Stockholm Convention on Persistent Organic Pollutants

Persistent Organic Pollutants Review Committee (POPRC)

DRAFT RISK MANAGEMENT EVALUATION

for

Commercial octabromodiphenyl ether

Draft prepared by:

The ad hoc working group on commercial octabromodiphenyl ether

April, 2008

Draft Risk Management Evaluation for Commercial octabromodiphenyl ether

Note:

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

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

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Executive Summary

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 plastics industry for polymers used for housings of office equipment. The estimated annual world-wide production of commercial OctaBDE (c-OctaBDE) in 1994 was 6,000 tonnes. Globally 70% of c-OctaBDE has been used in acrylonitrilebutadiene-styrene (ABS). Other minor uses included high impact polystyrene (HIPS), polybutylene terephthalate (PBT) and polyamide polymers.

Production was phased out in the EU, Norway, Switzerland, Canada and the USA in the early to mid 2000’s. There is no information available that indicates it is still being produced in developing countries. It has been reported that it is at present essentially impossible to buy c-OctaBDE at global level. Therefore, releases from production, handling and processing in these countries/regions have already ceased or are 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 was estimated to be 0.54% of its c-OctaBDE content. The corresponding estimate for particulate loss is 2%. These releases enter industrial/urban soil (~75%), air (~0.1%) and surface water (~24.9%). Releases during the service life of products and particularly at their disposal contribute the most significant share to the total releases. Releases after disposal are considered negligible.

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

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 in the world. Since this is a global, transboundary problem, global actions to phase out c-OctaBDE should be considered.

Comment [RCC1]: Not all of the component congenersin OctaBDE have been found in the environment.

Comment [RCC2]: “High” is a relative term. High in relation to what?

Comment [RCC3]: Severe is again relative. Severe in relation to what?

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Several countries have reported that they would have problems regulating a commercial mixture of OctaBDE. Listing the polybrominated diphenylethers (PBDE) congeners having POP characteristics[1] would be consistent with existing national legislations and would facilitate the national monitoring and control of emissions, production and use.

Conclusion and recommendation

[1] The risk management dossier will have to be updated to specify which BDE congeners have POP characteristics when the intercessional work linked to the above recommendation of the POP RC is finalized:

"*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;" [Based on the ‘Background document for POPRC Members and Observers on Reductive Debromination of Bromo-aromatics’ by Professor Ian Rae dated April 2008, “The extent to which different PBDEs can be degraded under various conditions, the role of metabolism in addressing the bioaccumulation potential, and the identity of all lower congeners that may be produced, is an active research field.” Therefore latest scientific data do not indicate the need of including the environmental and health relevance of de-bromination]

Having evaluated the risk profile for c-OctaBDE, and having concluded that this chemical is 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.

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 the PBDE congeners having POP characteristics in Annex A of the Convention, as described above.

Introduction

1.1 Chemical identity of the proposed substance

Background

The European Union and its Member States, which are Parties to the Stockholm Convention, submitted a proposal in July 2006 for listing octabromodiphenyl ether in Annex A of the Stockholm Convention. At its third meeting in November 2007, the Persistent Organic Pollutants Review Committee, decided 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 establish an intercessional working group to prepare a risk management evaluation that includes an analysis of possible control measures for commercial octabromodiphenyl ether in accordance with Annex F to the Convention (UNEP, 2007a).

The term "c-OctaBDE" designates a commercial mixture containing polybrominated diphenyl ethers with varying degrees of bromination, typically consisting of penta- to deca-bromodiphenyl ether isomers and containing approximately 79% (by weight) organically bound bromine.[2]

These synthetic brominated compounds have mainly been used as flame retardants principally in the plastics industry for flame retarded polymer products, typically the housings of office equipment and business machines. 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.

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 may diffuse out of the treated material to some extent 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.

Because of the chemical and toxic properties of its main 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[3].

Chemical identity of the proposed substance

This evaluation considers the following commercial flame retardant product:

[2] This % bromine corresponds to the bromine content of a true OctaBDE molecule and so the commercial products were often called "OctaBDE" even though the product contained a range of BDEs.
[3] This could be updated if needed (see footnote 1)

– IUPAC Name: Diphenyl ether, octabromo derivative (c-octabromodiphenyl ether, c-OctaBDE)

– CAS Number: 32536-52-0

– EINECS Number: 251-087-9

– Chemical Formula of OctaBDE isomers: $C_{12}H_2Br_8O$

There are several components in the commercial product and so any assessment of the commercial product requires an assessment of the individual components. The commercially supplied OctaBDE is a complex mixture consisting (as of 2001 within the EU member States) typically of ≤ 0.5% pentabromodiphenyl ether isomers (PentaBDE), ≤ 12% HexaBDE, ≤ 45% HeptaBDE, ≤ 33% OctaBDE, ≤ 10% nonabromodiphenyl ether isomers (NonaBDE) and ≤ 0.7% decabromodiphenyl ether (DecaBDE). The composition of older products or products from non-EU countries may be different from this (European Commission 2003a). Table 1 shows typical composition of c-OctaBDE flame retardants (UK, 2007).

Table 1: Typical composition of c-OctaBDE flame retardants

Main components	% by weight			
	Up to 1994[a]	1997[c]	2000[d]	2001[e]
PentaBDE	10.5-12.0[b]		1.4-12.0[b]	≤0.5
HexaBDE		5.5		≤12
HeptaBDE	43.7-44.5	42.3	43.0-58.0	≤45
OctaBDE	31.3-35.3	36.1	26.0-35.0	≤33
NonaBDE	9.5-11.3	13.9	8.0-14.0	≤10
DecaBDE	0-0.7	2.1	0-3.0	≤0.7

Note: a) The 1994 data are taken from WHO (1994).

b) The value is for the total amount of PentaBDE + HexaBDE.

c) The 1997 data are from a composite sample from three suppliers to the EU at that time (Stenzel and Nixon, 1997).

d) The 2000 data are taken from RPA (2001) and represent the composition reported to the OECD under a Voluntary Industry Commitment.

e) The 2001 data from the Great Lakes Chemical Corporation represent the mean composition based on random sampling of selected production lots from August 2000 to August 2001.

Should we consider inserting the following c-OctaBDE composition of table in here since it shows that there are only a handful of specific congeners and not 100's as implied by using the generic congener families as shown above?

Hexa	153	<0.5

Hexa	154	~1
Hepta	183	40-45
3 Other Heptas	171, 180, 190	0-2% each
Octa	197	20-25
Octa	196	~10
Octa	203	~5
Nona	207	~10
Nona	206	~2%
Deca	209	0-1

Based on *Bestimmung polybromierter Diphenylether in Kunststoffen und Untersuchungen zum Emissionsverhalten*; Meike Bergmann; BAM-Dissertationsreihe - Band 20 and *Detailed Polybrominated Diphenyl Ether (PBDE) Congener Compositionof the Widely Used Penta-, Octa-, and Deca-PBDE Technical Flame-retardant Mixtures*; LaGuardia et al; Environ. Sci. Technol. 2006, 40, 6247-6254

1.2 Conclusions of the Review Committee of Annex E information

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-OctaBDE (UNEP, 2007a) was developed and accepted in 2007 (UNEP, 2007a). The POP Review Committee concluded as follows (UNEP, 2007b):

"*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.*"

Comment [RCC4]: Since the finalisation of the Risk Profile on c-OctaBDE Prof Ian Rae (Australia) produced the Background document for POPRC Members and Observers on Reductive Debromination of Bromo-aromatics. This document needs to be addressed in the RME. Given that one of the conclusions in this document indicates that the field of debromination is an active research field and since the RP shows that the congeners of greatest POP concern (HexaBDEs 153 and 154) are present in c-OctaBDE it would be appropriate to address these HexaBDE isomers by proposing these for listing. Higher isomers (hepta or above) should not be under consideration within the RME of the Convention until after the specific isomers have been nominated and through the Risk Profile.

Comment [b5]: This statement is not an accurate citation of Article 8(7a). Article 8(7a) refers to proceeding on proposals from the phase of the Risk Profile to the Risk Management Evaluation in the absence of scientific certainty. However, since the finalisation of the Risk Profile on c-OcttaBDE Prof Ian Rae has produced the Background document for POPRC Members and Observers on Reductive Debromination of Bromo-aromatics. Given that the conclusions in this document indicate that the field of debromination is an active research field octa and nona bromodiphenyl ethers should no longer be under consideration within the RME of the Convention. There are a large number of Octa and NonaBDE isomers and few (if any) were shown to have POP characteristics in the current Risk Profile. The current wording suggests that substances which were not evaluated or discussed in the Risk Profile are being proposed for listing by simply including them in the RME. However, procedurally, these substances would need to first appear in the Risk Profile before they can undergo RME.

1.3 Any national or regional control actions taken

Most developed countries have taken some actions to limit the production and use of c-OctaBDE. Until 2004, production was situated in the Netherlands, France, USA, Japan, UK and Israel (UNEP 2008, BSEF 2006) but it is no longer produced in the EU, USA and the Pacific Rim and there is no information that it is produced in developing countries 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

Within the European Union, there were two reported producers of c-OctaBDEs in the EU IUCLID database in 1994. However, both companies stopped production within the EU (1996/1998).

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

In the EU, OctaBDE was identified as a priority substance for risk assessment under Regulation 793/93/EEC. Based on the risk assessment, UK prepared a Risk Reduction Strategy and analysis of advantages and drawbacks of possible measures (RPA, 2002).

As a result of the European Union Risk Assessment process, Directive 2003/11/EC was adopted in 2003 (European Union, 2003). This Directive 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 15 February 2004 and apply the measures from 15 August 2004.

The European Union banned the use of OctaBDE in new electronics and electronic products as of July 1, 2005 pursuant to the Directive on restrictions on hazardous substances (RoHS) Directive (European Union, 2002a).

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). Following the objective to improve environmental performance of all operators and in particular of those operators involved in the treatment of WEEE, the Directive in its article 5 obliges Member States to adopt appropriate measures to minimise disposal as unsorted waste and to achieve a high level of separate collection of WEEE. Since 13 August 2005 systems for collection from households at least free of charge and take-back obligations were required. By December 31, 2006 at the latest a separate collection of at least four kilograms of WEEE per inhabitant per year from private households shall be achieved. Following article 6 treatment is only allowed in authorised installations complying with minimum technical requirements set out in Annex III of the Directive. In addition minimum treatment requirements were specified such as the separation of all brominated flame retardant containing plastics prior to being recovered or disposed of according to article 4 of Council Directive 12/2006. In addition specific targets are set in article 7 of the Directive as concerns recovery rates per appliance (by weight).

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

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

The Ordinance on Risk Reduction related to the use of certain particularly dangerous substances, preparations and articles (Switzerland, 2005) severely restricts marketing and use of OctaBDE in Switzerland. It is prohibited to place on the market and to use OctaBDE or substances and preparations with an OctaBDE content equal to or greater than 0.1% by mass, except for analysis and research purposes and it is prohibited for new articles to be placed on 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

In Norway the use of c-OctaBDE is banned since 1.7.2004. From 1.1.2004, products containing more than 0.25 % c-OctaBDE are classified as hazardous waste when they are discarded (UNEP, 2007c Norway).

United States of America

In the USA c-OctaBDE is subject to EPA's 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 (UNEP 2007, USA).

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

According to BSEF several American States have passed legislation restricting or banning c-OctaBDE in the USA (BSEF, 2006):

California:	Bill banning all PBDEs introduced in 2003, but decaBDE later removed by bill's author; phase out of OctaBDE only signed into law.
Hawaii:	Legislation signed by Gov. Linda Lingle in 2004 phases out OctaBDE.
Illinois:	Bill to phase out all PBDEs introduced in 2005; amended to remove decaBDE. Bill as signed bans manufacture of Octa-BDE.
Maryland:	Maryland bill signed in 2005 prohibits manufacture, processing, sale or distribution of new products containing OctaBDE.
Maine:	Bill signed into law in 2004 requires phase-out of any product containing OctaBDE, effective January 1, 2006.
Michigan:	Bill requires as of January 3, 2005, OctaBDE may no longer be manufactured, processed or distributed in Michigan.

New York: Bill requires as of January 2006, the manufacture of products containing more than 1/10th of 1 percent of OctaBDE will be prohibited. State is convening Task Force to better understand brominated flame retardants.

Oregon: Bill passed in 2005 ends use of OctaBDE as of January 2006.

Rhode Island: Bill enacted July 14, 2006 bans OctaBDE.

Washington[4]: 2004 Executive Order required Departments of Ecology, Health to develop actions state can take to reduce exposure to select PBDEs. The State of Washington has since released its PBDE Chemical Action Plan.

Comment [RCC6]: We need to get the updated situation clarified now that Washington has a law restricting the uses of PBDEs.

Canada

c-Octa BDE has never been produced in Canada (UNECE survey 2007, Canada). According to the draft report by Environment Canada, only small amounts of c-OctaBDE are imported. In Canada, results from a recent survey conducted for the 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).

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 as a result of human activity. PBDEs were added to Schedule 1 (List of Toxic Substances) to CEPA, (Canada Gazette, 2006b). Canada publicly released a proposed risk management strategy for addressing PBDEs in the Fall of 2006 which describes how the identified risks posed by the use and/or release of PBDEs will be addressed.

In December 2006, Canada published proposed Polybrominated Diphenyl Ethers Regulations for a formal 60 day public comment period. These Regulations prohibit the manufacture of seven PBDEs (TetraBDE, PentaBDE, HexaBDE, HeptaBDE, OctaBDE, nonaBDE and decaBDE) in Canada. The proposed 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. Comments have been received and are being reviewed. The prohibitions described will not be in effect until the Regulations are finalized. These Regulations represent an important first step in the risk management of PBDEs in Canada, with a focus on the three PBDEs that meet the criteria for virtual elimination under CEPA 1999.

Canada is developing additional risk management actions to complement the proposed regulations, specifically a regulation targeting PBDEs in manufactured products.

[4] Comment made by Canada (e-mail by Maya Berci from 25 May 2007): "This information is out of date, legislation that sets a North American precedent was recently passed in Washington State. House Bill 1024 was passed April 19, 2007 which prohibits manufacture, sale or distribution of most items containing PBDE as long as a safer alternative exists. The legislation calls for a ban on the manufacture and sale of mattresses containing PBDE effective January 1, 2008, and the manufacture and sale of televisions, computers and residential upholstered furniture containing PBDE by January 1, 2011, if a safer and technically feasible alternative is found. Wording to be checked with Washington State."

Asia

There is no specific legislative control of OctaBDE in Japan (BSEF, 2006), although the Japanese Chemical Substances Control Law (CSCL) applies to them. Voluntary phase out of Penta- and OctaBDE by industry is underway in Japan.

According to the state of knowledge of the Bromine Science Environmental Forum, there is no existing legislation in the Asia-Pacific region restricting the use of any brominated flame retardants (BSEF, 2006).

At the end of February 2006, China promulgated a law similar to the EU RoHS Directive. Substances targeted are the same as those targeted in the EU RoHS. Essentially, it will prohibit PentaBDE and OctaBDE use in new electric and electronic equipment when fully implemented. The implementation of phase 1 of the law is set for March 1, 2007; the implementation schedule for Phase 2 (full restrictions) is currently unclear but is expected to be implemented in a relatively short time frame, e.g. 1 year after Phase 1 (Canada Gazette, 2006a).

International institutions

The UNECE Convention on Long-range Transboundary Air Pollution

United Nations Economic Commission for Europe (UNECE) works for sustainable economic growth among its 55 member countries. The UNECE Convention on Long-range Transboundary Air Pollution requires Parties to endeavour to limit and, as far as possible, gradually reduce and prevent air pollution including long-range transboundary air pollution. The Convention has been extended by eight protocols. The Protocol for POPs focuses on a list of 16 substances that have been singled out according to agreed risk criteria for total ban, elimination at a later stage or restrictive use. In 2005, c-OctaBDE was nominated as a new POP to the Convention. In December 2005 c-OctaBDE was considered by the Executive Body of the Convention to meet the screening criteria for POPs. In 2006 the management options c-OctaBDE were assessed to give a basis for later negotiations on restrictions.

OSPAR Commission[5]

c-Octa-BDE is part of the list of substances of possible concern. According to BSEF (UNEP, 2007a BSEF), under the reviewed list, c-Octa-BDE is put under section C – about the substances put on hold because they are not produced and/or used in the OSPAR catchments or are used in sufficiently contained systems making a threat to the marine environment unlikely.

Helsinki Commission (HELCOM)

The Baltic Marine Environment Protection Commission (HELCOM) has included OctaBDE on their 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.

OECD (Organisation for Economic Cooperation and Development)

The bromine flame retardants industry signed a Voluntary Industry Commitment with OECD in 1995. In 2003, the industry was discussing a review of the commitment with OECD. The major global brominated flame retardant manufacturers committed (among other commitments) to

[5] 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.

minimize levels of hexa- and lower brominated diphenyl oxide congeners in c-OctaBDE and also to provide data regarding various toxicity and environmental studies including studies on the safe disposal and recycling of products containing brominated flame retardants (BSEF, 2006).

Production, use and releases

2.1 Levels and trends of production

Overall demand and production

The annual world-wide production of all commercial polybrominated diphenyl ethers was in 1994 estimated as 40,000 tonnes/year, which was broken down as 30,000 tonnes/year (i.e. 75%) of c-decaBDE, 6,000 tonnes/year (i.e. 15%) of c-OctaBDEand 4,000 tonnes/year (i.e. 10%) of c-PentaBDE (WHO 1994). It is likely that the production volumes have since decreased. More up to date figures are available for use volumes (see chapter 2.2).

Information on production of PBDEs in general is given in the Environmental Health Criteria document on PBDEs (WHO 1994). In this report it is stated that in the early 1990s there were eight producers of PBDEs (commercial penta-, octa- or deca-) in the world, with one in the Netherlands, one in France, two in the United States, three in Japan and one in the United Kingdom. The same total number of manufacturers was reported by KEMI (1994), but production was also reported to occur in Israel as well.

According to the Bromine Science and Environmental Forum, c-OctaBDE is no longer produced in the EU, USA and the Pacific Rim and there is no information that it is produced in developing countries. Until 2004, production was situated in the Netherlands, France, USA, Japan, UK and Israel (UNEP 2007c, BSEF). Investigations showed that it is at present essentially impossible to buy c-OctaBDE at global level (Canada Gazette, 2006a).

Within the European Union, there were two reported producers of c-OctaBDEs in the EU IUCLID database in 1994. However, both companies stopped production within the EU (1996/1998).

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

In the USA c-OctaBDE is subject to EPA's 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 (UNEP 2007c, USA). Production in the USA has since ceased. A voluntary phase out was complete before the end of 2004 (UNECE survey 2007, BSEF).

c-OctaBDE has never been produced in Canada (UNECE survey 2007, Canada). According to the draft report by Environment Canada only small amounts of c-OctaBDE are imported. In Canada, results from a recent survey conducted for the 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 2).

2.2 Use of c-OctaBDE

Use volumes

Arias (2001) reported that worldwide demand for c-OctaBDE was 3,825 tonnes/year in 1999. According to BSEF, the market demand for c-OctaBDE in 2001 was a comparable amount with 3,790 tonnes/year (UNEP, 2007c Canada 1) of which 40% are used in the Americas[6], 16% in Europe[7], 40% in Asia[8] and 4% in the rest of the world.

Within the EU, the placing on the market and use of c-OctaBDE was totally banned in 2003 (European Union, 2003). Before the ban, the combined import and production figure for the EU (i.e. the total EU consumption) of all PBDE flame retardants was 10,946 tonnes/year (in 1989) (WHO 1994).

In addition, it is possible that c-OctaBDE has been imported into or exported from the EU as a component of finished articles or master batch (polymer pellets containing additives). Reliable figures for likely quantities involved are not available. Manufacturers estimate that a figure of around 1,350 tonnes/year was realistic for the imports of c-OctaBDE into the EU in finished articles or master batch in 1999 (this figure then means that around 33% of the global amount of c-OctaBDE produced entered the EU either as c-OctaBDE itself or in finished or semifinished articles) (European Commission 2003a). Since the ban of c-OctaBDE in 2004 the import of articles containing c-OctaBDE into the EU is prohibited.

The UNECE survey (2007) has led to the following information on the use of c-OctaBDE in EU Member States:

- Belgium: the use of c-Octa-BDE has stopped; no information when;
- Czech Republic: c-OctaBDE has never been used;
- Cyprus: c-OctaBDE is not imported in Cyprus; no data is available on c-OctaBDE in imported products;
- Italy: according to industry statements use of c-OctaBDE has stopped since the 1980;
- Netherlands: use stopped in 2004;
- France: goods containing polyBDEs imported to France in 2004 cause imports of 133 tonnes of polyBDEs (including c-OctaBDE) to France. Volumes of exported polyBDE were negligible;
- United Kingdom: use of c-OctaBDE as flame retardant in polymer pellets and as flame retardant in finished products (wearing apparel, textiles, rubber and plastic products and furniture) stopped since 1997.

In Norway, a prohibition against production, import, export and the use of c-OctaBDE has been in place since 2004. It is also prohibited to produce, import, export or use products or flame retardant parts of products with over 0.1 % of BDE-196 by weight. An exception for use in evacuation equipment in aeroplanes ended 21 March 2006. Waste with a content of BDE-196 of 0.25 % or greater is treated as hazardous waste, for OctaBDE this means destruction. Recycling of articles

[6] All countries in North, South and Central America
[7] All countries in Eastern and Western Europe
[8] Australia, New Zealand and the Indian subcontinent

containing banned BFRs (Brominated Flame Retardants) is therefore only accepted, if the producers of the new product can guarantee that it will not contain BFRs (UNEP, 2008 Norway).

For Switzerland figures are available on the amount of c-OctaBDE still in use in plastics in electrical and electronic appliances but the use was declining. Since 2005 marketing and use of c-OctaBDE is prohibited. According to a substance flow analyses on the end of the 1990ies approximately 5.2 tonnes of c-OctaBDE have been imported for the use in domestic production of electric and electronic goods and approximately 36 tonnes have been imported in finished products. Consumption of c-OctaBDE in finished products is estimated to be 22 t/y. Preparations of c-OctaBDE are not used in Switzerland. About 60% of the 22 t c-OctaBDE which are used per year in consumer goods are used in electric and electronic goods, 40% in cars. During the past two decades a stock of 680 tonnes of OctaBDE in products has been accumulated in Switzerland. Currently this stock is reduced by 40 t/year. About 70% of the total c-OctaBDE stock of 680 t can be found in electric and electronic goods. The most important products for stocks and emissions are TVs (40%), cars (20%) and building materials such as plastic foils (10%; these do, however, not contain c-OctaBDE anymore). Exports were around 19 tonnes in finished products and 62 tonnes in solid waste (UNEP 2007c Switzerland; SAEFL 2002).

According to the Annex E response of Canada on c-OctaBDE (UNEP, 2007c Canada), a very small amount of c-OctaBDE was imported into Canada in 2000. The volumes reported do not include quantities imported in finished articles. According to Environment Canada (2006b), no ABS (main use type for OctaBDE flame retardant) is produced in Canada; however, Canadian imports of ABS terpolymers were 70.9 kt in 2000 and 66.2 kt in 2002. Of the 54 kt of ABS consumed in Canada in 1994, the major uses included pipes and fittings (50%), automotive parts (33%), business machines (7%), and appliances (7%) . Information gathered through an Environment Canada use pattern survey in 2001 identified that c-OctaBDE was used in Canada in 2000. Significant reformulation activity has occurred in recent years. All companies that reported use of c-OctaBDE in 2000 reported minor remaining uses in 2005, and complete phase-out by 2006 (UNECE survey 2007, Canada).

According to BSEF, the use of c-OctaBDE as flame retardant in polymer pellets in the USA stopped in 2004 and there are no more stockpiles present (UNECE survey 2007, BSEF). According to the US-EPA, production, not use, was phased out in the USA. However US-EPA expects, that levels of the stockpiles will decrease over time (UNECE survey 2007, USA).

No use is reported from Turkey and Mauritius (UNEP, 2007c).

Watanabe and Tatsukawa (1990) reported that around 1 000 tonnes of c-OctaBDE were used in Japan in 1987. Use in Japan has declined from 1,100 tonnes in 1992 to 3 tonnes in 2002 (UNEP, 2007c Japan).

Use types

Polybrominated diphenyl ethers in general are used as flame retardants. They are mostly used in applications in the plastics and textile industries. Historically about 70 per cent of c-OctaBDE had been used in ABS polymers. Other minor uses included HIPS, PBT and polyamide polymers. c-OctaBDE was mainly used as flame retardant in ABS type plastics which were used in consumer and commercial electronics and office equipment (UNEP, 2008 BSEF). As is common with BFRs in general, a synergist is also added (frequently antimony trioxide) to increase the overall effectiveness of the flame retardant treatment. PBDEs are flame retardants of the additive type, i.e. they are physically combined with the material being treated rather than chemically combined (as in reactive flame retardants). This means that there is the possibility that the flame retardant may diffuse out of the treated material to some extent.

The amount of flame retardant used in any given application depends on a number of factors such as the flame retardancy required of the finished product, the effectiveness of the flame retardant and synergist within a given polymer, the physical properties of the end product e.g. colour, density, stability etc.) and the use to which the end product will be put. Typically, the flame retardants are added at concentrations between 5 and 30% by weight (WHO 1994). Further information provided by industry indicates that c-OctaBDE is always used in conjunction with antimony trioxide. In the EU, it was primarily used in ABS polymers at 12-18% weight loadings in the final product (European Commission, 2003a). Globally, 70% of c-OctaBDE has been added to ABS polymers (Environment Canada, 2006b)

The main type of use indicated in the Annex E responses in 2007 is the use in ABS polymers. According to the European Union Risk Assessment Report (European Commission, 2003a), around 95% of the total c-OctaBDE supplied in the EU was used in ABS. Other minor uses, accounting for the remaining 5% use, included HIPS, PBT and polyamide polymers, at typical loadings of 12-15% weight in the final product. In some applications, the flame retardant is compounded with the polymer to produce pellets (masterbatch) with slightly higher loadings of flame retardant. These are then used in the polymer processing step to produce products with similar loadings as given above.

The flame retarded polymer products are typically used for the housings of office equipment and business machines. Other uses that have been reported for c-OctaBDE include nylon and low density polyethylene (WHO, 1994), polycarbonate, phenol-formaldehyde resins and unsaturated polyesters (OECD, 1994) and in adhesives and coatings (WHO, 1994).

2.3 Global demand in the future

The annual world-wide production of c-OctaBDE was about 6,000 tonnes/year in 1994. The production volumes have since decreased to about 3,800 tonnes/year in 2001. Considering a value of 3.6 €/kg this corresponded to a global market value of 13.7 m€. Due to the phase out of production in the USA, first voluntary phase out activities in Asia (Japan) and marketing and use restrictions in the EU, Norway and Switzerland and an already significantly increased use of alternatives (UBA, 2003b) it can be assumed that the demand has already further decreased and will continue to do so.

2.4 Emissions from production and processing

The European Union Risk Assessment on c-OctaBDE (European Commission, 2003a) contains release estimates from production, handling, compounding and conversion (processing), use of products, disposal and recycling and dismantling. Table 2 and Table 3 give an overview on estimated releases of c-OctaBDE based on the European Union Risk Assessment for 1994 and 1999 use volumes respectively. Due to the ban of c-Octa BDE in the EU the actual releases from production, handling, compounding and conversion are considered to be zero.

Table 2: Overview on estimated releases of OctaBDE based on the European Union Risk Assessment (European Commission, 2003a) for 1994 use volumes[9]

	1994 (tonnes/year)				
Emissions/releases from	to air	to water	to wastewater	to waste	to

[9] Note: The figures diverge from the summary figures in the European Union Risk Assessment (see European Commission, 2003a, Table 3.1, Summary of estimated releases of octabromodiphenyl ether to the environment) as the release is indicated for the EU as a total and not for the continental model. To present results for the continental model figures would have to be reduced by 10%.

					soil
Production					
Handling				5.4	
compounding and conversion	1.28		1.28		
use of products	0.0557	13.9			41.8
Disposal				2480	
Recycling and dismantling					
EU total per medium	1.3357	13.9	1.28	2485.4	41.8
EU total	**2543.7157**				

Table 3: Overview on estimated releases of OctaBDE based on the European Union Risk Assessment (European Commission, 2003a) for 1999 use volumes.

	1999 (tonnes/year)				
Emissions/releases from	to air	to water	to wastewater	to waste	to soil
Production					
Handling				0.945	
compounding and conversion	0.225		0.225		
use of products	0.0269	6.69			20.2
Disposal				1316	
Recycling and dismantling					
EU total per medium	0.2519	6.69	0.225	1316.945	20.2
EU total	**1344.3119**				

As there is no production of c-Octa BDE in the EU , Switzerland, Norway, Canada and the USA, releases from production are considered zero for the Europe and North America.

Releases from polymer processing sites may arise during handling and compounding and conversion. Due to marketing and use restrictions, there is currently no compounding and conversion of c-Octa BDE in the EU.

In Canada releases have been estimated for historic polymer processing in the year 2000. Releases of c-OctaBDE to solid waste/water and air were estimated to be very low, at 0.03 tons/year and 0.01 tons/year respectively from compounding and conversion processes (unpublished internal report, Environment Canada, 2003). Processing of c-OctaBDE has stopped in Canada since 2006 (UNECE survey 2007, Canada).

Table 4: Estimated releases from historic use in 2000 (UNEP, 2008 Canada)

Source of Release	**Release (ton/year)**	**Compartment of release (air, water, soil)**
Materials Handling - removal from drums/sacks, pouring etc.	0.4	liquid waste
Compounding -formulation into resin, simple mixing; and Conversion – open process: foam articles	0.03 (0.023 from compounding + 0.010 from conversion	Soil
Compounding - formulation into resin, simple mixing; and Conversion – open process: foam articles	0.01 (0.002 from compounding; + 0.02 0.010 from conversion)	Air
Emissions from OctaBDE from plastic products in service	0.7	Air
Emissions from OctaBDE from ABS products at disposal	>3.09 tons/year, with >150.97 tons per year remaining in the disposed products	solid waste/water

Releases from current processing are considered zero in the EU and Canada.

As in the USA production of c-OctaBDE (not use) was phased out there may still some releases be expected from processing. It is assumed that levels of any existing stockpiles will decrease over time and it can be expected that releases from processing will correspondingly decrease. However the processing of imported c-OctaBDE in polymer pellets cannot be completely ruled out. To conclude, still remaining releases from processing of c-OctaBDE in the USA are considered to be zero or close to zero with decreasing trend.

Comment [RCC7]: In the US, importation is the same as manufacturing. EPA TSCA prohibits importation of OctaBDE even in the form of mixtures (pellets) for further processing.

According to Annex E responses 2007 from Germany and BSEF (UNEP, 2007c), c-OctaBDE releases may occur when applying flame retardant treatments to textiles. In France OctaBDE was measured in waste waters of seven out of 667 so called "classified plants for environment protection". Five out of these seven plants dealt with textile treatment (UNECE survey 2007, INERIS 2006).

General process and release descriptions, and exposure estimates for OctaBDE are available in an April 2003 risk assessment conducted by an industry sponsor under US EPA’s Voluntary Children’s Chemical Evaluation Program (US EPA, 2003b; UNECE survey 2007, USA). The study contains no information on amounts released from production, handling, use, waste or recycling/recovery.

2.5 Emissions from handling and transport

Releases from polymer processing sites may arise during handling of c-OctaBDE containing polymer raw material. Losses of powders during the handling of raw materials have been estimated as 0.21% for powders of particle size >40 µm. These losses will initially be to the atmosphere, but it is expected that the dust will rapidly settle and so losses will be mainly to solid waste, which may be recycled or disposed of, or washed to wastewater (European Commission, 2003a).

In the EU and Canada handling of polymer pellets containing c-OctaBDE does not occur at present.

In Canada the release estimate for the year 2000 from historic handling (materials handling - removal from drums/sacks, pouring etc.) was 0.36 tonnes/year to solid waste/water. Processing of c-OctaBDE has stopped in Canada since 2006 (UNECE survey 2007, Canada).

In the USA handling of polymer pellets containing c-OctaBDE has already ceased or is very limited and is expected to decrease over time.

2.6 Emissions from the use of products containing c-OctaBDE

In the light of the ban and phase out of c-OctaBDE, it is important to focus on the fate in products (ECE EB, 2006). Emissions of c-OctaBDE occur from volatile and leaching losses over the service life of polymers or textiles, and also particulate losses over their service life and at disposal. In practise it is expected that total emissions will be dominated by volatile losses from polymers over their service life (e.g. >91% of the total emission of c-OctaBDE to air).

Volatilisation

According to the European Union Risk Assessment (European Commission, 2003a) the loss during the service life of a product are estimated to be 0.54% (assuming a life of 10 years). The available information for 1999 indicates that the amount of c-OctaBDE present in finished articles in the EU could be around 1,350 tonnes/year (the estimate includes both articles manufactured in the EU and imported articles containing c-OctaBDE). This corresponds to a loss of 0.73 tonnes/year in the EU, based on the 1999 EU consumption figure of 1,350 tonnes/year. These figures overestimate the current EU usage of c-OctaBDE but, as a result, will also account to some extent for the (unquantifiable) amount of c-OctaBDE that may be imported into (or exported from) the EU in finished articles or masterbatch. The losses will initially enter the atmosphere. It should be born in mind that since the products may be used over a 10 year lifetime or longer, and that each year new products containing c-OctaBDE are likely to enter into use during this time, the actual amount of c-OctaBDE present in plastic products, and hence potentially released, could be around 10 times the amount estimated above. The estimated amount of volatile losses in the EU from products in service life is therefore 7.29 tonnes/year using the 1999 data.

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According to estimations for Canada the estimated amount of volatile losses from products in service life is 0.6 tonnes[10] per year for the year 2000 (UNECE survey 2007, Canada). Extrapolating the Canadian estimation in an analogous way to the use figures for all countries in North, South and Central America for 2001 result in an estimated amount of volatile losses from products in service life of 0.86 tonnes per year for this region in 2001.

Leaching

Given that the major use of plastics containing c-OctaBDE appears to be in electrical applications and that the substance has very low water solubility, the potential for leaching of c-OctaBDE from the products during use appears to be small.

[10] Estimated based on an emission factor of 0.054% per annum, and a vapour pressure of 4.9 E -8 mm Hg at 20°C, and 1223.22 tons estimated market demand for OctaBDE in plastics in Canada in 2000

“Waste remaining in the environment”

“Waste remaining in the environment” can be considered to be particles (or dust) of polymer product, or dust generated from polymer products that contain c-OctaBDE. These particles are primarily released to the urban/industrial soil compartment, but may also end up in sediment or air. End-products with outdoor uses are most likely to be sources of this type of waste, where releases can occur over the lifetime of the product due to weathering and wear.

In addition, releases of this type can occur from disposal processes, particularly where articles are dismantled or subject to other mechanical processes, regardless of the method of ultimate disposal (or recycling/recovery). Air and dust monitoring data at dismantling plants confirm that this is a source of release of polybrominated diphenyl ethers (European Commission, 2003).

At present there is no agreed methodology given in the Technical Guidance Document (European Commission 2003b) for assessing the risks from this type of waste. However, a methodology was outlined in the draft risk assessment report for di-(2-ethylhexyl)phthalate (DEHP) (European Commission, 2000) and a similar approach is taken in the European Union Risk Assessment (European Commission, 2003a). The release estimates obtained show a high degree of uncertainty.

According to this approach the amount of “waste remaining in the environment” for the EU in 1999 can therefore tentatively be estimated as indicated in Table 5:

Table 5: Release estimates during service life and disposal of products containing c-OctaBDE for the EU in 1999

	1999 data
Total amount of octabromodiphenyl ether present in polymers	1,350 tonnes/year
Amount lost through volatilisation over the service life	7.29 tonnes/year
Total amount remaining in plastics	1,343 tonnes/year
Estimated fraction of plastic used for outdoor applications	0.1%
Amount of in plastic used for outdoor applications	1.34 tonnes/year
Estimated loss as “waste remaining in the environment”	2% over lifetime
Emission as “waste remaining in the environment” over lifetime	0.027 tonnes/year
Total amount remaining in plastics at disposal	1,343 tonnes/year
Estimated loss as “waste remaining in the environment” at disposal	2%
Emission at disposal	26.86 tonnes/year
Amount remaining in plastics for disposal (or recycling)	1,316 tonnes/year

As indicated in the table the estimated amount of “waste remaining in the environment” in the EU, which is particularly related to waste treatment at disposal, is 26.9 tonnes/year (26.86 tonnes per year from disposal + 0.027 tonnes per year from product lifetime) for the EU in 1999. According to the European Union Risk Assessment it has been assumed that these releases enter industrial/urban soil (~75%), air (~0.1%) and surface water (~24.9%).

For Canada releases have been estimated for the year 2000. The estimated amount of emissions of c-OctaBDE from ABS products at disposal will exceed 2.8 tonnes per year[11], with >137 tonnes per year remaining in the disposed products (UNECE survey 2007, Canada).

Extrapolating the Canadian estimation in an analogous way to the use figures for all countries in North, South and Central America for 2001 i.e. approximately 1,500 tonnes per year this would result in an amount of waste remaining in the environment of approximately 3.5 tonnes per year from disposal.

Consequently as current products reach the end of their service life, proper management of this waste will eliminate service life losses over the coming years.

2.7 Emissions from waste containing c-OctaBDE

Emissions at disposal

In addition to the "waste remaining in the environment" during the service life of a product a second fraction of "waste remaining in the environment" occurs at disposal. These emissions at disposal are already covered in the release estimates during the service life of a product.

Emissions after disposal

According to the European Union Risk Assessment (European Commission, 2003a), emission of c-OctaBDE also occurs after disposal.

In a Swiss study (SAEFL 2002) a substance flow analysis of c-OctaBDE has been performed for Switzerland. During the past two decades a stock of 680 tonnes of OctaBDE in products has been accumulated in Switzerland. Currently this stock is reduced by 40 t/year. With respect to the fate of c-OctaBDE in waste the study shows that c-OctaBDE usually enters the solid waste stream. Common pathways for disposal and elimination are incineration, landfilling and export (which amounted in Switzerland according to the study to approximately 86%, 10% and 4% respectively). Comparable pathways and possibly also relations might be extrapolated to other countries in the UNECE region as well. Assuming that an amount of 1,350 t of c-OctaBDE is placed on the EU market in products each year and an average product lifetime of 10 years leads to a rough estimation of a stock of c-OctaBDE of 13,500 tonnes in products in the EU. Assuming that since 2005 no more c-OctaBDE containing products entered the market, the current stock can be roughly estimated to amount to approximately 9,450 tonnes (in 2007).

Plastics containing c-OctaBDE will usually be disposed of either to landfill or by incineration. It is expected that emissions from incineration processes will be near zero, although the question of formation of brominated dibenzofurans and dibenzo-p-dioxins has been raised as a potential problem. According to SAEFL 2002 the destruction efficiency of c-OctaBDE in incineration was estimated 99.9% with the remainder of 0.1% being mainly disposed of to landfill.

When plastic containing c-OctaBDE is disposed of to landfill, in theory it could volatilise to the atmosphere or leach out of the plastic and groundwater.

Using the assumption that the amount of plastic containing c-OctaBDE produced each year replaces that disposed of each year the amount of c-OctaBDE disposed of in plastic articles could be around 1,316 tonnes/year for the EU based on the 1999 consumption data.

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[11] Estimated based on a loss to the environment of approx 2% of the quantity disposed

No experiments appear to have been carried out on the leachability of c-OctaBDE from polymers in landfills, but, by comparison with the decaBDE (see the risk assessment report of decaBDE(European Commission, 2002)), it would not be expected to leach to a significant extent from polymers, unless the polymer itself undergoes some form of degradation. In addition, c-OctaBDE is likely to adsorb strongly onto soil which will significantly lower its leaching potential from landfills into groundwater. Similarly, the low vapour pressure of the substance would limit its volatility from landfills. In addition, release to the environment of volatilised c-OctaBDE is very limited due to the coverage of landfills and the capture and treatment of waste gas from landfills.

To conclude, releases after disposal, if handled correctly and by applying BAT and BEP, can be considered to be negligible.

Emissions from recycling and dismantling

Volatile and/or particulate emissions of c-OctaBDE occur during recycling/recovery and dismantling, particularly where articles are dismantled or subject to other mechanical processes, regardless of the method of ultimate disposal (or recycling). These emissions can be allocated to emissions at disposal and are already covered in the release estimates during the service life of a product.

Air and dust monitoring data at dismantling plants confirm that this is a source of release of polybrominated diphenyl ethers (European Commission, 2003). According to the European Union Risk Assessment the estimated loss as “waste remaining in the environment” at disposal is estimated to be 2% of the total amount of c-OctaBDE that is contained in products at the end of their service life.

In the European Union Risk Assessment (European Commission, 2003) it has been assumed that this release is distributed to industrial/urban soil (75%), air (0.01%) and surface water (24.9%).

Summary information relevant to the risk management evaluation

3.1 Management options

There are in principle several control measures that could be implemented to reduce the use of c-OctaBDE 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-labelling schemes; economic instruments; and a deposit refund system.

A ban/restriction on the production and use of c-OctaBDE 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, 2001). 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.

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.

Efficacy and efficiency of possible control measures

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

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.

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 make 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.

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.

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 benign 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).

3.2 Substitution

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 the 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.

Environmental Health Criteria 192 on Flame Retardants (WHO, 1997) provides a general review of all flame retardants and their effects to the human health and the environment.

Among the countries that responded to the UNECE survey 2007 Belgium, Czech Republic, Cyprus, Germany, the UK, Switzerland and the USA indicated to have no information on possible substitutes of c-OctaBDE (Italy did not respond to the relevant question). France refers to the RPA Risk reduction strategy (RPA, 2002) and analysis of advantages and drawbacks for c-OctaBDE and states that, instead of looking for a chemical substitution, it may be worth investigating possibilities of eco-design that lower risks of ignition.

According to BSEF tetrabromobisphenol A (TBBP-A; minor use) can be used as substitute for c-OctaBDE as flame retardant in polymer pellets. Another possibility is the use of alternative polymers that are less inflammable (eg. PVC, PC/ABS) or the use of other flame retardants (UNECE survey 2007, BSEF).

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, resorcinol bis (diphenylphosphate) and brominated polystyrene. A summary of potential substitution options compared to OctaBDE is presented in Table 6.

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Table 6: Summary of Potential Substitution Options Compared to OctaBDE (RPA, 2002).

Substance	Potential Health Risks a)	Potential Environmental Risks a)	Cost and Other Considerations
Tetrabromobisphenol-A b)	No evidence of equal or greater risks	Data indicate may be classified as 'very toxic to aquatic organisms, may cause long term adverse effects in the aquatic environment' c)	Less expensive (~50%) but greater flame retardant loading required. ESR risk assessment ongoing and concerns expressed about substance in some member states
1,2-bis (pentabromophenoxy) ethane b)	No evidence of equal or greater risks	PBT properties appear of less concern than octa. However, fewer data and BCF values questioned	~ 30% more expensive
1,2-bis (tribromophenoxy) ethane b)	No evidence of equal or greater risks	Very limited data	Greater flame retardant loading probably required; expected to be comparable in price
Triphenyl phosphate	No evidence of equal or greater risks	High toxicity and relatively high potential for bioaccumulation but is readily biodegradable	Less expensive but polymer/flame retardant system expected to be more expensive overall. Poorer plastic recyclability
Resorcinol bis (diphenylphosphate)	No evidence of equal or greater risks	Acutely toxic or very toxic but biodegradable	Less expensive but polymer/flame retardant system expected to be more expensive overall. Poorer plastic recyclability
Brominated polystyrene	No evidence of equal or greater risks (but some concerns expressed re: impurities in commercial product)	No data but losses and exposure expected to be lower	Slightly more expensive

Notes:

a) Note that in most cases, the information available on toxicological and ecotoxicological effects is less than that for octabromodiphenyl ether.

b) Can be used in ABS as well as other polymers. Other flame retardants listed are not suitable for use in ABS.

c) Note that in-service losses will be lower where used as reactive flame retardant in non-ABS polymers.

Based upon this analysis, there are alternatives to c-OctaBDE available for which existing data do not indicate an equivalent or higher level of risk to health or the environment. This is especially true for reactive type flame retardants that will have significantly lower emissions during the service life of products. However, for all of the potential substitutes identified, the existing data on toxicological and ecotoxicological effects are fewer than for c-OctaBDE. The RPA report (RPA, 2002) pointed out that, given that none of these substances had yet undergone a risk assessment as rigorous as those carried out under the European Union Risk Assessment, it was inevitably not possible to compare the risks on a like-for-like basis. The results of the further testing and assessment that is ongoing for some of the potential substitutes should help to resolve the differences in data availability to a degree.

According to the RPA report (RPA, 2002), there are also other options for replacing c-OctaBDE, without utilising a substitute flame retardant. These include re-design of the electrical or electronic products or use of polymers with lower rates of combustion. Whilst there is inadequate data to estimate the likely costs of such techniques, it is considered that they are likely to be more expensive than using c-OctaBDE in most cases, at least in the short-term.

Canada refers to substitution options compared to c-OctaBDE as provided by RPA (RPA, 2002) and states furthermore that alternative techniques to reduce the use of PBDEs are generally known:

1) Use of materials that are less prone to fire hazard in electronics equipment (such as aluminium or "super-plastics" with very high oxygen requirements for combustion);

2) use of barrier fabrics, wrapping or coatings for foams to replace chemical flame retardants;

3) design-for-environment (DFE) techniques for re-use of components containing PBDEs, as an alternative to landfilling or recycling plastic materials containing PBDEs.

The US EPA has recently completed a preliminary assessment of a PentaBDE substitute, Firemaster® 550 (main component triphenyl phosphate), and concluded that this alternative chemical is not persistent, bioaccumulative or toxic to aquatic organisms. It is available in the Americas and Asia Pacific regions only. The substitute also provides the important fire safety performance standards necessary for use in consumer products. The Agency will continue to work with Great Lakes and other companies on the development of substitutes, alternatives and additional health and exposure testing on the substitutes. US EPA will also continue its efforts to gain a better scientific understanding of flame retardant chemicals (US EPA, 2003a).

Comment [RCC8]: This is not an alternative to c-OctaBDE. It isn't clear why this paragraph needs to be included.

The German Environmental Protection Agency has published a guidance document for the application of environmentally safe substances which focuses on substitution of PBDEs. The study focuses on substitution of c-decaBDE but it is stated that the results can be used for the substitution of other additive type flame retardants (UBA, 2003b).

It has to be differentiated between flame retardants of the additive type that are physically combined with the material being treated rather than chemically combined, as in reactive flame retardants (such as usually TBBP-A or specific esters of phosphoric acid). Additive type flame retardants may migrate and diffuse out of the treated material to some extent. Usually additive type flame retardants are used in thermoplastic material (e.g. Polypropylene, Polyethylene, Ethylene-Vinylacetate, PVC). They can be applied ex post to the raw polymer. Reactive type flame retardants are usually used in thermosetting material (e.g. polyester resins, epoxy resins, polyurethanes).

Generally it is considered that a substitution by additive type flame retardants that are PBT (i.e. Persistent, Bioaccumulative and Toxic) such as PBDEs, SCCPs (short chain chlorinated paraffin) , MCCPs (medium chain chlorinated paraffin) or additive TBBP-A is related to a higher risk of release to the environment during use and disposal of products – irrelevant whether they contain halogens, nitrogen or phosphorus – compared to reactive type flame retardants. Halogenated flame retardants are in addition related to the risk to generate non-desired reaction products in the case of fires (UBA, 2003b).

The use of halogenated flame retardants in the EU is significantly decreasing (with the exception of chlorinated phosphoric esters). Mineral type flame retardants such as Aluminum-tri-hydroxide (ATH) or Magnesium-hydroxide or Nitrogen containing flame retardants (e.g. melamin derivates) show significant increases. An important driving force for these market adjustments is the consideration of environmental risks (UBA, 2003b).

Halogen free flame retardants are suitable substitutes in many relevant cases. In electric and electronic equipment an efficient flame retardancy of used plastics is important. Approximately 25 % of all plastic components in this sector are flame retarded. The main share thereof is thermoplastic housings, followed by thermosetting printed circuit boards and electronic small parts. For thermoplastic housings suitable and efficient substitutes are available. In injection moulding for thermoplastic housings the flow of the molten plastic is a critical parameter. Therefore mineral type flame retardants are not appropriate substitutes. Suitable alternatives that have to be evaluated in each single case are (according to UBA, 2003b) for example:

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- halogen free systems on phosphorus-organic basis (organic triaryl- and biphosphates such as phenylcresylphosphate mixtures, triphenylphosphate, resorcinolbisdiphenylphosphate or bisphenol-A-diphenylphosphate for PC/ABS and high-impact HIPS housings).

- brominated systems with low dioxin/furan formation potential, in particular with respect to recycling/recovery processes (e.g. 1,2-bispentabromophenylethane or ethylenbistetra-bromophthalate).

It has to be noted that the halogen free systems based on organophosphorus compounds cannot be generally considered to be the environmentally preferable substitute. However, the ecologic advantages outweigh the disadvantages at least in comparison with decaBDE or additive TBBP-A if

- substances that have been sufficiently tested for toxicological properties and have proven degradability and low volatility are used as additive type flame retardant in these systems or

- organophosphates that have been sufficiently tested for toxicological properties are used as reactive type flame retardant.

In the guidance document the technical practicality of substitution is demonstrated by means of several examples (UBA, 2003b).

UBA 2003a contains a comparison of 9 typical flame retardants in plastic materials and considerations on possible adverse effects: decaBDE, TBBP-A (additive), hexabromocyclodecane, trischloropropylphosphate, antimony trioxide, aluminum trihydroxide, ammonium polyphosphate, resorcinol bisdiphenylphosphate and zinc borate. The comparison takes health (mutagenicity, genotoxic carcinogenicity, reprotoxicity, carcinogenicity, and allergic effects) and environmental (persistency, bioaccumulation and aquatic toxicity) aspects into consideration. There is no unambiguous result that enables to determine the most appropriate flame retardant. Ammonium polyphosphate has neither CMR (Carcinogenic, Mutagenic, and Reprotoxic) nor PBT (Persistency,

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Bioaccumulation, Toxicity) properties but has restricted practicability due to technical reasons. This underlines the need that the evaluation has to be done on a case by case basis. However, CMR and PBT substances should generally not be used, except if their potential release is proven to be negligible.

3.3 Measures to reduce emissions

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.

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.

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

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).

Specific measures concerning the handling of waste at disposal and recycling/recovery could be to separate articles containing c-OctaBDE from those without the substance (problematic to identify these articles) and to direct them to controlled disposal (e.g. treatment as hazardous waste) or to set targets for the phase out of the use of existing products containing c-OctaBDE and to implement collection of these products.

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 alter 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).

In general measures as identified to reduce environmental emissions at compounders and processors could principally also be applied to disposal, recycling/recovery and dismantling facilities. These should aim to minimise dust and air emissions and to avoid input to waste water. In particular measures could be suggested to reduce releases at disposal by applying BAT/BEP (Best Available Technologies/Best Environmental Performance) at disposal and recycling/dismantling/reuse. A source for possible measures could be the BREF[12] on waste

[12] BREF = Best available techniques REFerence document

treatment, even if specific measures for recycling/recovery and dismantling have not been identified in the BREF (European Commission, 2006). Possible measures include simple technical and organisational measures and end-of-pipe controls reducing 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;
- using local exhaust ventilation to control dust and volatile emissions;
- shredding in closed systems including dust separation and thermal treatment of exhaust air.

3.4 Impacts on society of implementing possible control measures

Benefits of phasing-out c-OctaBDE

The most obvious benefits to the global society of phasing out c-OctaBDE 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, 2007b). Some components of c-OctaBDE can enter into the food chain and bioaccumulates in the fatty tissues of top predators, including humans. They have been detected in several endangered species.

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

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 European Commission (European Commission, 2005), the available alternatives function as well as c-OctaBDE. Most of the alternatives are in themselves less hazardous to the environment than c-OctaBDE.

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-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), and so no good estimates are available of the potential cost of damage avoided.

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

Cost implications for industry

Production was recently phased out in the EU, Norway, Switzerland, Canada and the USA. No information that indicates it is being produced in developing countries. Processing is considered zero in the EU and Canada. Some processing of c-OctaBDE may still occur in the USA but it is considered to be zero or close to zero. Appropriate substitutes for c-OctaBDE are available.

Canada expects no cost implications on industry for the substitution of c-PentaBDE and c-OctaBDE (Canada Gazette, 2006a). In the light 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.

Canada have also stated it is not possible to quantify and monetise the preventative (health and environment) benefits of the proposed Regulations given that PBDE use by industry has been discontinued and future demand for the substance cannot be estimated. However, costs to industry and government of the proposed regulations have been estimated. The economic criterion that was considered was the cost to industry to reformulate away from the use of PentaBDE and OctaBDE. This cost was deemed to be minor (zero) as drop-in substitutes are available, and PentaBDE and OctaBDE are 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).

Against this background it can be concluded that industry will not experience any incremental costs, as a result of the proposed options.

Also if a ban of c-OctaBDE will come into force it would be reasonable to implement BAT/BEP (Best Available Technologies/Best Environmental Performance) at disposal and recycling/recovery installations in order to reduce releases from products containing c-OctaBDE at disposal and recycling/recovery. Additional costs could particularly arise from technical measures to be 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. Costs related to the application of BAT are per se economically viable as this term designates economically and technically available techniques. The best environmental performance is usually achieved by the installation of BAT and its operation in the most effective and efficient manner.

The installation of end-of-pipe control technologies could be costly. However, in most countries requirements for 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 in those countries.

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 the light of the ban and phase out of c-OctaBDE the analyses is not any more up-to-date, in particular the economic assessment.

Cost implications for consumers

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.

Cost implications for state budgets

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

Canada has performed a cost estimate for the proposed regulations on PBDEs for the costs that would be incurred by the federal government as a result of enforcement and compliance promotion activities related to the proposed Regulations. The regulatory impact analyses statement is published in the Canada Gazette (Canada Gazette, 2006a).

The key assumptions used for the analysis include the following:

- Regulatory time frame: the proposed Regulations are assumed to come into force at the end of 2007, with the ban on PentaBDE and OctaBDE imports and uses being fully in effect in 2008 when uses reach zero.

- 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[13].

- 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.

Total enforcement and compliance promotion costs for the Canadian Government over the 25-year time frame were reported to be in the order of $439,646 Canadian dollars which can be split up as follows:

- With respect to enforcement costs, for the first year following the coming into force of the proposed Regulations, a one-time amount of $250,000 will be required for the training of enforcement officers.

- In addition, for years one through five following the delivery of the training, the enforcement costs are estimated to require an annual budget of $56,220 broken down as follows: $37,750 for inspections (which includes operations and maintenance costs, transportation and sampling costs), $14,330 for investigations and $4,140 for measures to deal with alleged violations (including environmental protection compliance orders and injunctions).

[13] 1€ = 1.53 Canadian dollars

- For the subsequent years (that is years 6 through 25), the enforcements costs are estimated to require a total budget of $62,738 broken down as follows: $27,000 for inspections (which includes operations and maintenance costs, transportation and sampling costs), $17,642 for investigations and injunctions, and $18,096 for prosecutions.

- Compliance promotion activities are intended to encourage the regulated community to achieve compliance with the proposed Regulations. Compliance promotion costs would require an annual budget of $118,000 during the first year of coming into force of the proposed 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 following enforcement activities compliance with the Regulations is found to be low. For subsequent years, no additional compliance promotion activity is expected, and therefore, total compliance promotion costs are estimated at $154,800.

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

3.6 Identification and discussion of possible management options under the Stockholm Convention

Possible management options

The objective of the Stockholm Convention is to control, reduce or eliminate discharges, emissions and losses of Persistent Organic Pollutants.

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 the product or similar products is currently possible.

Possible management options are to restrict or eliminate production and use of c-OctaBDE or its congeners having POP characteristics. Listing the individual congeners 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 trace.

Options for the regulation of c-OctaBDE have also been discussed in the risk management evaluation of PentaBDE (UNEP, 2007d). It was suggested that, if a decision is taken to list the separate 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.

In agreeing 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

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

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.

A ban on the BDE congeners having POP characteristics would be related to the following advantages:

- *Better practicality*. Several countries have reported that they will have problems to regulate a commercial mixture of PentaBDE (UNEP 2007d). This is also valid in the case of c-OctaBDE. Most national regulations concern compounds. It will therefore be more practical to list the BDE congeners having POP characteristics, meaning BDE 153, 154 and BDE 180. All mixtures with one of the congeners having POP characteristics will then be covered.

- *More efficient monitoring and control*. Listing the individual congeners could facilitate the monitoring and control of emissions, production and use.

- *Target oriented and long term effective*. Listing of the harmful congeners will contribute to the control of the relevant components of all commercial BDE mixtures. Even if producers will change the formulation of commercial BDE mixtures in the future it will be assured in the long term that the relevant harmful components will be banned.

Synthesis of information

4.1 Summary of evaluation

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 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).

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

Comment [b9]: For reasons of better practicality, scientific certainty and consistency with the RME of c-PentaBDE , the draft RME should name here the specific isomers listed: BDE 153, 154 and 180.

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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.

Suitable and economically viable alternatives are available for all uses of c-OctaBDE. The human health or environmental impacts of these alternatives made them preferable alternatives over c-OctaBDE. However, some alternatives currently in use caused concern because of their properties. Reactive type flame retardants and halogen free substitutes appear to be generally preferable under environmental and health aspects.

Incremental costs as a result of a complete ban are not expected for the industry.

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..

Costs implications for consumers are not expected.

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.

4.2 Elements of a risk management strategy

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 would be best served by a global ban on production and use of c-OctaBDE covering all sectors. Listing BDE congeners having POP characteristics of c-OctaBDE 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.

Listing the BDE congeners having POP characteristics 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.

The provision of 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.

Waste fractions containing c-OctaBDE should be handled more stringently than ordinary household and consumer waste. as hazardous waste. 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'.

Comment [RCC10]: This term has different meanings under different national legislation. Is there an internationally accepted meaning for this term as used in this document?

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Concluding statement

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) in that some 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.

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 the congeners in c-OctaBDE having POP characteristics in Annex A of the Convention, as described above[14].

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[14] This could be updated if needed (see footnote 1).

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