dismantling.

664. In order to achieve long term elimination and prevent re-introduction of C-OctaBDE or the congeners having POP characteristics, production and use should be completely banned. Only this action would ensure the long term elimination of all risks from the POP components contained in commercial BDE mixtures and would contribute to achieving maximum non-quantifiable benefits. This would also prevent new production of c-PBDE using different congeners of hexa- and heptaBDEs to formulate new c-PBDE mixtures.

665. Several countries have reported that they will experience problems to regulate a commercial mixture of PentaBDE (UNEP 2007d) because most national regulations concern compounds. This is also valid for C-OctaBDE. For this reason, POPRC has recommended listing tetra- and pentabromodiphenyl ethers using specific BDE congeners as markers for enforcement purposes. Likewise, for C-OctaBDE, hexa- and hepta-, bromodiphenyl ether congeners could be listed and the following relevant congeners could be used as markers for enforcement: BDE153/154 (hexaBDE) and BDE175/183 (heptaBDE). This has two advantages. First, the markers serve as precise regulatory indicators to support more efficient monitoring and control. Second, production and use of all components of the C-OctaBDE mixture will be prohibited in keeping with Convention objectives.

666. Based on the chemistry of the PBDE formation reactions, it is unlikely that it would be cost-effective for industry to produce mixtures excluding the major identified congeners using current manufacturing processes.

3. Synthesis of information

3.1 Summary of evaluation

667. The term “C-OctaBDE” designates a commercial mixture containing polybrominated diphenyl ethers, typically consisting of penta- to decabromodiphenyl ether congeners. The specific composition of older mixtures or mixtures from various countries may be different. C-OctaBDE has been used as an additive flame retardant mainly in the plastics industry for polymers used for housings of office equipment. The risks it poses to human health and the environment have been explored in the Annex E Risk profile adopted by the POPRC in November 2007 (UNEP, 2007b).

668. There are national and international standards for fire safety for some product groups. This applies for example to electrical material, industrial packaging, upholstered furniture, curtains, electronic household appliances and electrical cables. These standards specify the flame-retarding properties that are required. Traditionally brominated flame retardants have been considered to be the most cost-effective way of imparting ignition resistance to many types of articles. However, in many cases these are being replaced with flame retardants without bromine, or the design of the product is changed so that there is no need for the continued use of flame retardant chemicals.

669. Suitable and economically viable alternatives are available for all uses of C-OctaBDE. Their human health or environmental impacts render them preferable over C-OctaBDE. However, some alternatives currently in use cause concern because of their properties or lack of available data. Reactive-type flame retardants, where these can be used, and halogen-free substitutes appear to be generally preferable regarding environmental and health aspects.

670. Incremental costs as a result of a complete ban are not expected for the industry.

671. A ban of C-OctaBDE would ultimately eliminate emissions from the production, manufacturing and use in new products. It would neither affect the emissions from products already in use nor directly influence emissions from disposal or recovery. Application of BAT/BEP at disposal and recycling/dismantling/reuse could be an efficient and economically reasonable way to minimise related emissions.

672. Costs implications for consumers are not expected.

673. Financial costs for Governments would depend on the management actions taken. There might be costs associated with mandated control measures e.g. monitoring and enforcement of waste management facilities. There might also be costs associated with monitoring and controlling articles containing C-OctaBDE.

3.2 Elements of a risk management strategy

674. Since the dissemination of bromodiphenyl ethers into the environment is a global, transboundary problem, some global actions to phase out C-OctaBDE should be considered. Risk management could be best served by a global ban on production and use of C-OctaBDE covering all sectors. Listing congeners of C-OctaBDE having POP characteristics under Annex A of the Stockholm Convention would be the most appropriate measure, given that most developed countries have already banned production. Developed countries have in place all monitoring and control capacities as well as legislative tools to enforce a ban. Thus, the main enforcement challenge would be for the developing countries to get sufficient capacities in place.

675. Using relevant congeners of the C-OctaBDE mixture as markers for enforcement purposes would be consistent with existing national legislation in several countries for components of C-OctaBDE and would facilitate the national monitoring and control of emissions, production and use.

676. Providing guidance on criteria for the selection of alternatives to C-OctaBDE should be part of the risk management strategy for the elimination of this substance. It will be important to discourage the replacement of C-OctaBDE with other environmentally harmful substances.

677. Waste fractions containing C-OctaBDE should be handled in a safe, efficient and environmentally sound manner. A cost effective way to identify such wastes is needed. This could impose extra costs on some countries and sectors. The solutions for waste handling should, to a large extent, depend on local conditions and be designed to fit into existing systems and traditions, taking the broad rules of the Stockholm Convention into consideration, including the general guideline on waste handling in the Basel Convention, which includes in its Annex VIII such substances as PCBs, polybromobiphenyls and 'other polybrominated analogues'.

4. Concluding statement

678. This risk management statement has been prepared in accordance with the content specified in Annex F of the Convention, and builds on the Risk Profile adopted by the POPRC in November 2007 (UNEP, 2007b). It concludes that components of commercial octabromodiphenyl ether are likely, as a result of long range environmental transport, to lead to significant adverse human health and/or environmental effects such that global action is warranted.

679. The Stockholm Convention, through the Persistent Organic Pollutants Review Committee aims at protecting human health and the environment from POPs, while being mindful of the Precautionary Approach as set forth in Principle 15 of the Rio Declaration on Environment and Development. It seeks to adopt measures to eliminate releases from intentional POP production and use, to reduce or eliminate releases from unintentional POP production, and to reduce or eliminate POP releases from its stockpiles and wastes in support of the goal agreed at the 2002 Johannesburg World Summit on Sustainable Development of ensuring that by the year 2020, chemicals are produced and used in ways that minimize significant adverse impacts on the environment and human health.

680. Therefore, in accordance with paragraph 9 of Article 8 of the Convention the Committee recommends to the Conference of the Parties to consider listing and specifying the related control measures of hexa- and hepta-, bromodiphenyl ether congeners in Annex A of the Convention, as described above, and using as markers for enforcement purposes: BDE153/154 (hexaBDE) and BDE175/183 (heptaBDE).

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Pentachlorobenzene
UNEP/POPS/POPRC.4/15/Add.2

Executive Summary

681. 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.

682. 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[27].

683. 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 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.

684. Unintentional anthropogenic sources can be divided into point sources and diffuse sources.

685. As regards point sources, combustion and thermal processes and industrial processes are most important and releases 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 releases formed by combustion. Most measures taken to reduce PCDD/F releases, as described in the Stockholm Convention's BAT/BEP guidelines for incinerators and other thermal processes, will lead to a significant reduction of the releases of PeCB. The most relevant diffuse sources are impurities in products such as, solvents, pesticides and wood preservative products, and barrel burning, open fire places, accidental fires and forest burning for agricultural purposes. For these sources abatement techniques are not feasible and release reduction measures can only be enacted by legislation and/or providing information and education by the national and local authorities.

686. 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 releases. 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/Fs, PCBs and HCB) under the Convention.

1. Introduction

1.1 Chemical identity

Background

687. 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

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

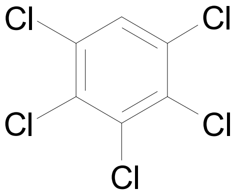
of the Convention. The complete original proposal is contained in document UNEP/POPS/POPRC.2/INF/5. A summary of the proposal prepared by the Secretariat was provided in document UNEP/POPS/POPRC.2/13. The risk profile of PeCB was adopted on the third meeting of the Persistent Organic Pollutants Review Committee in November 2007 (UNEP/POPS/POPRC.3/20/Add.7).

Chemical identity of the proposed substance

688. 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: None

Figure 3. Structure of 1,2,3,4,5-Pentachlorobenzene



1.2 Conclusion of the Review Committee, Annex E information

689. 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.

690. 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.

691. 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 has 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.

692. 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

693. 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). During the process of drafting the RME additional information was received from Australia, Germany, the Republic of Korea, Mauritius and Slovakia.

694. In addition, information is gathered from the open literature. Relating to the UN-ECE 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

695. 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:

- Listing of PeCB in annex I to the Protocol in order to prevent production and use;
- Listing of PeCB in annex I and annex III to the Protocol.

696. 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

697. 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 allows exemptions where they are used with PCBs. PCBs are regulated under the *Chlorobiphenyls Regulations* and *Storage of PCB Material Regulations*.

698. Various other initiatives also contribute to reductions in PeCB emissions in Canada, such as:

- Canada-wide Standards for dioxins and furans;
- 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;
- Wood Preservation Strategic Options Process; and
- Regulations for the control of tetrachloroethylene from the dry-cleaning sector.

Czech Republic

699. 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

700. 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 stopped after June 2002).

701. 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).

Republic of Korea

702. Pentachlorobenzene is not regulated under the Hazardous Chemicals Management Act. According to a survey conducted in 2006, the chemical was not manufactured nor imported in the Republic of Korea.

Mauritius

703. PeCB is neither produced nor used in the Republic of Mauritius.

Moldova

704. 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.

Mozambique

705. Pentachlorobenzene (proposed by the European Community and the Members

706. States that are Parties to the Stockholm Convention) has been never used in Mozambique.

United States

707. 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.

708. 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

General information on sources, releases and measures

709. 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 releases 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.

710. 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 release sources and related reduction measures is given in Figure 4.

711. Anthropogenic sources can be divided into intentional and unintentional sources.

712. 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 cannot 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.

713. Unintentional anthropogenic sources can be divided into point sources and diffuse sources.

714. As regards point sources, large scale combustion processes and industrial processes are most important and releases are controlled by abatement techniques and/or legislation.

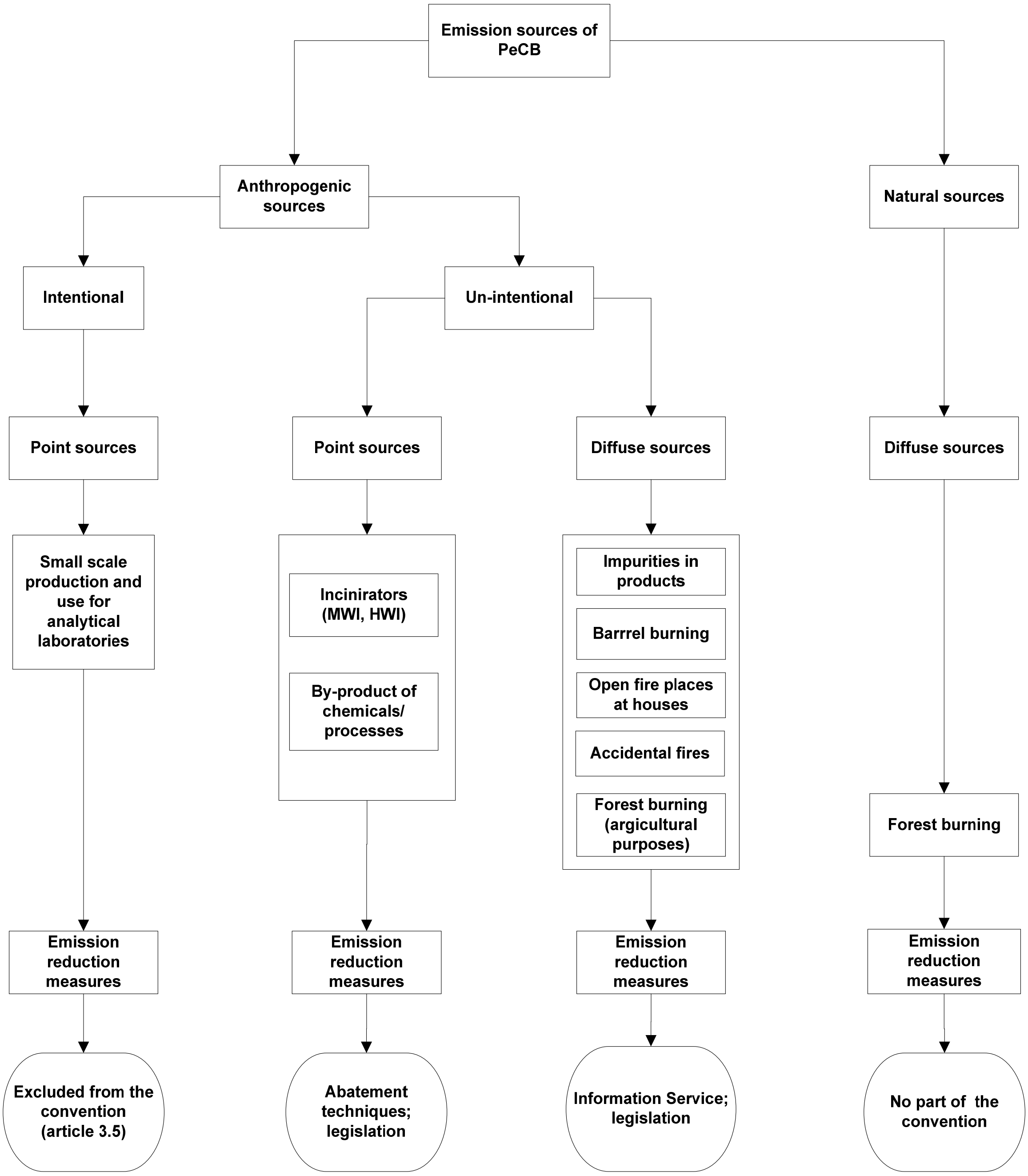
715. The most relevant diffuse sources are;

- As an impurity in products such as, solvents, pesticides and wood preservative products,
- Uncontrolled combustion such as barrel burning an open fire places,
- Accidental fires and
- Forest burning for agricultural purposes.

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

717. Forest and bush fires can be expected to be a source of PeCB, but no data are available to quantify possible releases. However, there is good correlation between the releases of PCDD/F and PeCBs during the open burning of household wastes (Lemieux et al., 2004; EPA 2002), and the information of PCDD/F releases from forest fire simulations (Gullett and Touati, 2003). Article 5 of the Stockholm Convention states 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 and forest fires are not further discussed.

Figure 4. Emission sources of PeCB of current activities and related possible release reduction measures



718. 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.

719. Total releases for the US between 2000 and 2004 as reported in the TRI varied between 763 and 1512 kg/year (UNEP, 2007). Global releases of PeCB, including natural sources, are estimated to be 85,000 kg (Bailey, 2007). Data on other sources are provided in the risk profile for Pentachlorobenzene.

Pentachlorobenzene production and use

720. 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.

721. 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. Quintozene is registered for use in 13 products in Australia against fungal diseases in turf, cotton, horticulture and ornamentals (comment Australia 14-05-08). Bailey (2007) 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 to draw a general conclusion on PeCB content of quintozene and the worldwide production and use of quintozene.

722. Production of quintozene 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 Columbia in Canada reported sales for quintozene to be 15,581 kg in 1995 (Government of British Columbia, 2008).

723. Combining the quintozene sales data for the US 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 it still may be a relevant source to achieve for reduction.

724. 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 Canada. 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.

725. PeCB can still be ordered on the internet. In most cases these sales are related to analytical standards of 100 or 200 ug/ml in various solvents (methylene choride, methanol, isooctane) and sold in quantities of 1 – 1.2 ml. 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 Bailey (2007) 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 has 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.

Pentachlorobenzene within the scope of the UNECE Protocol

726. The Executive Body of the UNECE LRTAP Convention mandated that draft amendments to the POPs protocol to be negotiated including the options of listing PeCB in either Annex I or Annexes I and III[28]. The decision to negotiate for either Annex I or Annexes I and III 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:

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

727. 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 releases of PeCB. The UNECE indicated that no information was available on costs and impacts of emission reduction addressing residential/domestic combustions sources such as barrel burning. Costs within the UNECE region for State budgets were expected to be negligible and no price increases for consumers were expected (UNECE 2008).

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

2.2 Intentional point sources

Identification of possible control measures

728. 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 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. PeCB nowadays is not used anymore for this purpose. Release from historical use, stockpiles and waste is unknown. Actions taken to eliminate the use of PCBs will subsequently eliminate any related PeCB releases (UNEP, 2007).

729. 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.

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

730. Except for quintozene production for which the information does not allow a straightforward conclusion to be drawn on a global scale, no remaining uses have been identified.

731. 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.

Information on alternatives (products and processes)

732. As there is no current commercial demand for PeCB, no alternatives have been identified or developed For the production of quintozene, an alternative process using the chlorination of nitrobenzene is available.

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

733. No discernible negative impacts on society have been reported from prohibition or phasing-out PeCB within the UNECE region. Most uses seem to be phased out world wide, except possibly for quintozene production and use. The information provided does not allow a conclusion to be drawn 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 costs 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

Identification of possible control measures

734. 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 releases. This would include an obligation to promote best available techniques and best environmental practices for PeCB sources.

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

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

736. Comprehensive data on releases of PeCB from incineration and thermal processes and on the effectiveness of control are not (yet) available. Best available techniques (BATs) and Best Environmental Practices (BEP) 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).

737. 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 and with optimal abatement techniques, releases in stack gases of organic compounds can be minimised. Hence, incinerators complying with the demand of the low PCDD/F releases will undoubtedly minimize the releases of PeCB. Efficiencies similar to that of dioxins (> 99.9%) can

be obtained, e.g. in the case of catalytic destructions above 300° C (Sakurai and Weber, 1998) or the use of carbonaceous adsorbents as cleanup of flue gases (EC, 2006).

738. However, different releases 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 releases 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 PeCB will be more present in the 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.

739. 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 the emission of PeCB during combustion in incinerators.

Information on alternatives (products and processes)

740. Alternatives and methods to reduce persistent organic pollutants when formed and released unintentionally from anthropogenic sources are dealt with under UNEP guidelines (2006).

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

741. Countries already have obligations to implement control measures for other un-intentionally produced POPs (HCB, PCBs, PCDD/F) under the Convention. These may for a large part be similar to those for PeCB. Measures to reduce un-intentional releases of PeCB through listing in Annex C would positively impact human health and the environment.

2.4 Un-intentional diffuse sources

Identification of possible control measures

742. For these sources abatement techniques are not feasible and emission reduction measures could consist of legislation and providing information and public education by national and local authorities.

743. PeCB can be found as an impurity in several biocides and pesticides currently in use. The relative contribution of PeCB as an impurity in quintozene to total releases has been provided in 2.1.2. The other pesticides reported to contain PeCB are expected to have a much smaller impact. HCB products, which could contain up to 1.8% PeCB are already in the Convention and efforts to reduce and eliminate HCB may also reduce PeCB from this source. PeCB has been detected as an impurity in technical grades of endosulfan, chlorpyrifos-methyl, atrazine, and clopyrilid at concentrations of 0.25 to 6 ppm (US EPA, 1998). The source of the PeCB is not clear, since it is chemically unrelated to the other substances. If endosulfan is added to the Convention, actions taken to eliminate or restrict its use will subsequently affect the related PeCB releases. In cases where PeCB is found as an impurity of biocides and pesticides whose use is continuing further legislative measures could be taken to reduce the amounts of impurities.

744. 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 releases. This would include an obligation to promote best available techniques and best environmental practices for PeCB sources, including municipal solid waste incineration, hazardous waste incineration, magnesium production, wood treatment plants, barrel burning, open fire places and forest burning for agricultural purposes. For example open burning can be prohibited or permitted only under pre-approved conditions (see Annex F submission of Canada).

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

745. 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 releases. Control measures to reduce the amount of PeCB in these biocides may also be an effective measure. However, considering the amount of PeCB present as impurity, these additional measures are not likely to have a significant impact.

746. 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.

Information on alternatives (products and processes)

747. 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.

748. Alternatives and methods to reduce persistent organic pollutants when formed and released unintentionally from anthropogenic sources are dealt with under the Stockholm Convention BAT/BEP guidelines of the UNEP (2006) and BREFs (BAT reference documents) of the EU (EC, 2006).

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

749. Listing in Annex C would mean that PeCB would become subject to measures that prevent, reduce or eliminate its formation and release. The control measures under the Convention for other unintentionally produced POPs (PCDD/F, HCB, and PCBs) could be applied also to unintentionally released PeCB. Monitoring, enforcement and supervision could lead to additional costs.

2.5 Other considerations

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

751. In Armenia information to the public is provided through a national electronic database on legislative documents (IRTEC), through the journal “Official bulletin” where relevant normative-legislative documents are published by the Centre for Monitoring of Environmental Impacts, as well as through annual statistical reports.

752. In Canada public access to risk management information on PeCB is available on Environment Canada's Management of Toxic Substances Web Site at http://www.ec.gc.ca/TOXICS/EN/detail.cfm?par_substanceID=188&par_actn=s1. Links are provided regarding sources of the substance, risk assessments, and the risk management strategy, tools, and activities.

753. Various initiatives that indirectly contribute to reductions in the PeCB emissions in Canada are:

- 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.

754. Further details on measures by Canada can be found in the information on unintentional release submitted by Parties and observers during the intersessional period between the 3rd and 4rd session of the POPRC, as contained in the annex to the risk profile.

755. In the Czech Republic information on PeCB is part of the SC/UNECE CRLTAP[29] education and awareness raising campaign under the national implementation plan.

756. 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

757. According to the risk profile, PeCB meets all screening criteria, i.e. long-range environmental 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 a fungicide and as a flame retardant. Based on all available information, there is no indication that production or intentional use of PeCB still takes place.

758. PeCB is currently 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.

759. 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

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[29] UNECE Convention on Long-Range Transboundary Air Pollution.

can be divided into point sources and diffuse sources. As regards point sources, combustion processes and industrial processes are probably the most relevant. Releases from these sources can be controlled by abatement and substitution techniques and/or legislation. The most relevant diffuse sources are (a) as an impurity in products such as, solvents, pesticides and wood preservative products, (b) small scale combustion such as barrel burning and open fire places, (c) accidental fires and (d) forest burning (for example for agricultural purposes). For these sources abatement techniques are not feasible and emission reduction measures can only be enacted by legislation and/or providing information and education by national and local authorities. Natural sources (forest fires) might contribute to the worldwide emission of PeCB. Note that natural sources are excluded from the Convention.

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

761. To prevent present use and re-introduction of intentional use, listing 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.

762. Listing in Annex C would mean that PeCB would become subject to measures that prevent, reduce or eliminate its formation and release. This would include an obligation to develop an action plan and to promote best available techniques and best environmental practices for PeCB sources, applying the guidelines on BAT&BEP developed under the Convention.

763. Countries already have obligations under the Convention to take these control measures for other unintentionally produced POPs (PCDD/F, HCB, and PCBs). For PeCB formed as unintentional by-products in combustion processes, there is a clear relation to HCB and PCDD/F releases formed by combustion. Most measures taken to reduce PCDD/F releases will lead to significant reduction of the PeCB releases. The action plans developed under Article 5 of the Convention to minimize and where feasible eliminate releases of these substances would therefore also address PeCB.

764. Listing of PeCB in Annex C would oblige Parties to include PeCB in their report of unintentional releases submitted pursuant to Article 15. This could be facilitated by inclusion of PeCB emission factors in the Standardized Toolkit for Identifying and Quantifying Releases of Dioxins and Furans if these factors can be developed for the various source categories.

4. Concluding statement

765. Having evaluated the risk profile for PeCB 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.

766. 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 releases of dioxins will lead to significant reduction of the PeCB releases.

767. 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 and C.

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Alpha and beta hexachlorocyclohexane
UNEP/POPS/POPRC.4/15/Add.3, Add.4

Executive summary

768. Mexico, a Party to the Stockholm Convention, proposed lindane as well as alpha- and beta-hexachlorocyclohexane (HCH) to be included in Annex A, B or C of the Stockholm Convention. After the evaluation of the risk profiles by the Persistent Organic Pollutants Review Committee (POPRC) at its third meeting in November 2007 the Committee concluded that alpha-HCH and beta-HCH are likely, as a result of their long range environmental transport, to lead to significant adverse human health and environmental effects such that global action is warranted. Also at that meeting the risk management evaluation on lindane was adopted and its inclusion in Annex A of the Stockholm Convention was recommended, including considerations for possible specific exemptions.

769. Technical HCH (including alpha-HCH and beta-HCH) is subject to two international agreements: the Protocol on Persistent Organic Pollutants of the Convention on Long-Range Transboundary Air Pollution and the Rotterdam Convention. Also national and regional legislation and agreements focus on effective control measures for alpha- and beta-HCH: the North American Regional Action Plan on Lindane and Other Hexachlorocyclohexane Isomers, the Commission for the Protection of the Marine Environment of the Northeast Atlantic, the EU POP Regulation (EC) No 850/2004 and the European Water Framework Directive 2000/60/EC, amongst others.

770. After almost forty years of extensive worldwide use, there has been a gradual replacement of technical HCH by lindane. No significant current uses of alpha- and beta-HCH (as constituents of technical HCH) have been reported by Parties and observers to the Stockholm Convention in 2008.

771. Alpha- and beta-HCH control measures currently implemented in several countries include: production, use, sale and import/export prohibition, prohibition of lindane production, establishment of inventories, clean-up of contaminated sites, access to disposal facilities for hazardous waste and management of obsolete stocks.

772. Nowadays the primary source of alpha- and beta-HCH is the manufacture of lindane (as high-volume by-products). In this respect control measures for lindane also affect alpha- and beta-HCH because the production of one ton of lindane generates approximately up to eight tons of alpha- and beta-HCH. Past production in connection with inappropriate handling of these HCH residuals as well as existing stockpiles have generated huge amounts of waste, releasing alpha- and beta-HCH into the environment of developed and developing countries.

773. The usage of waste HCH residuals from lindane production for the synthesis of other chemicals such as trichlorobenzene is unlikely to be an economic and technically successful option.

774. The assessment of the efficacy and efficiency of control measures is country dependent; however, while all of the countries who provided comments consider that control measures currently implemented are technically feasible, access to suitable disposal facilities and financial resources for remediation of contaminated sites is limited in some countries.

775. Hence, the hazardous waste management and disposal of existing stocks together with the remediation of contaminated sites could be costly for countries and thus financial and/or technical assistance to developing countries might be needed. Therefore international mechanisms of co-financing to establish incentives would be crucial to reduce the environmental legacies of obsolete HCH-stockpiles and contaminated soils.

776. The implementation of control measures is expected to reduce the risks from exposure of humans and the environment to alpha- and beta-HCH. Positive impacts can especially be anticipated for human health, including reduced risks to Arctic Indigenous Peoples, agriculture, and biota. No negative economic impact is expected.

777. Several countries reported that alpha- and beta-HCH are part of their national and international monitoring programmes.

778. A thorough review of existing control measures, which have already been implemented in several countries including control measures for lindane, shows that risks from exposure of humans and the environment to alpha- and beta-HCH can be reduced significantly. Control measures are also expected to support the goal agreed at the 2002 Johannesburg World Summit on Sustainable Development of ensuring that by the year 2020, chemicals are produced and used in ways that minimize significant adverse impacts on the environment and human health.

779. In accordance with paragraph 9 of Article 8 of the Convention, the Committee recommends that the Conference of the Parties to the Stockholm Convention considers listing alpha- and beta-HCH in Annex A.

780. As elaborated in the risk management evaluation of lindane (UNEP, 2007c) the Conference of the Parties may wish to consider allowing a specific one-time, transitional exemption for alpha- and beta-HCH concerning the

production of lindane for control of head lice and scabies as a human health pharmaceutical only. The high ratio of alpha- and beta-HCH wastes to lindane product along with the availability of efficacious and cost-effective lindane alternatives should be reflected in these considerations.

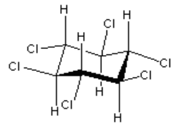
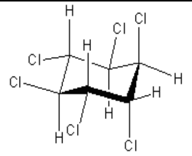
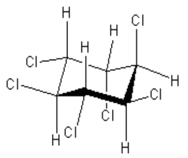
781. Further consideration may also be given to control measures regarding the production of lindane such as prevention and sound management of generated waste including alpha- and beta-HCH.

1. Introduction

1.1. Chemical identity of the proposed substances

782. Alpha-HCH and beta-HCH are produced as the main constituent of technical HCH by photochemical chlorination of benzene. The yields of the five stable isomers vary due to technical differences in the production process. The reported ranges are: alpha-HCH (55 - 80%), beta-HCH (5 - 14%), gamma-HCH (8 - 15%), delta-HCH (6 - 10%) and epsilon-HCH (1 - 5%) (Breivik et al., 1999). The chemical characterisation of alpha- and beta-HCH is compiled in table 8.

Table 8. Chemical identity

Chemical name:	**Beta-hexachlorocyclohexane(beta-HCH)**	**Alpha-hexachlorocyclohexane (alpha-HCH)**
IUPAC name:	(1-alpha, 2-beta, 3-alpha, 4-beta, 5-alpha, 6-beta)-Hexachlorocyclohexane	(1-alpha, 2-alpha, 3-beta, 4-alpha, 5-beta, 6-beta)-Hexachlorocyclohexane
CAS number	319-85-7	Racemic: 319-84-6, (+) alpha-HCH: 11991169-2 (-) alpha-HCH: 119911-70-5
Chemical formula:	$C_6H_6Cl_6$	$C_6H_6Cl_6$
Molecular weight:	290.83	290.83
Chemical structure (modified from Buser et al.,1995)	 beta-HCH	 (+)-alpha-HCH  (-)-alpha-HCH

783. The physico-chemical properties (see table 9 for selected properties) of both isomers allow for long-range transport and "cold condensation", an enrichment of the substance in cold climates compared to concentrations near sources, on altitudinal and latitudinal scales as well as for bioaccumulation in aquatic and terrestrial species (UNEP, 2007a).

Table 9 Physico-chemical properties

	Beta-HCH	**Alpha-HCH**
Melting Point (K)	588_{2}	431_{2}
Boiling Point (K)	333 at 0.5 mmHg	561
Water solubility (mol*m^{-3} at 25°C)	1.44	0.33
Vapour pressure (Pa at 25°C)	0.053	0.25
Henry's Law Constant (Pa m^{3} mol^{-1})	0.037	0.74
Log Kow (25°C)	3.9	3.9
Log Koa (25°C)	8.7	7.5

Source: All data taken from Xiao et al. (2004) except boiling points from ATSDR (2005)

1.2. Conclusions of the Review Committee

784. Mexico submitted proposals for listing the alpha and beta isomers of hexachlorocyclohexane (HCH) in Annexes A, B and/or C to the Convention on 26th July 2006, as contained in documents UNEP/POPS/POPRC.2/INF/7 and UNEP/POPS/POPRC.2/INF/8. The Committee concluded that alpha- and beta-HCH met the screening criteria listed in Annex D to the Convention (decision POPRC-2/9 and POPRC-2/10).

785. On its third meeting the Review Committee evaluated in accordance with Annex E the draft risk profiles for both isomers. After adoption of the risk profiles (UNEP/POPS/POPRC.3/20/Add.8 and UNEP/POPS/POPRC.3/20/Add.9) the Committee decided (decisions POPRC-3/9 and POPRC-3/10) that alpha-HCH and beta-HCH are likely, as a result of long-range environmental transport, to lead to significant adverse human health and/or environmental effects such that global actions are warranted.

786. Therefore an ad hoc working group was established with the mandate to prepare a risk management evaluation that includes an analysis of possible control measures for alpha- and beta-HCH in accordance with Annex F to the Convention.

787. The risk management evaluation of lindane (gamma-HCH) was also evaluated by the Committee during POPRC 3 and the decision to recommend listing lindane in Annex A of the Convention was taken (POPRC-3/4). Because of the production process and the linkage of the HCH isomers this decision is also relevant for the risk management evaluation of alpha- and beta-HCH.

1.3. Data sources

788. The draft risk management evaluation is based on the following data sources:

- Information submitted by Parties and observers according to Annex E of the Convention:
- Armenia, Bahrain, Croatia, Czech Republic, Mozambique, Myanmar, Republic of Moldova, Principality of Monaco, Netherlands, Qatar, United States of America and the International POPs Elimination Network (IPEN). This information is available on the Convention's website. (http://www.pops.int/documents/meetings/poprc/AnnexF_submission_2008.htm)

789. Risk profiles for alpha- and beta-HCH (UNEP/POPS/POPRC3./20/Add.8 and UNEP/POPS/POPRC3./20/Add.9), 2007.

- Toxicological profile of hexachlorocyclohexanes, United States of America Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, 2005. (http://www.atsdr.cdc.gov/toxprofiles/tp43.html)
- The North American Regional Action Plan (NARAP) on Lindane and Other Hexachlorocyclohexane (HCH) Isomers. 2006. North American Commission for Environmental Cooperation (http://www.cec.org/pubs_docs/documents/index.cfm?varlan=english&ID=2053)

790. Assessment of lindane and other hexachlorocyclohexane isomers, USEPA, 2006. http://www.epa.gov/oppsrrd1/REDs/factsheets/lindane_isomers_fs.htm

791. In addition to these information sources, supplementary literature was obtained from free Internet based databases by a literature search of the public data base Pubmed (http://www.ncbi.nlm.nih.gov /entrez/query.fcgi?DB=pubmed). In general search terms include the chemical name or CAS number and/or a combination of technical terms because of the multiplicity of entries.

792. The information submitted by Parties or observers and the reports listed above contained individual references which have not been listed specifically in this draft risk management evaluation.

1.4. Status of the chemical under international conventions

793. Alpha-HCH and beta-HCH are constituents of technical HCH, which is regulated by at least two international agreements

794. The first one is the 1998 Aarhus Protocol on Persistent Organic Pollutants under the Convention on Long-Range Transboundary Air Pollution. Technical HCH is listed in Annex II of the Protocol which restricted its use to an intermediate in chemical manufacturing only.

795. The second agreement is the Rotterdam Convention on the Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade. HCH (mixed isomers) is subject to the PIC Procedure and is listed in Annex III of the Convention.

1.5. Any national or regional control action taken

796. Canada, Mexico and the United States signed the North American Regional Action Plan[30] (NARAP) on Lindane and other Hexachlorocyclohexane isomers in 2006. The goal of the NARAP is to reduce the risks associated with the exposure of humans and the environment to lindane and its other HCH isomers.

797. HCH (including lindane) is listed as a Level II substance in the Great Lakes Binational Toxics Strategy[31] between the United States and Canada, which aims to reduce toxic substances in the Great Lakes Basin Ecosystem by pollution prevention activities.

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[30] Commission for Environmental Cooperation. November 2006. The North America Regional Action Plan (NARAP) on Lindane and Other Hexachlorocyclohexane (HCH) Isomers: http://www.cec.org/files/PDF/POLLUTANTS/LindaneNARAP-Nov06_en.pdf.

[31] Great Lakes Binational Toxics Strategy: http://www.epa.gov/glnpo/gls/index.html

798. In the European Union, the production and use of technical HCH as an intermediate in chemical manufacturing was phased out by the end of 2007 at the latest (Regulation (EC) No 850/2004)[32]. It also includes provisions for the management and notification of existing stockpiles. Regulation (EC) No 1196/2006 and Regulation (EC) No 172/2007 deal among others with concentration limits for HCH (sum of alpha-, beta- and gamma-HCH) in waste. HCH is also among the priority substances (Decision No 2455/2001/EC) of the adopted EU Water Framework Directive 2000/60/EC.

799. Hexachlorocyclohexane isomers are on the List of Chemicals for Priority Action under the OSPAR Commission for the Protection of the Marine Environment of the Northeast Atlantic[33]. The objective is the prevention of pollution of the maritime area by continuously reducing discharges, emissions and losses of hazardous substances.

800. In Armenia alpha- and beta-HCH as constituents of technical HCH are not allowed for plant protection purposes. Also the country approved appropriate measures to improve the ecological situation in the vicinity of the burial place of obsolete pesticides, including organochlorine pesticide. Also a national programme was adopted to strengthen capacities as well as to enhance chemicals and waste management including obsolete pesticides (submitted Annex F information by Armenia, 2008).

801. Bahrain takes control action for all kinds of hazardous chemicals but there are no specific measures on alpha- and beta-HCH (submitted Annex F information by Bahrain, 2007).

802. The Netherlands performed monitoring in food from polluted soil and remediation of contaminated sites (submitted Annex F information by the Netherlands, 2008)

803. The Republic of Moldova reported use prohibition for technical HCH and concentration limits for the workplace and environmental standards (submitted Annex F information by Moldova, 2008).

804. In 2007, in the Republic of Korea, alpha- and beta-HCH were added to the list of banned chemicals of the Hazardous Chemicals Management Act under the registration number 06-4-51. According to a survey conducted in 2006, alpha-HCH was not manufactured nor imported in the Republic of Korea. In 2006, a small amount of beta-HCH was imported for research purposes (submitted comment by the Republic of Korea, 2008).

2. Summary information relevant to the risk management evaluation

2.1 Identification of possible control measures

805. Alpha- and beta-HCH are isomers of HCH, and were components of a mixture that was used as an agricultural and non agricultural pesticide and as a pharmaceutical until the 1990s. In this respect no production and/or use was reported by Armenia, Bahrain, Croatia, Czech Republic Mozambique, Myanmar (no import/export), Republic of Moldova, Principality of Monaco, Netherlands, Qatar and the United States (submitted Annex F information, 2008).

806. Usage of technical HCH was banned in most western countries and Japan in the 1970s followed by China, Russia, India and Mexico. Since 2000 technical HCH is virtually no longer in use worldwide (Li and Macdonald, 2005).

807. Thus effective control measures (e.g. ban, prohibitions) have caused the replacement of technical HCH for insecticidal purposes by suitable alternatives, mainly lindane and other insecticidal active substances (UNEP, 2007a).

808. Nowadays the primary source of alpha- and beta-HCH is from the manufacture of lindane as by-products (Annex F information submitted by United States and IPEN, 2008). To yield 99% pure lindane the mixture of technical HCH is subject to fractional crystallization and concentration. For the production of one ton of lindane approximately six to ten tons of other HCH-isomers are generated, with up to eight tons being alpha- and beta-HCH (CEC, 2006). Despite thorough investigations, it was not possible to optimize the production process to yield higher contents of gamma-HCH (than up to 14-15%) in the original HCH mixture (Vijgen, 2006).

809. In this respect lindane production, use, sale and import prohibitions, use restrictions, registrations and use cancellations as prescribed in the risk management evaluation of lindane (UNEP, 2007c) are also possible control measures for alpha- and beta-HCH. In addition control measures for alpha- and beta-HCH will affect the mixture that comprises technical HCH.

810. Even though there is no known current intentional usage of alpha- and beta-HCH they are still produced in some countries as high volume by-products of lindane manufacture and may be used in some countries (submitted Annex F information by IPEN, 2008). Thus prohibitions of import, production and use have been stated as major control measures by all responding parties (submitted Annex F information, 2008).

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[32] Regulation (EC) No 850/2004 of the Europena Parliament and of the Council of 29 April 2004 on persistent organic pollutants and amending Directive 79/117/EEC; OJ L 158, 2004-04-30, p.1.

[33] Convention for the Protection of the Marine Environment of the North-East Atlantic (OSAPR): http://www.ospar.org/eng/html/welcome.html

811. Another measure mainly applied in the past was the usage of waste HCH residuals from lindane production for the synthesis of other chemicals like trichlorobenzene (submitted Annex F information by the United States, 2007).

812. The HCH isomers including alpha- and beta-HCH are likely to be released into the environment from hazardous waste sites, obsolete stocks which are not always controlled or maintained safely or contaminated sites (UNEP, 2007a). Control measures implemented in several countries include the establishment of an inventory, the clean-up of contaminated sites, and management of obsolete stocks (submitted Annex F information by the Czech Republic, Republic of Moldova and the Netherlands, 2008). Some countries report that they do not have access to appropriate hazardous waste facilities.

813. A ban on production and use of alpha- and beta-HCH would also affect waste issues. Listing a substance under the Stockholm Convention implies a ban on recycling and reuse of stockpiles of alpha- and beta-HCH. Article 6 in the Convention requires that wastes and stockpiles are handled in a safe, efficient and environmentally sound manner, so that the content is destroyed or irreversibly transformed, taking into account international rules, standards and guidelines. Regarding contaminated sites, Article 6 in the Convention requires each Party to endeavor to develop appropriate strategies to identify sites contaminated by chemicals listed in Annex A, B, or C. If remediation of those sites is undertaken, this remediation should be performed in an environmentally sound manner. The article also bans disposal operations that lead to recovery, recycling, reclamation, direct use or alternative use of POPs material.

814. Also monitoring activities were reported by a Party as a control measure e.g. for meat from cattle from sites close to former production sites (submitted Annex F information by the Netherlands, 2008).

815. Other possible control measures taken by countries include amongst others occupational exposure limits, maximum residues limits in food and environmental standards (e.g. limit for water quality). These limits for alpha- and beta-HCH are well established in several countries including the United States and Europe (HSDB, 2006; submitted Annex F information by the Republic of Moldova, 2008)

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

816. Information provided by Parties and observers regarding this section was limited.

817. The efficacy and efficiency of implemented control measures is country dependent and is influenced by factors such as complete legal and government administrative systems, surveillance measures, risk communication and public participation and access to safe disposal facilities and techniques. Also, scientific involvement is needed to ensure that the technology proposed is appropriate, consistent with Stockholm Convention objectives and guidelines, and efficient, directly impacting costs.

Technical feasibility

818. Alpha- and beta-HCH are no longer intentionally released to the environment by pesticidal usage of technical HCH indicating that technically feasible alternatives have already been identified and used (UNEP, 2007a). Chemical and non-chemical alternatives for lindane have been compiled in the risk management evaluation on lindane and are efficient, available and technically feasible for most uses (UNEP, 2007c).

819. For the United States the prohibition of the production of HCH to make lindane is a technically feasible control measure (submitted Annex F information by the United States, 2007).

820. For the Republic of Moldova it is not possible to destroy all obsolete stocks and remediate all contaminated sites at the same time. Currently no disposal plant for hazardous waste, including POPs pesticides, is available in Moldova. Environmentally sound disposal of obsolete stocks has been undertaken in the frame of the GEF/WB project.

821. For the Czech Republic destruction of obsolete waste and remediation of contaminated sites such as soils, sediments and industrial hot spots is technically feasible (submitted Annex F information by the Czech Republic, 2008). They successfully finished the remediation of a former production facility Spolana Neratovice by application of the base-catalyzed decomposition (BCD) technology.

822. Also technical guidelines for the environmentally sound management of POPs waste are available and effective, based on work accomplished under the Basel Convention. Disposal and remediation of alpha- and beta-HCH have been extensively studied (Ukisu and Miyadera, 2005; IHPA, 2007).

823. Depending on the occurrence of pollution and possible remediation measures the intensity of the contamination is a general dividing line for management strategies. Obsolete stocks and intensively contaminated soils (‘hot spots’) are still a primary source for emissions and therefore would be worth employing ex-situ- and off-site-treatment strategies involving excavation, regionally centralised intermediate storage and treatment plants. Treatment itself can involve thermal and extraction techniques and should be undertaken in a manner consistent with Convention guidelines.

824. For polluted soils with a low intensity of HCH more extensive strategies for on-site and in-situ-treatment and reduction are probably more appropriate. The degradation processes (preferably anaerobic) taking place in soil are described for alpha-, and beta-HCH and the principles for ex-situ biological treatment techniques (e.g. slurry reactors, landfarming, composting systems) are established. Any of the available extensive bioremediation techniques should be

adapted regionally with respect to soil properties as well the available materials for stimulating degradation and should be undertaken in a manner consistent with Convention guidelines.

825. To reduce alpha- and beta-HCH residuals during lindane production one possible management option reported by industry is to transform the waste isomers into the solvent trichlorobenzene (CEC, 2006) and hydrochloric acid, but this has been discontinued since the 1970s. It could not yet be estimated how much HCH has been used for this purpose, but amounts up to several hundred thousands of tons could well be possible according to Vijgen, 2006. Trichlorobenzene is made nowadays by direct chlorination of benzene (Euro Chlor, 2002). Vijgen (2006) describes chemical methods for the conversion of HCH isomers to trichlorobenzene, trichlorophenoxyacetic acid, HCl, hexachlorobenzene, sodium pentachlorophenolate and trichlorophenol. However at that time it was discovered that during dehydrochlorination of HCH and during further processing of chlorinated derivatives of benzene, trace amounts of polychlorodibenzodioxins can be created, among them 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD).

826. In addition, indications exist that China and Russia still manufacture PCP (pentachlorophenol) from HCB (hexachlorobenzene), which utilizes the alpha-HCH from lindane manufacture (Vijgen, 2006). However HCB can also be synthesised by other pathways e.g. by chlorination of benzene or from tetrachlorohydrochinone in presence of phosphor trichloride and pentachloride (Fiedler et al., 1995).

Identification of critical uses

827. Alpha-HCH and beta-HCH do not have any critical uses as final end products.

828. As previously stated, the mixture of HCH isomer including alpha-HCH as main isomer as well as beta-HCH are by-products of the manufacture of lindane by physical processes (i.e. fractional crystallization). Thus the only production of alpha- and beta-HCH is linked to the production of lindane. Except for lindane, no other products are made from technical HCH in the UNECE region (UNECE, 2005).

Costs and benefits of implementing possible control measures, including environmental and health costs and benefits

829. Due to no reported usage of alpha- and beta-HCH, major costs of possible control measures will arise from environmentally sound management of hazardous waste and stockpiles of HCH residuals, as well as from the remediation of contaminated sites.

830. Since the production of one ton lindane generates approximately up to eight tons alpha- and beta-HCH, past production in connection with inappropriate handling of these HCH residuals as well as existing stockpiles have generated huge amounts of waste spread into the environment in developed and developing countries.

831. Reasons for improper management of these waste isomers during past production were the underestimation of the hazards of alpha- and beta-HCH, a lack of control measures during production and illegal transport and dumping. Uncontrolled spreading of HCH residuals into the environment from production facilities and dumping grounds especially raised the remediation costs. For example the Basque Region spent 50 million EUR for clean-up (Vijgen, 2006).

832. Also the Dutch government spent approximately 27 million EUR to clean up soil contaminated with waste HCH isomers in the eastern region of the Netherlands. Currently there are additionally 200 000 tons of less contaminated soils remaining that may need remediation in the future (submitted Annex F information by the Netherlands, 2008).

833. The Czech Republic estimated the remediation cost of a former lindane production site is 100 million EUR. For contaminated sites exact estimates are not available and usually also other types of contaminants are concerned. In the absence of exact data, costs can be in the order of tens of millions EUR (submitted Annex F information by the Czech Republic, 2008).

834. Under the Arctic Council´s Arctic Contaminants Action Program a project was initiated for the environmentally sound management of obsolete pesticides stockpiles in the Russian Federation to protect the Arctic environment from pesticide emissions. In 2001-2008 US$2,000,000 have been spent for activities including repackaging and safe storage of 300 tons of HCH products produced between 1960-1980 (ACAP, 2008).

835. In the United States it is estimated that there are over 65,000 tons of HCH wastes. Alpha- and beta-HCH have been identified in at least 146 and 159 sites respectively of the 1662 hazardous waste sites that have been proposed for inclusion in the Environmental Protection Agency National Priorities List (ATSDR, 2005). Some of the former lindane production sites in the US are now designated as Superfund sites, meaning that they are uncontrolled or abandoned places where hazardous waste is located, possibly affecting local ecosystems or people. According to data of the International HCH and Pesticides Forum (IHPA) the cost of cleaning up HCH waste is US$ 2,000 to 3,000 per ton (Fitzgerald, 2005). The removal of obsolete pesticides costs around US$ 3,000 to 4,000 per ton (UNIDO, 2002; FAO, 1998). Costs for the collection of hazardous waste are difficult to estimate, because they depend highly on the number and geographical distribution of waste sources.

836. Benefits of the collection and decontamination of waste, containing alpha- and beta-HCH are that their release and thus their impacts on human beings and the environment, is avoided. The generation of additional contaminated

sites is prevented, so that costs for their remediation are saved. Health impacts on staff of production companies and on citizens, living in the vicinity of companies and of contaminated sites, are prevented. A monetary assessment of these benefits is not possible due to lack of data.

837. Although the exact amounts of HCH-residuals are not known, estimates are in the range of 1.6 to 4.8 million tons worldwide. The extent of this problem is thereby far beyond present estimates on obsolete pesticides in Africa (55,000 tons) and in the Eastern European region (500,000 tons) (Vijgen, 2006).

838. Concerning costs of possible control measures associated with lindane production at least 52 countries have banned this pesticide, as evidence that the environmental, social and health costs of continued lindane production outweigh benefits. Furthermore the replacement of intentional uses of alpha- and beta-HCH demonstrates that costs of alternatives have not inhibited their substitution (submitted Annex F information by IPEN, 2008)

839. For the United States there would be no additional costs to prohibit the production of HCH to make lindane. Official records indicate that production of HCH in the United States ceased in 1976 (submitted Annex F information by the United States, 2007).

840. Costs are also associated with the pharmaceutical use of lindane, specifically, the cost of managing alpha- and beta-HCH residuals. The annual pharmaceutical usage estimate from the United States is about 133 kg or 293 pounds of lindane. If existing stocks of pharmaceutical lindane are not used, additional lindane may be produced that would result in the generation of approximately 1,160 kg HCH residuals per year (estimate based on the lindane usage multiplied by a factor of 8), dominated by alpha-HCH, which would have to be disposed[34].

841. Based on the conclusions of the risk profiles on alpha- and beta-HCH (UNEP, 2007a; UNEP 2007b), their ubiquitous occurrence and high levels in biota and humans, and the urgent need to manage waste isomers and obsolete stocks in developed and developing countries, benefits of globally implemented control measures for human health and the environment can be expected. However environmentally sound management of these HCH residuals is costly and financial and technical assistance to developing countries might be necessary.

842. Concerning costs for the replacement of alpha-HCH for the production of HCB as an intermediate in the manufacture of PCP no information was provided by the concerned Parties or observers to the Stockholm Convention.

843. The benefits of implementing possible control measures include reduction of contaminants in the environment, in food and breast milk with subsequent reduction in environmental and health risks associated with alpha-HCH and beta-HCH. Lindane and other HCH isomers are associated with adverse effects to the environment and human health, including neurotoxicity, increased cancer risk, reproductive harm, and immune suppression (UNEP, 2007a; UNEP, 2007b; UNEP, 2007c).

844. A recent study on lindane quantifies the ecological and health benefits in the United Sates stemming from reduced water pollution by following a ban of pharmaceutical lindane in California with consequent beneficial implications for the elimination of alpha- and beta-HCH waste by-products inextricably linked to lindane production (Humphreys et al., 2008).

2.2. Information on alternatives (products and processes) where relevant

845. Alpha and beta isomers of HCH are by-products of the production of lindane. These by-products have no registered uses (submitted Annex F information by the United States, 2007).

846. Also there are no alternative processes for the production of lindane available (Vijgen, 2006).

847. There are alternative pathways for the manufacture of PCP from HCB, which utilizes alpha-HCH from lindane production available (cf. section 2.2.1).

2.3. Summary of information on impacts on society of implementing possible control measures

Health, including public, environmental and occupational health

848. Due to extensive use over the past 50 years, persistence and long-range transport alpha- and beta-HCH can be detected in all environmental media including humans (USEPA, 2006). Human exposure to alpha- and beta-HCH results mostly from ingestion of contaminated plants, animals and animal products. High exposure is expected in contaminated areas due to extensive use, former production, disposal sites and stockpiles. Also high levels are found in Arctic marine mammals (UNEP, 2007a; UNEP, 2007b).

849. One important benefit is the reduced risk to human health and the environment due to the prevention of releases at the workplace and the reduction of uncontrolled exposure and releases from adequate management of hazardous waste, contaminated sites and stockpiles. Due to the adverse effects in wildlife and human health in contaminated and remote regions including the Arctic region (UNEP, 2007b) the elimination of production and reduction of emissions is of great importance. In 2006, a U.S. EPA risk assessment indicated potential risks from dietary exposure to the alpha-

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[34] USFDA 2008. 2007 IMS prescription data provided to the United StatesFood and Drug Administration.

and beta-HCH isomers to communities in Alaska and others in the circumpolar Arctic region who depend on subsistence foods, such as caribou, seal and whale (USEPA, 2006).

850. The listing of alpha- and beta-HCH in Annex A without exemptions would prevent further production and result in measures to reduce releases from stockpiles and waste and contaminated sites. The listing of lindane in Annex A without exemptions would contribute to prevent further HCH waste residuals.

851. The implementation of control measures is expected to reduce the risks from exposure of humans and the environment to alpha- and beta-HCH. Workers, local communities in the proximity to local high exposure such as production facilities and vulnerable groups such as children and people with compromised immune systems should be protected from unnecessary harm caused by HCH contamination (submitted Annex F information by IPEN, 2008). Also the risk for Arctic Indigenous Peoples gives another reason for the quick control and elimination of all HCH isomers from traditional foods (UNEP, 2007a).

Agriculture, including aquaculture and forestry

852. Usage of alpha- and beta-HCH for agriculture ceased in 1990s (Li and Macdonald, 2005). Prohibition of further production and waste site cleanups could benefit agriculture by decreasing alpha- and beta-HCH soil and water contamination (submitted Annex F information by IPEN, 2008).

Biota (biodiversity)

853. Elimination of any further production of alpha- and beta-HCH will ensure that the levels of HCH isomers found in biota, especially in the Arctic from long-range transport, decreases over time. Thus the health impacts for wildlife associated with exposure to these isomers will be reduced (submitted Annex F information by IPEN, 2008) and this may positively influence ecosystem functions.

854. It can be anticipated that reduced releases to the environment may have benefits to biota because it was shown that HCH isomers negatively affect wildlife in field investigations. Impacts on biota may include neurotoxicity, hepatotoxicity and carcinogenicity. Also, reproductive and immunosuppressive effects and effects on fertility were seen in laboratory animals (UNEP, 2007b).

855. Inappropriate storage, handling and transportation of obsolete pesticides and waste (including alpha- and beta-HCH) may result in spreading of these isomers over considerable areas. Thus the prevention of local pollution will also have global effects (Wei et al., 2007).

Economic aspects, including costs and benefits for producers and consumers and the distribution of costs and benefits

856. No negative economic impact is apparent for the suggested control measures for alpha- and beta-HCH. Costs of control measures for lindane including alternatives were evaluated in the Risk Management Evaluation on Lindane (UNEP, 2007c). However in addition any ongoing production of lindane would include costs for safe disposal of alpha- and beta-HCH.

857. The costs to set up an appropriate system for collecting and treating hazardous waste are expected to be high. In the first instance, the producers of waste will have to bear these costs, but subsequently will pass them on to the consumers via an increased product price. However, the distribution of these costs among those who produce the waste, governments and communities is also country dependent. Costs for appropriate waste management are still much lower than those for remediation of contaminated sites.

858. Information regarding costs of implementing possible control measures is also provided in this document in section 2.2.3

Movement towards sustainable development

859. A prohibition of alpha- and beta-HCH production could contribute to sustainable development by potentially reducing health damages in the future and reduce overall cost incurred by the society which thus frees those resources for other areas. (This was also stressed in the EU strategy Cleaner Air for Europe[35]).

860. It may also raise governmental and public awareness to the existing waste problems leading to waste avoidance.

861. As the persistent, bioaccumulative and toxic properties of alpha- and beta-HCH as well as their potential for a long-range transboundary transport were proved under the UNECE Protocol and by the POP Review Committee of the Stockholm Convention, a positive impact on globally sustainable development from a ban/restriction of these chemicals is to be expected.

862. Reduction and elimination of alpha-HCH and beta-HCH are consistent with sustainable development plans that seek to reduce emissions of toxic chemicals. A relevant global plan is the Strategic Approach to International Chemicals

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[35] http://ec.europa.eu/environment/air/cafe/

Management (SAICM) that emerged from the World Summit on Sustainable Development[36]. The Global Plan of Action of SAICM contains specific measures to support risk reduction that include prioritizing safe and effective alternatives for persistent, bioaccumulative, and toxic substances (SAICM, 2006).

Social costs (employment, etc.)

863. Usually waste management practices can and should cause a positive stimulating effect for employment and hence have overall positive economic effects. One may also infer positive scale effects (e.g. labour division or rationalisation) for other waste management practices (such as usage of exiting collection systems for hazardous waste) due to the implementation of such practices as well as the introduction of new technologies. In addition, land presently contaminated could be made available for use following remediation.

864. HCH isomer control and waste management measures will also be beneficial for the Arctic Indigenous Peoples by reducing contamination of their traditional foods. Alaska Native Peoples rely on traditional foods because of cultural importance, availability, preferences in taste and nutrition to store-bought foods. Any steps taken to reduce further deposition and exposure of Arctic Indigenous Peoples to alpha- and beta-HCH will have beneficial social outcomes, since their traditional foods are an integral part of their social and cultural identity (submitted Annex F information by IPEN, 2008).

Other impacts

865. No information received.

2.4. Other considerations

Access to information and public education

866. In the Republic of Moldova a campaign to promote and facilitate access to information, public education and awareness was conducted within the GEF/WEB Project "POPs Stockpiles Management and Destruction" by 2007 (submitted Annex F information by the Republic of Moldova, 2008).

867. Armenia reported the availability of the national electronic database on legislative documents as well as a journal where the normative legislative documents are published (submitted Annex F information by Armenia, 2008)

868. The Czech Republic has an education and awareness POPs campaign (SC/UN ECE CRLTAP) based on the Czech National Implementation Plan (Annex F information provided by the Czech Republic, 2008).

869. The North America Regional Action Plan on Lindane and Other Hexachlorocyclohexane (HCH) Isomers (NARAP) has laid down outreach and education steps for the parties of the North America Agreement on Environmental Cooperation (NAAEC), i.e. Canada, Mexico and United States of America. The focus of the outreach and education is on lindane as the active isomer. The Parties will ensure that indigenous populations are suitably advised in a culturally acceptable manner on the possible risks associated with the use of lindane, with the presence of lindane and/ or HCH isomers in the environment, with the risk of exposure through traditional foods, and on the use of available alternatives as applicable (CEC, 2006).

Status of control and monitoring capacity

870. In Armenia alpha-HCH is monitored in surface water (submitted Annex F information by Armenia, 2008).

871. Control and monitoring institutions in the Czech Republic include: RECETOX MU for monitoring in ambient air, surface waters, sediments, soils, mosses and needles: Water Research Institute for monitoring of surface and ground waters and sediments, Central Institute for Supervising and Testing in Agriculture (CISTA), Research Institute of Amelioration and Soil Conservation (RIASC), State Veterinary Inspection and Czech Food Inspection for food control, and National Institutes of Public Health for human exposure and dietary studies (Annex F information provided by the Czech Republic, 2008).

872. The Principality of Monaco reported no environmental or bio-monitoring (submitted Annex F information by the Principality of Monaco, 2008)

873. In the Republic of Moldova, the Monitoring Division on Environmental Quality of the State Hydrometeorological Service monitors alpha- and beta-HCH concentrations in surface water, precipitation, soil, fish, and sediments. The Laboratory of Sanitary-Chemical Researches of the National Scientific Practice Centre of Preventive Medicine (Ministry of Health) monitors POPs, including alpha- and beta-HCH in soil, water, animal and vegetable food products. Biological liquids including breast milk are monitored, but not on a regular base (submitted Annex F information by the Republic of Moldova, 2008).

874. The Netherlands reported for alpha- and beta-HCH a downward trend based from extrapolation of monitoring data from lindane concentrations in precipitation (submitted Annex F information from the Netherlands, 2008).

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[36] http://www.chem.unep.ch/saicm/

875. Also within the North America Regional Action Plan on Lindane and Other Hexachlorocyclohexane the parties take actions on environmental (e.g. monitor for lindane and its isomers in the National Fish Tissue Study) and human monitoring studies for lindane and other HCH isomers (CEC, 2006).

876. In the United States alpha- and beta-HCH are not registered for use as a pesticide under the Federal Insecticide, Fungicide and Rodenticide Act. Official records indicate that production of HCH in the United States ceased in 1976 (Annex F information provided by the United States of America, 2008).

877. Similarly, alpha- and beta- HCH are not registered for pesticide use in Canada under the Pest Control Products Act.

878. Registrations of technical HCH pesticides were discontinued in the early 1970's.

3. Synthesis of information

879. The hazard profiles of alpha- and beta-HCH exhibit persistent, bioaccumulative and toxic properties as well as long-range transport. High exposure is expected in polluted areas, which are still present around the globe and the Arctic region. Alpha- and beta-HCH are present in the terrestrial and the aquatic food chains and concentrations are a human health concern.

880. Alpha- and beta-HCH are themselves not effective insecticides and the widespread use of technical HCH in the past was due to the presence of the active isomer gamma-HCH and its low cost. Technology developed to purify technical HCH to gamma-HCH, resulting in a market for lindane and the creation of waste alpha and beta isomers.

881. Therefore all responding parties suggested prohibition of production and use as a technically feasible and efficient control measure for alpha- and beta-HCH noting its link to lindane production as by-products.

882. One major source of alpha- and beta-HCH pollution was the production of lindane with only a few producing countries remaining, but former production and the inefficient production process over the years have left an enormous amount of waste products in developed and developing countries.

883. Listing of alpha- and beta-HCH in Annex A would also mean 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.

884. Based on the conclusions of the risk profiles on alpha- and beta-HCH (UNEP, 2007a; UNEP 2007b), their ubiquitous occurrence and high levels in biota and humans, the managment of waste isomers and obsolete stocks by globally implemented control measures can be expected to result in benefits for human health and the environment.

885. However, environmentally sound management of these HCH residuals is costly, and financial and technical assistance to developing countries might be necessary. Also a joint effort in tackling this hazardous waste legacy among international bodies (e.g. Food and Agriculture Organization, Organization for Economic Co-Operation and Development, Global Environmental Facilities), authorities, industry and non governmental organizations is needed.

886. If a date for phase out for pharmaceutical uses of lindane is considered in the decision on Annex A listing for lindane (cf. UNEP 2007c), this date would thus also effect the total phase-out of alpha- and beta-HCH production and should be given when listing the chemicals in the Convention.

887. In conclusion alpha- and beta-HCH control measures have shown to be technically feasible, efficient and accessible and include: production, use, sale and imports prohibition, establishment of national inventories, monitoring, disposal of waste including stockpiles, clean-up of contaminated sites and prohibition of lindane production. Therefore, they may be appropriate for consideration as potential control measures to be implemented by countries.

4. Concluding statement

888. The POPs Review Committee of the Stockholm Convention has decided that alpha- and beta-HCH are likely, as a result of long-range transport, to lead to significant adverse effects on human health and the environment such that global action is warranted. After preparation of the risk management evaluation and evaluation of the risk profile, possible control measures were identified and deemed effective and acceptable to Parties of the Convention represented at the POPRC.

889. A thorough review of existing control measures that have already been implemented in several countries, shows that risks to humans and the environment from exposure to alpha- and beta-HCH can be reduced significantly. Control

measures are also expected to support the goal agreed at the 2002 Johannesburg World Summit on Sustainable Development of ensuring that by the year 2020, chemicals are produced and used in ways that minimize significant adverse impacts on the environment and human health.

890. In accordance with paragraph 9 of Article 8 of the Convention, the Committee recommends that the Conference of the Parties to the Stockholm Convention considers listing alpha- and beta-HCH in Annex A.

891. As elaborated in the Risk Management Evaluation of Lindane (UNEP, 2007c) the Conference of the Parties may wish to consider allowing a specific one-time, transitional exemption for alpha- and beta-HCH through the production of lindane for control of head lice and scabies as a human health pharmaceutical only. However, the high ratio of alpha- and beta-HCH wastes to lindane production along with the availability of efficacious and cost-effective lindane alternatives should be reflected in these considerations. If such a specific transitional exemption for lindane were to be allowed, then further consideration will be needed to ensure sound management of the wastes generated including alpha- and beta-HCH.

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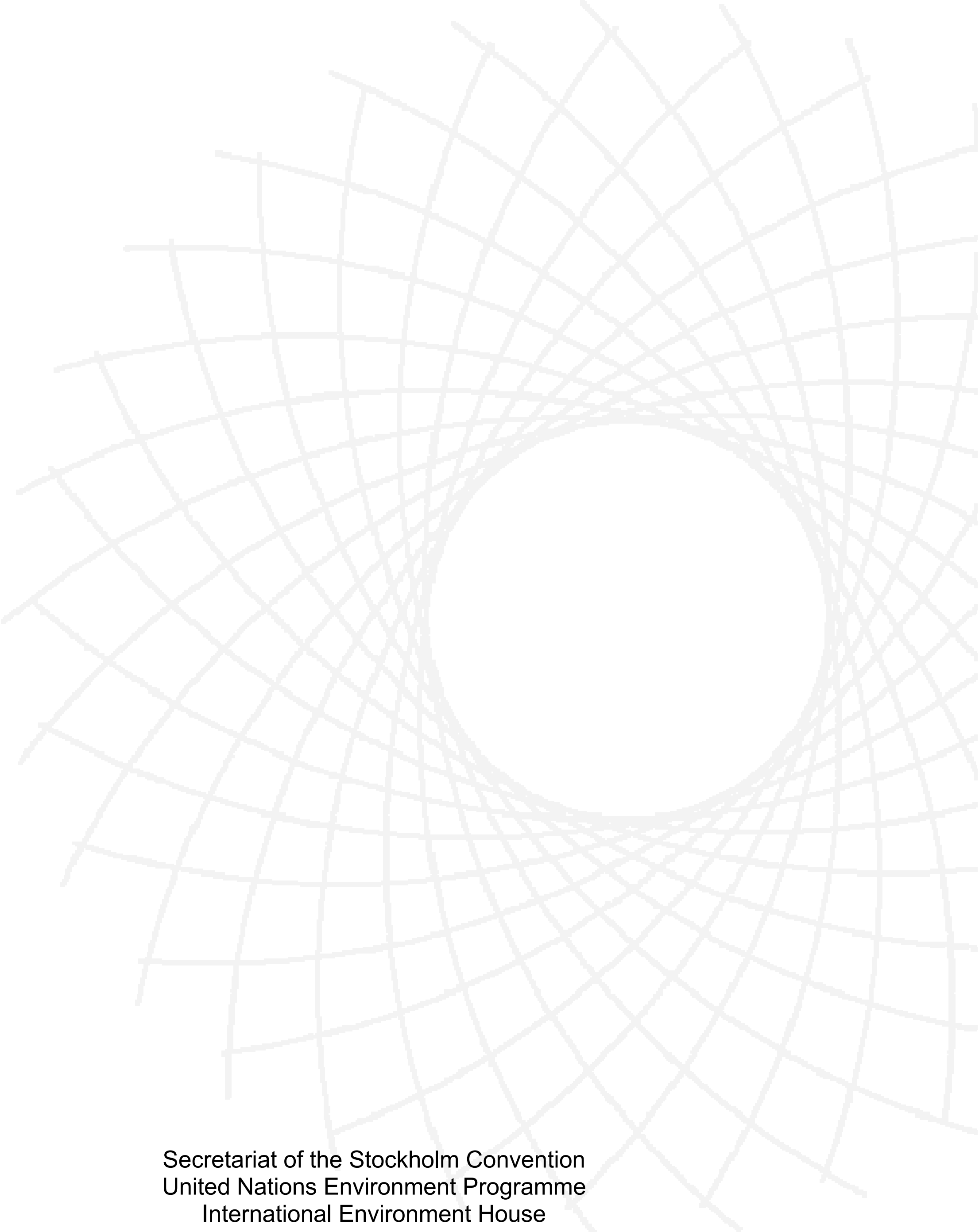

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