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Matters related to the implementation of the Convention: scientific and technical matters: technical guidelines

Analysis on waste-related information on decabromodiphenyl ether

Note by the Secretariat

As referred to in the note by the Secretariat on technical guidelines (UNEP/CHW.13/6), the annex to the present note sets out the analysis on waste-related information on decabromodiphenyl ether prepared by Norway, in consultation with the small intersessional working group on the development of technical guidelines on persistent organic pollutant wastes. The present note, including its annex, has not been formally edited.

* UNEP/CHW.13/1.

Annex

Analysis on waste-related information on decabromodiphenyl ether

(Draft of 19 January 2017)

Norwegian Environment Agency, Oslo

Consultancy service on collecting, summarising and analysing information on c-decaBDE in waste

Analysis of the information received by the Basel Convention related to c-decaBDE as called for in decision BC-12/3

Reference number: 2016/4072

Final Report

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Content

1 Background

1. At the twelfth Conference of the Parties to the Basel Convention in May 2015, Parties agreed to start collecting information on c-decaBDE[1] in waste streams. As called for in decision BC-12/3, Parties and others were invited to submit waste-related information on c-decaBDE by 30 August 2016. Norway has agreed to analyse the information received and share the analysis with the intersessional working group on POPs waste.

2. The present document is related to the specific objective to making an analysis of information related to c-decaBDE, based on information- received by the Basel Convention Secretariat 30 August 2016, (see Table 1).

Table 1: Information related to c-decaBDE as called for by decision BC-12/3 received by the Basel Convention Secretariat[2]

Parties	Submitted information / documents
Canada	1. **[Canada Env 2006]** Canadian Env. Protection Act 1999_PBDEs
	2. **[Canada Env 2010a]** Ecological State of the Science Report on Decabromodiphenyl Ether (decaBDE)
	3. **[Canada Env 2010b]** Final Risk Management Strategy for PBDEs
	4. **[Canada Env 2011]** PBDEs in the Canadian environment
	5. **[Canada Env 2014]** Background study on the content of shredder residue
EU	1. **[EU 2016]** Waste related information on decaBDE, Comments from the EU and its MS
	2. **[Danish EPA 2014]** Survey of Brominated Flame Retardants[3]
India	1. **[India 2016]** Waste related information on decaBDE, Submission from India
Japan	1. **[Japan 2016]** Information on decaBDE waste from Japan
Norway	1. **[Norway 2015]** Literature Study – DecaBDE in waste streams
	2. **[Norway 2016]** Consultancy service on collecting, summarizing and analyzing information on c-decaBDE in waste, Delivery part 1
	3. **[Leslie et al. 2016]** Propelling plastics into the circular economy — weeding out the toxics first.[4]

3. In the following analysis reference is made to these submissions. Where relevant, the original information source according to the submission is also cited. For the complete reference of the original source please refer to the corresponding submission. In addition to the submitted documents, selected information from the risk management evaluation and the risk profile in the context of the POPs Review Committee (POPRC) under the Stockholm Convention on decaBDE (UNEP/POPS/POPRC.11.10/Add.1 and UNEP/POPS/POPRC.10.10/Add.2) respectively[5]) and from a draft BAT/BEP Guideline under the Stockholm Convention (UNEP BAT/BEP 2016) [6] was used to develop the present document. The document has been circulated in the small intersessional working group on POPs, and comments from Parties and others have been incorporated in the current document.

[1] In this document the term "c-decaBDE" relates to commercial decaBDE and its main component which is BDE-209 if there is no other term used or there is no other specific statement. In some information sources it is not clear to what the specific individual information refers. Therefore it is not always possible to ascertain that the correct specific term is used in all places.

[2] The relevant submissions to the Basel Convention regarding decaBDE are available at http://www.basel.int/Implementation/POPsWastes/TechnicalGuidelines/tabid/5052/Default.aspx

[3] In its submission, the EU make reference to [Danish EPA 2014] which is available at http://www2.mst.dk/Udgiv/publications/2014/01/978-87-93026-90-2.pdf

[4] Submission by Norway: Leslie, P.E.G. Leonards, S.H. Brandsma, J. de Boer, N. Jonkers. Propelling plastics into the circular economy — weeding out the toxics first. Environment International 94 (2016) 230–234.

[5] Available at http://chm.pops.int/TheConvention/POPsReviewCommittee/POPRCRecommendations/tabid/243/Default.aspx

[6] Working draft: The Guidelines on best available techniques and best available environmental practices for the recycling and disposal of waste containing PBDEs listed under the Stockholm Convention is currently being revised and updated by the task team on BAT and BEP for PBDEs. The draft was considered at the expert meeting in Bratislava, Slovakia, 25-27 October 2016.

2 Information on national legislation relevant for c-decaBDE in waste

4. Information on waste related legislation and limit values was submitted by Canada, the EU, India, Japan and Norway. Table 2 gives an overview on submitted information on waste related legislation, relevant limit values and requirements to separate or specifically treat waste containing c-decaBDE (or PBDEs or brominated flame retardants (BFR)).

5. There are numerous regulatory initiatives concerning c-decaBDE that have been enacted in various jurisdictions around the world, the majority of which are targeting c-decaBDE and other PBDEs contained in electronic and electrical equipment (EEE). Increasingly, however, jurisdictions are targeting restrictions on the content of c-decaBDE in additional product types (in addition to EEE) (for details see e.g. chapter 5 of [Canada Env 2010b], chapter 2 of [Danish EPA 2015] or chapter 2.3.1 of [Norway 2015]).

6. Requirements to separate plastic with brominated flame retardants such as c-decaBDE containing waste from E-waste and to manage it properly are established in the EU and associated countries and in China. For other waste streams than E-waste, specific requirements to separate c-decaBDE do not exist.

Table 2: Information on legislation relevant for c-decaBDE in waste limit values (in bold) and separation requirements according to information submitted to the Basel Convention

Submission	Information; limit values in legislation	Requirement to separate
Canada	In general, initiatives e.g. in Canada, the US or Asia described in the submitted information are related to restrictions in production and use of c-decaBDE and not to the waste management phase. Canada prohibited the manufacture, import and use of Penta and Octa commercial mixtures in 2008, and proposed in 2010 to expand this prohibition to DecaBDE as well as products containing PBDEs [Canada Env 2011].	
EU	The WEEE Directive 2012/19/EU[7] on waste electrical and electronic equipment (WEEE) requires selective treatment and proper disposal for materials and components of WEEE with brominated flame retardants. [Danish EPA 2014] According to the RoHS Directive 2011/65/EU[8], EEE placed on the market shall not contain PBDEs, including c-decaBDE, in concentrations above 0.1 % (1,000 mg/kg) (see [Danish EPA 2014]). Regulation (EU) No 1257/2013[9] on ship recycling includes PBDEs to be included in an inventory of hazardous materials. In Denmark, plastics containing c-decaBDE and other BFR must be delivered to companies that are authorized to handle brominated waste under the Environmental Protection Act § 33 or similar legislation abroad. Plastic with bromine content **< 5 ppm (mg/kg)** can be returned for reprocessing and recycling [Danish EPA 2014]	To separate E-waste containing BFR
India	The regulation of hazardous substance in EEE in India is governed as per Rule 16 of E-Waste (Management) Rules, 2016. The PBDE content, including c-decaBDE, in EEE is restricted to 0.1% (1,000 mg/kg). The provisions of the E-Waste (Management) Rules, 2016 govern environmentally sound management of E-waste containing PBDEs. [India 2016]	
Japan	Parts of products using c-decaBDE are incinerated while other parts are being used for material recycling within the framework of laws relating to recycling, or ultimately end up in a landfill.	
Japan	Under Japanese PRTR law[10], the annual volume of c-decaBDE transferred and disposed as waste has to be reported to competent authorities (see [Japan 2016].	

[7] Available at http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32012L0019
[8] Available at http://eur-lex.europa.eu/legal-content/de/TXT/?uri=CELEX%3A32011L0065
[9] Available at http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013R1257

Norway	In Norway, c-decaBDE is included in the waste regulations which prescribes that waste containing c-decaBDE at or above **0.25%** (2,500 mg/kg) must be handled as hazardous waste [Norway 2016].	To handle waste with c-decaBDE above 0.25% (2,500 mg/kg)[11] as hazardous waste
Norway	Norway has implemented the European WEEE Directive on handling of E-waste, the RoHS Directive on Hazardous Substances in electronics which restricts the use of PBDEs, including c-decaBDE, in electronic products to 0.1% (1,000 mg/kg), and the European End of Life Vehicle Directive which promotes recycling and in this respect the removal of large plastic components if these materials are not segregated in the subsequent shredding process. (see [Norway 2016])	
Norway	In September 2016, the EU REACH committee voted to amend Annex XVII to Regulation (EC) No 1907/2006[12] concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) as regards bis(pentabromophenyl)ether (decaBDE). The Regulation is foreseen to be adopted by the EU Commission in the beginning of 2017, and will start to apply 24 months later. According to the Regulation, and safe for specifically exempted cases, decaBDE (CAS No 1163-19-5) shall a. not be manufactured or placed on the market as a substance on its own, and b. not be used in the production, or placed on the market in a concentration equal to or greater than 0,1 % by weight (1,000 mg/kg). Exemptions are given for aircrafts and spare parts for aircrafts and motor vehicles. For aircrafts and spare parts for aircrafts, the restriction will not apply until 10 years after entry into force of the Regulation. The restriction will not apply to electrical and electronic equipment within the scope of the RoHS Directive 2011/65/EU, as the placing on the market of such equipment containing polybrominated diphenyl ethers (‘PBDE’) in a concentration above 0,1 % by weight (1,000 mg/kg) is already regulated by that Directive. .	
Norway	With respect to E-waste, the Norwegian Waste Regulation § 1-22, fourth paragraph (letter k) requires to separate plastics with brominated flame retardants as a first part of the treatment process unless it can be proved at least as good environmentally responsible treatment by a mechanical, chemical or metallurgical process. [Norway 2016]	Requirement to separate plastics with Brominated Flame Retardants

7. According to the risk management evaluation, c-decaBDE is also restricted in China and Korea.

8. In China, PBDEs are not allowed in EEE at concentrations above 0.1% (1,000 mg/kg) by weight for environmental labelling of products. E-waste must be handled in accordance with the legislation on the Waste of Electrical and Electronic Equipment and e-waste containing PBDEs should be separated out and be disposed of as hazardous waste**.** China also recently announced a restriction for the use of PBDEs in cars with a concentration limit of 0.1 % (1,000 mg/kg) from 1 January 2016 (see (UNEP/POPS/POPRC.10.10/Add.2) referring to (Jinhui et al. 2015) and (BSEF 2015a)).

9. Korea implemented a law in 2008, which covers end-of-life and restrictions on electronic products and vehicles. Exemptions, limit values and restricted substances are the same as the EU RoHS Directive. C-decaBDE is exempted from the list of hazardous substances in polymeric applications under the Recycling of Resource in Electronic Equipment and Automobiles' Regulation (BSEF 2012). Similarly to the EU end of life vehicle directive, legacy spare parts for out of production vehicles are exempted from this restriction (see (UNEP/POPS/POPRC.10.10/Add.2) referring to (BSEF 2012)).

[10] The name behind this regulation is not indicated in the submitted information. A list of laws and regulations, etc., concerning the japanese PRTR is available at http://www.env.go.jp/en/chemi/prtr/regulations/index.html

[11] According to European Recycling Association, if deca -BDE is used in plastics, these concentrations will always be above 2500 ppm. EERA believes that this kind of ruling will stop the recycling of plastics from WEEE.

[12] Available at http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02006R1907-20140410

3 C-decaBDE in products, waste and recycled material

3.1 Production and use of c-decaBDE

10. According to the risk management evaluation under the Stockholm Convention, c-decaBDE consumption peaked in the early 2000's and c-decaBDE is still used worldwide. Available production data indicate that about 75% of all the world production of PBDEs was c-decaBDE. Today c-decaBDE is manufactured only in a few countries globally. Many countries have already restricted or initiated voluntary programs to end the use of c-decaBDE. Total production of c-decaBDE in the period 1970-2005 was between 1.1-1.25 million tonnes (see UNEP/POPS/POPRC.10.10/Add.2) and (UNEP/POPS/POPRC.11.10/Add.1)).

11. C-decaBDE has many applications and is used in many different sectors of the society. It is used in EEE like computers and TVs, in wires and cables as well as in adhesives, sealants, coatings, inks and pipes. C-decaBDE is also extensively used in commercial textiles for public buildings, in textiles for domestic furniture and in the transportation sector. The many uses and applications of c-decaBDE can be roughly divided into two main categories – in plastics polymers and in textiles. As discussed in detail in the risk profile (see (UNEP/POPS/POPRC.10.10/Add.2) c-decaBDE use within these applications varies between different countries and regions. Globally up to about 90% of c-decaBDE ends up in plastics, primarily in electronics, while the remainder ends up in coated textiles, upholstered furniture and mattresses (UNEP/POPS/POPRC.11.10/Add.1).

12. Table 3 gives an overview of relevant production and consumption quantities according to the information submitted to the Basel Convention secretariat.

Table 3: Overview of relevant production and consumption quantities of c-decaBDE according to information submitted

Chemical	Quantity	Remark	Source
c-decaBDE	30,000 t	Global consumption in 1994	[Danish EPA 2014] referring to (OECD 1994)
c-decaBDE	56,100 t	Global consumption in 2001	[Danish EPA 2014] referring to (BSEF 2006)
c-decaBDE	25,000-50,000 t	Global consumption in 2011	[Danish EPA 2014]
c-decaBDE	56,150 t	Market demand of c-decaBDE in 2001 in America (24,500 t), Europe (7,600 t) and Asia (24,050 t)	[Canada Env 2006] referring to (BSEF 2003)
c-decaBDE	3,000 t	Entrance into the Canadian market in 2009 from all sources (substance and within imported products); some PBDEs are exported from Canada in finished products	[Canada Env 2010b]
c-decaBDE	4133 t	Imports to EU27 in 2012 (decreasing trend from 11,484 t in 2007 to 4,133 t in 2012)	[Norway 2015] referring to (RPA 2014)
c-decaBDE	1,000 – 2,500 t	Volume sold in Europe by VECAP/EFRA member companies in 2014	[Norway 2015] referring to (VECAP 2014)
c-decaBDE	1,600 t	Consumption in Japan in 2013	[Norway 2015] referring to (UNEP POPS POPRC.10/10/Add.2)
c-decaBDE	< 1,000 t	DecaBDE manufactured and imported was less than 1000 tons in 2013 (manufacturing and import still ongoing in 2014)	[Japan 2016]
c-decaBDE	8,215 t	US national production volume including domestic production and import in 2012	[Norway 2015] referring to (UNEP POPS POPRC.10/10/Add.2)

13. Data on use of c-decaBDE Reports indicate that prior to 2008, 80–90% of c-decaBDE (Cheminfo 2008) was used in EEE products, with textile applications accounting for most of the remaining 10–20%. Since 2008, the EU RoHS Directive, has been restricting c-decaBDE use in certain EEE products. As a result, the use profile has changed so that transportation and textiles now represent a much larger percentage of c-decaBDE use in products [Canada Env 2010b]. European Automobile Manufacturers Association (ACEA) see the same decrease of volume for applications where decaBDE is used in automobiles to provide flammability protection.

14. Substantial stocks of c-decaBDE are still present in c-decaBDE containing products in the technosphere (see [Norway 2015]).

3.2 Concentration levels of c-decaBDE in products

15. Typically c-decaBDE is used in plastics/polymers at concentrations of 10-15% by weight (up to 20%). Available information indicates that c-decaBDE treated textiles contain up to 12% of c-decaBDE by weight [Norway 2015]. Specific concentration levels of c-decaBDE have been identified in the course of a comprehensive literature review in approximately 20 information sources (see specific references in annex to this report, reproduced from Norway 2015). Reported concentration levels of c-decaBDE cover a broad range of products sampled at different locations globally.

16. Table 4 summarises reported concentration levels in products from relevant sectors.

Table 4: Reported concentration levels in products from relevant sectors (according to [Norway 2015])

Sector	Levels	Remark
EEE products	0 to 15% (0 to 150,000 mg/kg)	In EEE c-decaBDE is typically used in concentrations ranging from 10 to 15% (up to 20%). A number of studies have measured c-decaBDE/ BDE-209 levels in products and materials commonly used in EEE such as plastics used for EEE, computer casings, TV casings, PC boards, rice cookers, plastic parts from small EEE, white goods, small domestic appliances, plastics from cathode ray tube screens. Based on a literature review, Table 3 in [Norway 2015] provides an overview of reported concentrations of decaBDE in EE and the specific information sources (see Annex to the present document).
Transport	0-2.7% (0 to 27,000 mg/kg)	Reported c-decaBDE/ BDE-209 levels in car materials used in some car components. Levels above 2% are particularly reported for seat cover materials from old cars. Based on a literature review, Table 4 in [Norway 2015] gives an overview of reported c-decaBDE/BDE-209 levels in the transport sector and the specific information sources (see Annex to the present document). The reported results range from not detected (n.d.) to 27,000 mg/kg. The reported results demonstrate that many of the investigated car parts/materials did not contain decaBDE (n.d.) or only in some cases. Specific information on c-decaBDE levels in transport means other than cars was not submitted.
Construction	0-30% (0 to 300,000 mg/kg)	Specific information is scarce. Typical c-decaBDE/BDE-209 concentrations in electrical insulation range from 10-30% and in epoxy adhesives it is below 30%. Specific information on decaBDE levels in construction materials is very scarce. In PVC flooring it was not detected. In damp proof membrane filter it was detected below 0.1% and in rubber insulation board it was contained at a level of 6%. Table 5 in [Norway 2015] provides an overview of reported concentration levels of c-decaBDE/BDE-209 in the building and construction sector and the specific information sources (see Annex to the present document).
Textiles	Up to 12% (up to 120,000 mg/kg)	Specific information is scarce. Typical products are coated textiles, upholstery, window blinds, curtains, mattresses and carpets for public and domestic buildings, as well as tents and textiles used in the transportation sector. C-decaBDE is usually not used for clothing. Table 6 in [Norway 2015] provides an overview of reported concentration levels of c-decaBDE/BDE-209 in the textile and furniture sector and the specific information sources (see Annex to the present document).

3.3 C-decaBDE levels measured in waste

17. Production and use of c-decaBDE is decreasing, however, c-decaBDE containing products are continuously entering waste streams and occur in certain wastes in significant concentrations, in particular in E-waste. C-decaBDE is also present in plastics from ELV treatment and can occur in plastics from construction and demolition waste and textiles/furniture waste [Norway 2015].

18. Average concentrations of c-decaBDE in E-waste reported between 2003 and 2014 range typically between zero and 0.3% (3,000 mg/kg) with higher levels for CRT TVs and monitors and office equipment (results from Europe). Average concentrations in TV CRT screens sampled in Nigeria in 2011 were higher (0.08% (800 mg/kg) in PC CRT screens and 0.86% (8,600 mg/kg) in TV CRT screens). (Table 3 in [Norway 2015] provides an overview of reported c-decaBDE/BDE-209 levels in E-waste/electronic products[13]).

[13] Please note that [Norway 2015] contains an error related to the values reported by (Sindiku et al. 2014) in PC CRT screens and TV CRT screens. The concentrations indicated in [Norway 2015] Table 3 are the average concentration levels of "positive" samples (samples which were selected as bromine containing based on XRF screening). The average concentrations of all samples reported in [Sindiku et al. 2014] are 0.08% (not 0.86%) in PC CRT screens and 0.86% (not 5.7%) in TV CRT screens. The numbers are adjusted accordingly here because average concentrations of all samples (not only those containing bromine) are relevant.

19. Several measures have been taken by countries to restrict the use of c-decaBDE. In addition, initiatives to voluntarily phase-out c-decaBDE have been taken by industry (see e.g. (UNEP/POPS/POPRC.11.10/Add.1)). As a consequence it can be expected that c-decaBDE levels in waste and recycled materials will decrease over time.

20. Due to the use of c-decaBDE in electronic products, plastics and textiles, c-decaBDE occurs in many waste types including in E-waste, ELVs, bulky waste and municipal waste. Due to the particular use of c-decaBDE in the electronic sector, E-waste is of particular importance. E-waste is often treated together with ELVs in the same shredder plants. Several sources provide information on levels of c-decaBDE/BDE-209 and other PBDEs in different types of shredder residues from E-waste (E-waste SR), from cars (automotive shredder residues = ASR), and mixed input from E-waste and ELV and other input sources (mixed SR) (specific sources see Table 5). Specific information on c-decaBDE levels from other means of transport (other than cars) was not submitted for this analysis.

21. DecaBDE/BDE-209 levels reported in shredder residues range from 0- 0.33% (3,300 mg/kg) [Norway 2015]. Canada has submitted a literature and interview based study on the composition and fate of shredder residues in Canada (see [Canada Env 2014]). ELVs are one of the primary feedstocks for metal shredders in Canada. The PBDE content of ASR in Canada is estimated at 1,600 mg/kg, and plastics generally represent 20-45% of the ASR. While no specific information on the content of c-decaBDE was provided, it can be assumed that a certain amount is present in ASR based on their known uses. There is continual development of post-shredder technologies to utilize this shredder residue in value-added applications and to consequently divert it away from landfills [Canada Env 2014].

22. Reported c-decaBDE/BDE-209 levels in car materials range from zero to 2.7% (27,000 mg/kg). Levels above 2% (20,000 mg/kg) are reported for seat cover materials from old cars (see Table 4 in [Norway 2015]). Average concentrations in ASR range from ~0.003% to 0.22% (2.55 to 2,163 mg/kg) (). Specific levels in ASR demonstrate a decreasing trend over time. Specific information on occurrence levels of c-decaBDE in the construction and the textiles/furniture sector is scarce [Norway 2015].

23. Table 5 gives an overview on the c-decaBDE/BDE-209 levels reported for shredder residues.

Table 5: C-decaBDE/BDE-209 levels in mg/kg in shredder residues according to several sources (according to the information available, the values on ASR are related to pure ELV input or mainly to ELV input; source: [Norway 2015]; for details and specific references see chapter 3.2.1 in [Norway 2015])

Source	Country	Time	ASR	Mixed SR	E-waste SR
(IVM, IVAM 2013)	NL	2013	0.2-70	6-810	6.4-3,300
(COWI 2013)	NOR	~2012	av. 11-40		av. 5-12
(MOE survey 2011)	JP	<1996*	av. 406 (190-590)		
(MOE survey 2011)	JP	>2000*	av. 123 (37-180)		
(WRc addendum 2012)	UK	2011	av. 118-2,163 (11.5-3,915)		
((ELVES 2016))[14]	UK	2014	2.55 and 3.55		
(Petreas Oros 2009)	U.S.	2004		av. 43,5	
(Sinkkonen et al. 2004)	FI	~2003	0.01		60
(ARN 2015)	NL	~2015		800	
(BMRA 2013)	UK	~2012	n.d.		
(Ma et al. 2009)	China	2007			av. 3.26 (0.98 to 6.39)
(Schlummer et al. 2007)	DE				0-3,100

*Values marked with an asterisk indicate the time when the ELVs where produced, other values indicate the approximate time of sampling; av. = average; n.d. = not detected

24. Data from Japan indicate decreasing levels of c-decaBDE in ASR over time with higher levels in ASR from cars produced before the year 1996 compared to levels in ASR from cars produced after the year 2000 (MOE survey 2011). A recent study from Ireland has investigated the decaBDE levels in ASR and ASR fine. Mixed samples from 2014 were analysed, including 201 ELVs for the ASR sample (average age of the cars

[14] ELVES 2016 is available at http://www.google.de/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwi777GbsZvQAhXMDCwKHTDLDlkQFggeMAA&url=http%3A%2F%2Fwww.housing.gov.ie%2Fsites%2Fdefault%2Ffiles%2Fattachments%2Fanalysis_of_asr_from_the_irish_elv_composition_trial_feb_2016.pdf&usg=AFQjCNH7PGwl6g1GLJuGufsc9Pv-E2utYQ

15 years). BDE 209 was detected within "ASR" and "ASR fines" at a concentration of 3.5 mg/kg and 2.55 mg/kg respectively (ELVES 2016). This recent and well documented shredder trial indicates very low levels of decaBDE in current representative ASR stemming solely from automotive shredder residues in Ireland.

25. Specific information on c-decaBDE levels in construction and demolition waste and in waste from the textile and furniture sector has not been identified. C-decaBDE which is present in textiles used in the automotive sector is managed together with ELVs and contributes to the occurrence of c-decaBDE in ASR [Norway 2015].

3.4 C-decaBDE levels in recycled material and products made from recycled materials

26. Generally, plastics recycling saves resources and extends material life time while virgin material needs more resources. A life cycle assessment of environmental impact of post-consumer plastics from mixed, plastic rich WEEE treatment residues showed that plastic recycling have greater environmental benefits than alternatives in this study (ie municipal solid waste incineration and virgin plastic production) (Wager and Hischier, 2015). However, the results cannot be taken as conclusive evidence, because the study did not address hazardous substances in the output of recycling systems (Wager and Hischier, 2015)[15]. Studies show that PBDEs including c-decaBDE occur in recycled materials such as plastic pellets (e.g. PS and ABS), carpet padding and isolation materials (PU foams), plastic toys (several polymers), baby products (that contain PU foams) and food contact articles (FCAs; particularly black colored co-polymers of ABS and PP-PE) (for references, see table 6). Usually the c-decaBDE related congeners occur in the highest frequencies. This demonstrates that plastics containing PBDEs are being mixed with non□flame□retarded polymers for the production of products/articles which may contribute to human exposure and exposure of sensitive population groups such as children ([Norway 2015] referring also to (UNEP/POPS/COP7/INF22[16])). Traces of c-decaBDE and other BFRs in recycled plastics are also due to imperfect separation of bromine containing from bromine-free plastics. Table 6 gives an overview on reported levels of c-decaBDE/BDE-209 in recycled materials (further details see chapter 3.3 of [Norway 2015].

Table 6: Overview of reported c-decaBDE/BDE-209 concentration levels in recycled material (based on [Norway 2015])

Recycled material	Concentration (range) c-decaBDE/BDE-209 (mg/kg)	Type of product made from recycled material	References
carpet padding	0.014 - 0.08	carpet padding (PU foam)	[IVM, IVAM 2013]
plastic insulation	0.04	Insulation (PU foam)	[IVM, IVAM 2013]
recycled plastic	<0.026 - <0.18	pen	[IVM, IVAM 2013]
recycled plastic	<0.09	stapler	[IVM, IVAM 2013]
recycled plastic	<1.26	senseo	[IVM, IVAM 2013]
PS/ABS pellets	44 - 209		[IVM, IVAM 2013]
recycled plastic	44 - 800	toys (DJ mixer, plastic car, electric car, night light, electronic pet, magical plane, remote control car, plastic pistol)	[IVM, IVAM 2013]
recycled plastic fraction	5.1 - 53		[IVM, IVAM 2013]
	Median: 0.34	hard plastic toys	[Ionas et al. 2012]
	Max: 4232; median: 34.3	hard plastic toys	[Chen-S-J et al. 2009]

27. Within a recent investigation, the black parts of Rubik's cubes (children toy) and several other consumer goods were tested because manufacturers often blacken the colour of recycled plastics for aesthetic reasons. Laboratory analysis of forty-one Rubik's cubes and six additional samples (thermo cup, hair clip and hand band, finger skateboard, toy robot and hockey stick) from sixteen countries including EU Member

[15] According to Hazardous Waste Europe, in the study the emissions of bromine, copper and antimony by municipal waste incinerators are taken into account in the scenario where waste plastic is incinerated. But in the recycling scenario, the dispersion of these contaminants is neglected, in spite of multiple emissions sources.

[16] Available at http://chm.pops.int/TheConvention/ConferenceoftheParties/Meetings/COP7/tabid/4251/mctl/ViewDetails/EventModID/870/EventID/543/xmid/13075/Default.aspx

States, Eastern European and South-East Asian countries found that forty-two samples (89%) contained decaBDE. Sixteen of the samples (34%) contained DecaBDE at levels greater than 50 ppm. The data indicates that DecaBDE used in plastics for electronics are recycled into plastic children's toys (Di Gangi and Strakova 2016)[17].

28. Concerning the contamination of black coloured FCAs it has been demonstrated that typical elements used in E-waste occur together with PBDEs in FCAs. Concentrations found are below effective levels. It can be assumed that the PBDEs originate particularly from E-waste recycling activities. The occurrence of PBDEs in products where they are presumably not intentionally used indicates that the PBDEs enter these products via recycled materials. This has been demonstrated e.g. for PBDEs from E-waste found in FCA (samples of thermos cups and selected kitchen utensils such as spoons, stirring utensils, cutting material, a pudding form and an oil funnel) made from recycled (secondary) materials ([Samsonek and Puype 2013] and [Puype et al. 2015] as cited in Norway 2015) but can also be expected for PBDEs in other products and also plastic pellets from other recycling activities related to relevant applications of PBDEs such as EEE, transport and construction. This contributes to a global distribution of PBDEs due to recycling of PBDE containing waste via secondary materials [Norway 2015] and indicates that in a circular economy, PBDE waste management, recycling activities and marketing of recycled materials need improvement in order to ensure that restricted PBDEs are (a) not recycled for inappropriate uses such as FCAs and (b) not used above established limit values in other applications.

29. A mass flow analysis for the Netherlands focusing on the POP-BDEs (including hexa-, hepta-, tetra- and penta-BDE) and decaBDE, showed that 22% of all POP-BDE in E-waste is expected to end up in recycled plastics because they are not effectively separated out of plastic waste streams. In the automotive sector, this is 14%, while an additional 19% is expected to end up in second-hand parts (reuse).[18.] It follows that some new products made from recycled plastics contain these chemicals as well, particularly where manufacturers are not selective about the purity of the recycled plastic pellets they purchase. All carpeting and insulation materials made from recyclates studied in Leslie et al. (2016) contained either decaBDE (BDE-209) (up to 0.8 mg/kg (0.00008%)) or both decaBDE (BDE-209) and POP-BDEs (up to 0.4 mg/kg (0.00004%)). A quarter of the toys sampled contained POP-BDEs (up to 44 mg/kg (0.0044%)) and decaBDE (BDE-209) (up to 800 mg/kg (0.08%)) [Leslie et al. 2016]. The study builds on the assessments previously reported in IVM/ IVAM 2013. Overall, the study shows that decaBDE is present in plastic waste and recycled materials in the Netherlands and that decaBDE (BDE 209) is usually the predominant BDE congener found in waste plastic and plastic product samples including in recycled materials. In the samples it is usually detected in significantly higher concentrations than the sum of the POP-BDEs (see Table 1 in Leslie et al. 2016).

[17] Draft paper from DiGangi, J. and Strakova, J.: The recycling of plastics containing brominated flame retardants leads to contamination of plastic children's toys. Data presented at Dioxin Congress in Firenze, 2016. Publication planned in Organohalogene Compounds.

[18] The European electronics recycling industry (EERA) and automobile industry (ACEA) doubt that 22% and 14% of all POP-BDE end up in the recycling sector (comments from EERA and ACEA on the draft version of this document; November 2016). According to ACEA the figures are rather high, because in a broad range of spare parts Deca-BDE should not even be contained and the study does not clearly reference which parts are considered here. Furthermore, the findings are eventually based on the IVAM report. In this report IVAM states that POP-BDE's are rarely found in single automotive parts, but are frequently found in shredder material. In spite of this fact the total amount of POP-BDE for automotive waste per year is mentioned to be 0.20 tonnes over a total plastic flow of 20 ktonnes (including 0.67 kt plastic recycling and 3.7 kt reuse. See fig 3.7 of the report). 14% is expected to end up in plastic recycling and 19% is expected to end up for reuse. This means that the total plastic flow contains 10 ppm, plastic recycling 41.8 ppm and reuse 10.3 ppm POP-BDE.

4 Identification and management of C-decaBDE containing waste

4.1 Identification of c-decaBDE containing waste

30. Typically c-decaBDE is used in plastics/polymers at loadings of 10-15% by weight. Available information indicates that c-decaBDE treated textiles contain up to 12% of c-decaBDE. C-decaBDE can occur in significant levels in specific waste streams, particularly in E-waste, plastics from ELV treatment, plastics from construction waste or textiles/furniture waste. Higher levels of c-decaBDE in E-waste and ELVs are typically seen in older items e.g. TVs CRT monitors and older car models produced before 2001 (see e.g. [Danish EPA 2014]. Further details on c-decaBDE containing products are also given in the submissions from Canada and the EU.

4.2 Analysis and monitoring

31. Chemical analysis is usually using gas chromatography coupled to mass spectrometry in different variations in order to optimise the analysis according to the specific matrix. Details can e.g. be found in the references given in the following. The information submitted by parties on c-decaBDE levels in waste demonstrate the availability of sensitive methods (mass-spectrometry) for the detection of c-decaBDE in polymers and textiles (see specific references reporting corresponding levels e.g. in [Norway 2015] such as (Binici et al. 2013), (Shin and Baek 2012), (Kumari et al. 2014), (Aldrian et al. 2015), (Kajiwara et al. 2011), (Zhou et al. 2013), (Zennegg et al. 2014)). There was no specific information submitted on the global availability and accessibility of such methods. A new, cost-effective, fast screening method using a 'direct probe' coupled to atmospheric pressure chemical ionization-high resolution time-of-flight-mass spectrometry (APCI-HRTOF-MS) was used to determine the presence or absence of BDEs in waste and recycled plastic products (see [Leslie et al. 2016] referring to (Ballesteros Gomez et al. 2013)).

32. Results presented in [Canada 2010a] demonstrate environmental exposure to c-decaBDE in relation to waste management activities (see [Canada 2010a] referring to (DeBruyn et al. 2009), (La Guardia et al. 2007) in relation to waste water treatment plants, and (Wu et al. 2009) related to e-waste recycling workshops). Available information from Canada, suggests that releases of PBDEs, including c-decaBDE, from industrial or manufacturing processes will primarily be to wastewater, to air through vaporization and to land from spills and waste disposal ([Canada 2010b] referring to (ToxEcology Environmental Consulting 2003)). [Canada 2011] presents results on leachate samples from municipal solid waste landfill sites and provides information on the significance of wastewater effluent discharges and land application of treated biosolids as sources of PBDEs to the environment.

4.3 Disposal methods for c-decaBDE containing waste

33. Information on disposal methods, including separation of waste containing c-decaBDE, were submitted by several parties. The information mainly focus on existing waste management practices within countries. The information range from information on handling of stocks of c-decaBDE from manufacture to handling of c-decaBDE containing articles upon becoming waste. In several instances the information provided was generic information on disposal methods for PBDEs containing waste and not specific to c-decaBDE.

34. Recycling of c-decaBDE containing waste leads to spreading of c-decaBDE in other materials if it is not separated in the treatment process. The existing practice in the recycling industry in Europe and North-America is to separate waste based on total bromine content, and not on specific brominated flame retardants. According to European Electronics Recyclers Association (EERA), plastic recycling is capable to recycle from shredder residues and to separate plastics with BFR's. To this end different strategies and technologies including manual separation, sink and float, XRF screening, sliding spark screening, XRT technology, Raman spectroscopy are used either alone or in combination. In Europe and the United States respectively, recyclers have adopted standards whereby specific E-waste containing bromine at levels below 2,000 ppm (0,2 %) (EU CENELEC standard) and 3,000 ppm (0,3 %) (US EPEAT standard) are considered free of restricted brominated flame retardants ([Norway 2015] referring to (EERA 2015)). The EPEAT threshold of 3000 ppm was selected because of data demonstrating that only ~20-25% of the Br in recycled plastics from WEEE was due to PBDEs. The higher threshold encouraged a greater ability to use post consumer recycled plastics in new EEE applications by reducing the economic and technical barriers to recovering and producing recycled plastics from WEEE. Products covered under EPEAT still must have <1000 PBDEs per

the RoHS Directive, so separate testing may be necessary to confirm compliance.[19] [Norway 2015] refers to (UNEP POPS COP.7 INF.22) which describes technologies for the separation of POP-BDE containing polymers from waste streams. The technologies described are generally also valid for the PBDEs including c-decaBDE since the processes describe how BFR containing fractions (including PBDEs) can be separated (for details see chapter 4.3 of (UNEP POPS COP.7 INF.22). However, it has to be kept in mind that separation technologies are not capable to separate 100% of bromine containing plastics that can be dispersely allocated in complex products.

35. In addition, detailed technical information on sampling, screening, analysis and treatment of POP-BDE containing waste (so far not specifically for c-decaBDE) is available from a draft BAT/BEP Guideline under the Stockholm Convention (UNEP BAT/BEP 2016). This Guideline is currently being revised and updated by the task team on BAT and BEP for PBDEs. The main objective of this document is to provide guidance on best available techniques (BAT) and best environmental practices (BEP) for the recycling and final disposal of wastes containing POP-PBDEs in an environmentally sound manner, following the recommendations of the COP on the elimination of POP-PBDEs from the waste stream. In addition, this document addresses the recycling of products and articles containing POP-PBDEs, and the elimination of these chemicals. The guideline contains on the one hand general principles and cross-cutting considerations for the recycling and disposal of waste containing POP-PBDEs (see chapter 3 of (UNEP BAT/BEP 2016)). On the other hand, it contains specific information on BAT/BEP for POP-PBDE containing plastics in E-waste (see chapter 4 of (UNEP BAT/BEP 2016)), transportation sector (see chapter 5 of (UNEP BATBEP 2016)) and PUR foams (see chapter (UNEP BAT/BEP 2016)). Each specific chapter includes detailed information on waste separation and waste management operations (also including pre-treatment operations). Besides, the guidelines contain separate chapters (i.e. chapter 7 and 8) on energy/material recovery from POP-BDE containing material through thermal destruction and disposal of POP-PBDE containing wastes to landfill, respectively. The draft guidance recommends separating waste POP-PBDE plastics from other waste plastics in order to avoid contaminating the recycled part of the waste and eliminate the separated POP-PBDE waste fraction in an environmentally sound way.

36. Table 7 gives an overview on information submitted by parties related to the treatment (including separation) and disposal of waste.

Table 7: Information submitted by parties on the treatment (including separation) and disposal of waste containing c-decaBDE and other PBDEs

Waste category and country	Treatment	Reference
DecaBDE waste from manufacturing (Japan)	According to notification required by PRTR law, about 100 tons of c-decaBDE which was generated in the manufacturing process of c-decaBDE using products was moved out of facilities as contaminant in forms of liquid waste (for time trend see [Japan 2016]), and the majority was incinerated.	[Japan 2016]
DecaBDE containing waste (Japan)	Parts of products containing c-decaBDE are incinerated while other parts are being used for material recycling within the framework of laws relating to recycling, or ultimately end up in a landfill.	[Japan 2016]
PBDE containing waste (Canada)	The majority of PBDEs used in products remain in the product matrices at the time of disposal. At present, in Canada, the majority of solid articles containing PBDEs are disposed of in landfills. Incineration represents less than 5% of solid waste disposal in Canada. Some products, are sent to recycling facilities for processing (ToxEcology Environmental Consulting 2003). Landfilling may result in releases of PBDEs to soil, surface water and potentially to groundwater. Based on their properties, it is assumed that PBDEs will partition to soil and sediments and remain close to the point of release. Potentially PBDE-contaminated leachate collected from landfills is normally taken to municipal treatment facilities. Since PBDEs are not removed during treatment at these facilities, the PBDEs either pass directly through the facility and into the downstream aquatic environment or else are contained in bio-solid sludge that is either applied to land or returned to the landfill that originally generated the leachate (Cheminfo 2008).	[Canada Env 2010b]
E-waste (Europe)	[Canada 2010b] reported that, as a consequence of requirements of the European RoHS and WEEE Directives, methods have emerged for the treatment of plastics to remove BFRs (including PBDEs). These emerging technologies enable the use of recycled plastics into new EEE products, while still meeting the PBDE content restriction of the RoHS [Canada Env 2010b].	[Canada Env 2010b]
E-waste	After a pre-treatment, the majority of the waste electrical and electronic equipment	[Danish EPA

[19] Comment EERA on draft version of the present document; November 2016.

Waste category and country	Treatment	Reference
including ELVs (Denmark)	(WEEE) (excl. cables and wires) is exported for processing in other EU countries. A part is dismantled in Denmark. Plastic parts are disposed of in municipal waste incinerators. A part of the WEEE is incorrectly disposed of in municipal waste incineration with waste from households and enterprises. Some functioning equipment (in fact not WEEE) is exported to countries outside the EU for reuse of the equipment. Some WEEE is illegally exported to countries outside the EU. Electrical and electronic equipment from vehicles is expected to be disposed of as other WEEE. Wires and cables are to a large extent recovered in Denmark. The plastic parts are either recycled, incinerated or disposed of at controlled landfill. Plastic containing brominated flame retardants has to be removed from any separately collected WEEE and shall be disposed of or recovered in compliance with the Waste Directive. However, specific information on separation methods is not available in [Danish EPA 2014] Chapter 4.2 in [Danish EPA 2014] discusses the release of BFRs and degradation products from waste disposal operations such as incineration, landfilling, waste water treatment,	2014]
ELV and E-waste (Netherlands)	A small number of companies perform the separation of ELV and WEEE plastics which are free of POP-BDEs from those suspected of containing POP-BDEs: a key step that determines the plastics' fate as waste to resource, waste to energy or as a last resort, landfill. This separation sometimes occurs manually (according to product knowledge) but often proceeds by density separation. High density plastics are assumed to contain the heavy, brominated compounds (note: including c-decaBDE) which are sent to waste to energy, landfills and sometimes exported. (Figure S1 in [Leslie et al. 2016] describes the processing routes of plastics from ELVs and WEEE in the Netherlands)	[Leslie et al. 2016]
E-waste plastics and ELV plastics (Norway)	Based on a survey carried out in 2016, c-decaBDE that follows the waste streams to shredding usually ends up in the shredder light fraction (SLF). Further treatment is either direct energy recovery or separation by either sink/float method or sensor based method. One of the fractions resulting from applied separation methods is sorted as bromine containing. Consulted stakeholders stated that this fraction is energy recovered as well (details are available in [Norway 2016]).	[Norway 2016]
Textiles from vehicles (Denmark)	Mainly disposed of with shredder waste to controlled landfill	[Danish EPA 2014]
Building materials (Denmark)	Disposed of in municipal waste incinerators	[Danish EPA 2014]
Textiles, carpets and furniture (Denmark)	Disposed of in municipal waste incinerators	[Danish EPA 2014]

37. [Norway 2015] provides an overview of management practices of c-decaBDE containing waste at global level. Information on treatment operations is mostly available for western countries and to some extent also for countries in other regions including Africa and Asia. Sorting and separation techniques allowing the separation of high bromine containing waste fractions are globally available and accessible, however, the implementation of such technologies as well as the downstream treatment of the c-decaBDE containing fraction vary depending on the current waste management practice, legislation and economic factors within different countries (see chapter 4 of [Norway 2015]).

38. Hazardous Waste Europe recommends to classify waste containing POP-BDE above regulatory thresholds as hazardous waste in order to guarantee traceability of the waste brominated plastic, appropriate elimination of POP-BDE dispersion in soils, ground water etc and appropriate waste shipment management.[20]

39. Overall, the information submitted demonstrates, that c-decaBDE containing waste is either incinerated, landfilled or recycled. Specific information on the extent of incineration, landfilling and recycling is only sometimes available. Separation of c-decaBDE containing plastics is only carried out in

[20] Contribution from „Hazardous Waste Europe“ to a draft of the present document; November 2016

some cases. Specific information on separation methods is available from a draft BAT/BEP Guideline under the Stockholm Convention.

40. Collection and management practices worldwide depend very much on the country. Even in well-developed systems, not all E-waste is collected and managed according to legislative frameworks. Globally, an important share of WEEE is treated inappropriately under informal waste management regimes. ASR usually contains the c-decaBDE containing plastics from ELVs. Currently ASR is mostly landfilled or incinerated, in some parts of the world possibly under inappropriate conditions.

5 Environmental and human health impacts related to management of c-decaBDE waste

41. The environmental and health impacts of c-decaBDE, including those relating to emissions from waste and exposure to c-decaBDE containing waste, have been thoroughly assessed and described in the Stockholm Convention risk profile on c-decaBDE (UNEP/POPS/POPRC.10.10/Add.2). The findings from the Stockholm Convention evaluation of c-decaBDE shows that waste is a source to environmental emissions and that worker exposure may be a concern, especially in developing countries and for workers involved in handling of e-waste. Information on human and environmental impacts were however also submitted as part of this intersessional work on c-decaBDE in waste streams.

42. In Canada, environmental monitoring and national registers provide the authorities with information on emissions and releases from waste. The Government of Canada has been monitoring c-decaBDE and other PBDEs in the Canadian environment and in landfills and wastewater treatment plants under the Chemicals Management Plan since 2008 [Canada Env 2010b]. The National Pollutant Release Inventory (NPRI) 21 Program of the Government of Canada has collected data on decaBDE since 1994. The NPRI is Canada's legislated, publicly accessible inventory of pollutants released, disposed of and sent for recycling by facilities across the country. Industrial, institutional and commercial facilities which meet NPRI reporting requirements are required to report under the Canadian Environmental Protection Act, 1999 (CEPA 1999). The program's main objectives are to inform the public, encourage voluntary reduction, monitor progress and set priorities for action [Canada Env 2010b]. Consistent with other studies, monitoring data from Canada indicate that human activities, such as industrial processing, use of consumer products and waste disposal, are important sources of PBDEs in the environment [Canada Env 2011].

43. Results from these monitoring activities and initiatives shows that emissions of c-decaBDE to the environment may continue also in the waste phase, including from landfills and sewage sludge. It has been for example demonstrated that PBDEs and other BFRs are likely to leach out of plastics at relatively high rates in landfills due to the properties of landfill leachate. Shredder residue can contain potentially harmful substances such as metals, PBDEs, BFRs, PCDDs, PCDFs, PCBs and other POPs. Many of the POPs and other substances that can leach out of shredder residue are potentially damaging to the environment and human health [Canada Env 2014].

44. The main component of c-decaBDE (BDE-209) has been determined in blood serum from 19 workers dismantling electronic products alongside other PBDEs, therefore, absorption in by workers in waste treatment facilities occurred. The median concentration was 5.0 pmol or 4.8 ng BDE-209/g fat (ECB, 2002). For further information on human exposure to BDE-209 see chapter 6 [Danish EPA 2014].

45. In summary, the information submitted by parties to the Basel Convention on environmental and human health impacts overlaps with information previously assessed in the risk profile on c-decaBDE developed under the Stockholm Convention.

6 Foreseen and ongoing research related to c-decaBDE

46. There is limited information on c-decaBDE and its main constituent BDE-209 in wastes. Available information in this report includes information on c-decaBDE concentrations used in different materials, the use of those materials in products, measured levels in products and waste streams as well as regulations affecting c-decaBDE levels in waste and current waste management practices in the recycling industry and some countries globally.

47. Further information would be desirable to support the Basel Convention decision making process if c-decaBDE and its main constituent BDE-209 is listed in the Stockholm Convention in May 2017. This includes in particular on the practical application of available separation technologies and recycling standards for plastics containing c-decaBDE and the extent to which c-decaBDE and other PBDE containing waste is separated and subsequently recycled and further used as recycled materials. In addition to information on emissions and formation of brominated dioxins and furans in treatment processes including incineration, smelting/reformulation and shredder mills and levels in recycled material. Besides, further information and specific data on management of c-decaBDE containing textile waste and construction and demolition waste would be useful.

48. The EU will conduct a study on waste related aspects of decabromodiphenyl ether in 2017. The study will look into all waste streams consisting of, containing or contaminated with decabromodiphenyl ether and the size of these waste streams. It will analyse the technical and economic feasibility of possible waste management options. The study further intends to identify key issues to enable an environmentally sound management of these wastes (including traceability, identification, separation from non-POP wastes, and destruction of decabromodiphenyl ether in these waste streams) and recommend a low POP content level for decabromodiphenyl ether. The EU and its Member States are willing to share the results of the study with the Secretariat as well as Parties and others. Interim results may be available by the end of 2017 / beginning of 2018 and the final report is expected during the first quarter of 2018 [EU 2016].

49. The Government of Canada continues to examine and collect information on waste and recyclable materials processing facilities in Canada. Through this work, Canada will gain a better understanding of where and to what degree POP substances, including decaBDE, are entering and being released from waste management activities. In addition, Canada recently completed studies on the presence of decaBDE in plastics recycling as well as in construction, renovation and demolition waste.

50. In 2016 under the Canada-U.S. Great Lakes Water Quality Agreement, the Governments of Canada and the United States identified PBDEs as a substance of mutual concern. Once a chemical has been designated, Canada and the United States develop and implement strategies to address the chemical, reporting every three years on its status.[21]

51. Under the Stockholm Convention, there was recognition on the complexity around the types and quantities of articles recycled as well as the extent of recycling options for environmentally sound disposal of articles containing pentaBDE and octaBDE. A work program was established to obtain more information on these issues and to assist parties in the evaluation of the continued need for the recycling exemption for hexa, hepta, tetra and pentaBDE. Canada has indicated that it will participate in this work program[22] and will use the results to promote its risk management actions in this area [Canada Env 2010b].

[21] http://news.gc.ca/web/article-en.do?nid=1077729

[22] Note: the work program covers pentaBDE and octaBDE but not decaBDE

7 Annex

52. In the following, Tables 3 to 6 from [Norway 2015] on levels of c-decaBDE/BDE-209 are reproduced.

Table 3: Overview on uses of decaBDE in the EEE sector, related concentrations and sources [Norway 2015]

No.	Identified uses / part / material	Concentration	Source
	Plastics	10-15% w/w	[RPA 2014] quoting UK HSE (2012)
	FR2 laminates	36 g/m^2	[RPA 2014] quoting SAEFL (2003)
	PE insulating foam	20 g/kg	[RPA 2014] quoting SAEFL (2003)
	PE plastic sheeting	100 g/kg	[RPA 2014] quoting SAEFL (2003)
	PP plastic sheeting	100 g/kg	[RPA 2014] quoting SAEFL (2003)
	PVC plastic sheeting	50 g/kg	[RPA 2014] quoting SAEFL (2003)
	Heat shrinkable products	10% w/w	[RPA 2014] quoting Danish EPA (2007)
	Plastics from EEE products	n.d. to 72,300	[IVM, IVAM 2013]
	Computer display casing	1,5 mg/kg (n.d. and 6.08, min./max)	[Chen-S-J et al. 2010]
	TV casing	8 mg/kg (n.d. and 45.6, min./max)	[Chen-S-J et al. 2010]
	Computer component	254 mg/kg (n.d. and 1513, min./max)	[Chen-S-J et al. 2010]
	EEE materials	72 and 191 mg/kg (min./max.)	[Binici et al. 2013]
	PC boards	16 mg/kg	[Kajiwara et al. 2011]
	Rice cooker 1	11 mg/kg	[Kajiwara et al. 2011]
	Rice cooker 2	0.3 mg/kg	[Kajiwara et al. 2011]
	Computer mouse	0.55 mg/kg	[Kajiwara et al. 2011]

No.	Identified uses / part / material	Concentration	Source
	Motherboard computer	11584 mg/kg	[Kumari et al. 2014]
	Electrical wires	n.d.	[Kumari et al. 2014]
	Lamp	> 0.1 %	[Kant. Lab. BS 2009]
	Consumer electronic device	> 0.1 %	[Kant. Lab. BS 2009]
	Av. Concentration in small size EEE	510 mg/kg	[Morf et al. 2005]
	Casings of computer monitors	40 mg/kg	[Li et al. 2013] quoting [Zennegg et al 2014]
	Casings of TVs	100 mg/kg	[Li et al. 2013] quoting [Zennegg et al 2014]
	Plastic parts from small E-waste	1800 mg/kg	[Li et al. 2013] quoting [Morf et al. 2005]
	CRT TVs and monitors	500 and 3000 mg/kg (min./max.)	[EMPA 2010]
	Office equipment	500 and 3000 mg/kg (min./max.)	[EMPA 2010] quoting (Tange and Slijkhuis, 2009)
	Refrigerators	n.d. and 1000 mg/kg (min./max.)	[EMPA 2010] quoting (Tange and Slijkhuis, 2009)
	White goods	n.d. and 1000 mg/kg (min./max.)	[EMPA 2010] quoting (Tange and Slijkhuis, 2009)
	Small domestic appliances	n.d. and 1000 mg/kg (min./max.)	[EMPA 2010] quoting (Tange and Slijkhuis, 2009)
	remainder ICT equipment	n.d. and 1000 mg/kg (min./max.)	[EMPA 2010] quoting (Tange and Slijkhuis, 2009)

No.	Identified uses / part / material	Concentration	Source
	mixed plastics from CRT monitors	av. 3200 mg/kg (max. 7800 mg/kg)	[Wäger et al. 2011]
	CRT TVs	av. 4400 mg/kg (max. 7800 mg/kg)	[Wäger et al. 2011]
	PC CRT screens	av. 800 mg/kg[23]	Sindiku et al. 2014
	TV CRT screens	av. 8600 mg/kg [23]	Sindiku et al. 2014

Table 4: Overview on uses of decaBDE in the transport sector, related concentrations and sources [Norway 2015]

No.	Identified uses / part / material	Concentration	Source
	Cars	0.625 g/kg	[RPA 2014] quoting SAEFL (2003)
	Cars	1-5 g/car	[RPA 2014] quoting Danish EPA (2007)
	Cars	<1-<10 mg/kg car	[RPA 2014]
	Rail vehicles	85 g/kg	[RPA 2014] quoting SAEFL (2003)
	Seat foam from ELVs	n.d.	[BMRA 2013]
	Seat fabric from ELV	n.d.	[BMRA 2013]
	PUF Pontiac 1997	522 mg/kg	[IVM, IVAM 2013]
	Seat cover Pontiac 1997	22500 mg/kg	[IVM, IVAM 2013]
	Interior Pontiac 1997	18 mg/kg	[IVM, IVAM 2013]
	PUF Mazda 1998	n.d.	[IVM, IVAM 2013]

[23] Value corrected in order not to reproduce an error from [Norway 2015]

No.	Identified uses / part / material	Concentration	Source
	Seat cover Mazda 1998	22700 mg/kg	[IVM, IVAM 2013]
	Interior Mazda 1998	52 mg/kg	[IVM, IVAM 2013]
	PUF from US car seats	0.11 and 17 mg/kg (min. and max.)	[IVM, IVAM 2013]
	Different car components	n.d.	[IVM, IVAM 2013]
	Car seats	n.d. and 131 mg/kg (min. and max.)	[IVM, IVAM 2013]
	Car seat cover	256 mg/kg	[IVM, IVAM 2013]
	PUF from old car seats	n.d. and 2.1 mg/kg (min. and max.)	[Niinipuu 2013]
	Soundproofing material sample 1	n.d.	[MEPEX 2012]
	Soundproofing material sample 2	7000 mg/kg	[MEPEX 2012]
	Airbag material	n.d.	[MEPEX 2012]
	Seat cover material	27000 mg/kg	[MEPEX 2012]
	Interior material (door, headlining, cover)	17000 mg/kg	[MEPEX 2012]
	Luggage compartment material	n.d.	[MEPEX 2012]
	Radiator, outer material	n.d.	[MEPEX 2012]
	Printed circuit boards sample 1	200 mg/kg	[MEPEX 2012]
	Printed circuit boards sample 2	n.d.	[MEPEX 2012]

No.	Identified uses / part / material	Concentration	Source
	Printed circuit boards sample 3	n.d.	[MEPEX 2012]
	Printed circuit boards sample 4	33 mg/kg	[MEPEX 2012]
	Car interior	n.d.	[Ballesteros-Gomez et al. 2013]
	Car interior	8 mg/kg (n.d. to 32.6, min./max.)	[Chen-S-J et al. 2010]
	car interior foam (grey foam, dark grey foam and rubber filling) and different types of car interior materials (fabric seat cover, brown cushion foam in car seat)	n.d.	[Shin et al. 2012]

Table 5: Overview on uses of decaBDE in the building and construction sector, related concentrations and sources [Norway 2015]

Identified uses / part / material	Concentration	Source
Electrical insulation	10-30%	[RPA 2014]
Epoxy adhesive	< 30%	[RPA 2014]
PVC flooring	n.d.	[Kumari et al. 2014]
Damp-proof membrane/film	> 0.1%	[Kant. Lab. BS 2009]

Table 6: Overview on uses of decaBDE in the textile and furniture sector, related concentrations and sources

Identified uses / part / material	Concentration	Source
Tents	2 g/tent	[RPA 2014] quoting Danish EPA (2007)

Identified uses / part / material	Concentration	Source
Adhesive layer of reflective tapes	1-5% w/w	[RPA 2014]
Velour pile fabrics (70-80 g/m2)	21-32 g/m2	[RPA 2014] quoting ECB (2002)
Cotton (30-40 g/m2)	9-16 g/m2	[RPA 2014] quoting ECB (2002)
Flat woven (30-80 g/m2)	9-32 g/m2	[RPA 2014] quoting ECB (2002)
Various textiles	1.55-6.42 %	[RPA 2014] quoting Earls (2007)
Carpet	79 and 90 mg/kg (min./max.)	[Binici et al. 2013]
Household curtains of three different colours, three kinds of car interior foam (grey foam, dark grey foam and rubber filling), and three different types of car interior materials (fabric seat cover, brown cushion foam in car seat)	n.d.	[Shin et al. 2012]
Window blind	4,799 mg/kg	[Kumari et al. 2014]
Upholstery foam	7,023 mg/kg	[Kumari et al. 2014]
Commercial decaBDE treated polyester upholstery textiles used in curtain manufacture	120 g/kg (ΣPBDEs: 130 g/kg)	[Kajiwara et al. 2013]

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