Service request under the framework contract
No ENV.G.4/FRA/2007/0066

INTERIM REPORT – SUMMARY REPORT

“Study on waste related issues of newly listed POPs and candidate POPs”

26 August 2010

Consortium ESWI
Expert Team to Support Waste Implementation
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1 Background and objectives

The European Union is party to two international legally binding instruments related to persistent organic pollutants (POPs):

- The Global "Stockholm Convention" on POPs
- The "Protocol to the regional UNECE Convention on Long-Range Transboundary Air Pollution" (CLRTAP)

In 2009 a number of new substances have been added to the annexes of the Stockholm Convention by decision of the fourth conference of the Parties (COP-4). These substances and substance groups\(^1\) are thus to be subjected to corresponding destruction and elimination obligations or at least to limitations in use. In addition, it was decided to undertake a work programme to provide guidance on the best options to restrict and eliminate PFOS, its salts, PFOSF and other chemicals listed in Annex B or A, and Parties were invited to contribute to these tasks. Because α-, β-, γ-HCH, Chlordecone and HBB are already included in the Annexes to the EU POP Regulation since 2006, the remaining substances and substance groups

- tetra-, penta-, hexa-, and hepta- BDE (PBDEs), PeCB, PFOS and its derivatives\(^2\)

need to be analyzed and subject to POP content thresholds, as so-called “new POPs”.

In addition, 5 further substances and substance groups\(^3\) are proposed to be added or were recently added to the UNECE POP Protocol. These substances are currently under review procedures and are likely to be added or proposed to the Stockholm Convention in the course of the next years, so that they are called “candidate POPs”.

The EU POPs Regulation (EC) No 850/2004 is the Community legislation that implements besides others the requirements of the Stockholm Convention and the POP Protocol.

Based on the background of the amended Stockholm Convention, the intention of the study is in particular to provide the European Commission with

- A compilation and evaluation of existing data on new and candidate POPs
- An assessment of impacts of potential limit values on waste flows and competing legislation
- Justified proposals for low (LPCL) and maximum (MPCL) concentration limits for new and candidate POPs.

\(^1\) α-, β-, γ-HCH, chlordecone, HBB, tetra-, penta-, hexa-, and hepta- BDE, PeCB, PFOS (including salts) and PFOSF

\(^2\) Perfluorooctane sulfonic acid and its derivatives (PFOS) \(C_8F_{17}SO_2X\) (\(X=\)OH, Metal salt (O-\(M^+\)), halide, amide, and other derivatives including polymers

\(^3\) Short chained chlorinated paraffins, hexabromocyclododecane, pentachlorophenol, hexachlorobutadien and polychlorinated naphthalenes
Due to the entry into force of the amended annexes to the Stockholm Convention, banning production and use of tetra- to heptaBDEs, and PeCB, and restricting the use of PFOS its salts and PFOSF, highest priority has been given to the development of limits values in the POP Regulation for these substances. The assessment for candidate POPs will be performed in detail during later stages of the project. Results and proposals for limit values will be available in the draft and the final report in February and March 2011 respectively.

2 Overview on mass flows of new POPs

Results on mass flows and risks used for the elaboration of the POP content limits in this report, are based on three sources:

- the answers and evaluation reports to the Stockholm convention has launched a request for information on new POPs, including brominated diphenyl ethers and PFOS, in accordance with decision SC-4/194,
- on literature search
- on a questionnaire survey developed in close coordination with the Commission services on the basis of the specific information needs listed above and considering the questions already addressed in the SC Questionnaire SC-4/19, which was sent end of June 2010 to approximately 250 experts from Member State authorities and other stakeholders.

Mass and waste flows comprise all source sectors considered relevant as illustrated in Table 2-1.

Table 2-1: Overview on sectors and their relevance in the scope of the present study

<table>
<thead>
<tr>
<th>Sector</th>
<th>Substance concerned</th>
<th>Relevance of the sector according to the results of the mass flow analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of PUR foams in upholstery and furniture</td>
<td>C-PentaBDE</td>
<td>●</td>
</tr>
<tr>
<td>Use of PUR foams in automotive applications</td>
<td>C-PentaBDE</td>
<td>●</td>
</tr>
<tr>
<td>Use of C-PentaBDE in epoxy resins in imported printed circuit boards</td>
<td>C-PentaBDE</td>
<td>● (sector may be underestimated)</td>
</tr>
<tr>
<td>Use of C-PentaBDE in Polyvinylchloride (PVC), unsaturated polyesters, rubber, paint/lacquers, textiles, hydraulic oils</td>
<td>C-PentaBDE</td>
<td>●</td>
</tr>
<tr>
<td>Use of C-OctaBDE in Acrylonitrilebutadiene-styrene (ABS) polymers for housings/casings of EEE</td>
<td>C-OctaBDE</td>
<td>●</td>
</tr>
<tr>
<td>Use of C-OctaBDE in High Impact Polystyrene (HIPS), Polybutylene Terephthalate (PBT), Polyamide Polymers and other uses such as nylon and low density polyethylene, polycarbonate, phenol-formaldehyde resins, unsaturated polyesters</td>
<td>C-OctaBDE</td>
<td>●</td>
</tr>
<tr>
<td>Metal plating</td>
<td>PFOS</td>
<td>●</td>
</tr>
</tbody>
</table>

Further information on mass flows and justification for selected sources by substance is provided below.

**C-PentaBDE**

The most common use of C-PentaBDE in Europe was in flexible polyurethane (PUR) foams, accounting for approximately 95% of the total use of C-PentaBDE. The treated PUR foams were in turn mainly used for the production of automotive and upholstery applications (e.g. automotive seating, head rests, sofas, mattresses etc.).

Other applications and finished articles containing or possibly contaminated with C-PentaBDE are Polyvinylchloride (PVC), Epoxy Resins, Unsaturated Polyesters (UPE), Rubber, Paint/Lacquers, Textiles, and Hydraulic oils. Considering the minor amounts of C-PentaBDE (in total ~5%), used in all these applications, the diffuse distribution of such articles and limited data availability, these uses have not been taken into account. When considering imports of articles containing C-PentaBDE into Europe, it has to be acknowledged that particularly the imports of C-PentaBDE in printed circuit boards may be underestimated. However, due to the lack of relevant data it is also in this case not possible to go further into detail.

Therefore, this study exclusively focuses on C-PentaBDE treated PUR foams and associated applications and finished articles (i.e. automotive and upholstery applications).
The following figures provide an overview on the substance flows of the new POPs investigated in detail within the project for the determination of appropriate concentration limits. Mass flows contain all major current sources. Minor sources have partly been neglected.

Figure 2-1: Overall mass flow from C-PentaBDE from sources to current disposal/recovery operations in the EU

C-OctaBDE

The main historic use of C-OctaBDE was in Acrylonitrilebutadiene-styrene (ABS) polymers. Around 95% of C-OctaBDE supplied in the EU was used in ABS (globally ~70%). Thereby, C-OctaBDE was typically added at concentrations between 10-18% by weight. The ABS in turn was mainly used for housings/casings of Electrical and Electronic Equipment (EEE), typically office equipment and business machines.

Other uses are e.g. High Impact Polystyrene (HIPS), Polybutylene Terephthalate (PBT), Polyamide Polymers (with typical concentrations between 12-15%) or nylon, low density polyethylene, polycarbonate, phenol-formaldehyde resins, unsaturated polyesters, adhesives and coatings. The overall share of these uses to the total mass flow however, is <5%, and consequently they are not taken into consideration in the mass flow calculation.
In terms of individual congeners, the substance flow for PBDEs can be specified as indicated in Table 2-2.

Table 2-2: Overview on mass flow by relevant PBDE congener

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive PUR</td>
<td>75.42</td>
<td>136.25</td>
<td>19.46</td>
<td>2.43</td>
</tr>
<tr>
<td>Upholstery (PUR)</td>
<td>28.31</td>
<td>51.13</td>
<td>7.30</td>
<td>0.91</td>
</tr>
<tr>
<td>(W)EEE*</td>
<td>8.00</td>
<td>7.87</td>
<td>45.31</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>103.73</td>
<td>195.38</td>
<td>34.64</td>
<td>48.65</td>
</tr>
</tbody>
</table>

* note: penta and hexaBDE ~5%, HeptaBDE *50% of total C-OctaBDE mass flow

**PFOS**

In the past, perfluorooctane sulfonic acid (PFOS) and its derivatives have been used for a wide range of products and processes.

Among these are pesticides, plumbing fluxing agents, medical applications and devices, flame retardants, coatings and coating additives, adhesives, uses in rubber and plastics, leather and textiles. Of these past uses only leather upholstery and carpets have been further investigated due to their long lifetime. Products having a shorter lifetime, such as textiles, paper and cardboards do not influence current PFOS emissions anymore. Also industries which only use PFOS during their production processes, such as the mining industry, do not pose a current source in regard to PFOS.
emissions and therefore have been not considered in the mass and waste flows. Fire fighting foams, are investigated due to the high PFOS concentrations in remaining stocks although they have to be eliminated by June 2001.

Major continuous uses of PFOS are the metal plating industry (Cr), hydraulic fluids in the aviation industry, the photographic industry and the semiconductor industry. Sewage sludge is of relevance because it constitutes an important secondary source of PFOS.

PeCB has historically been used in small quantities in PCB containing liquids, as feedstock/intermediate in production of the pesticide quintozene, as flame-retardant, pesticide and in dyestuff carriers. Due to the low concentration in PCB containing liquids and their continuous phase-out (PCB thresholds already set), and due to changes in production procedures for quintozene and the quintozene ban in Europe in June 2002, none of these historic uses seems to be of relevance.

The most relevant current sources of PeCB are unintentional production in thermal processes similar to the ones generating PCDD/PCDF, PCB and HCB, namely metallurgical industry, power production, thermal waste treatment and domestic combustion. Data availability however, is very limited. Therefore the sector PP coal in the mass flow is composed of energy production from coal and metallurgical processes (consumption of >50% of coal), and domestic combustion is estimated very
roughly on the basis of contamination data for industrial boilers. Sewage sludge is investigated because it constitutes an important secondary sources of PeCB.

Figure 2-4: Overview on PeCB substance flow

3 Waste Flows in Relation to Limit Values

Whereas substance flows are important to identify major sources, the impacts of potential limit values on waste management can only be derived from waste flows, by comparing identified average contaminations with potential thresholds. In combination with assessments of future developments and impact assessment of economic impacts or shortcomings in appropriate treatment capacity, waste flows are the major parameter for the selection of feasible limits. As LPCL for PBDEs are intended to be set by congeners, the waste flows are presented accordingly.

Related to waste flows the investigations result in the following estimations as concerns quantities and concentrations. Waste flows represent best estimates, sometimes containing considerable uncertainty due to lack of data.

**PBDE**

The Waste flows for PBDE (in automotive PUR foam, upholstery PUR foam and WEEE) can be considered from the point of view of the commercial products and of the four individual congeners as listed in the Annexes of the Stockholm Convention and the EU POP Regulation. The chosen...
perspective is decisive for the major waste streams to consider and for the LPCL limits to set and hence is discussed separately below.

Concentrations in used products

PBDE treated PUR foams in automotive applications (part of vehicle seats) contain C-PentaBDE in concentration of roughly 4% or 40,000mg/kg (ppm), which expressed in terms of single congener corresponds to 12,400 ppm for TetraBDE, 22,400 ppm for PentaBDE (predominant congener in C-pentaBDE) and small concentrations ~3000 ppm and 400 ppm for Hexa- and HeptaBDE. PBDE treated PUR foams in furniture (upholstery) show similar concentrations for the commercial product and the individual congener in the treated product as for automotive applications. PBDE treated WEEE show a contamination level of the commercial substance (C-octaBDE) of ~17.5% (175,000 ppm), which in terms of single congener corresponds to contamination levels of slightly above 10,000 ppm (for Penta- and HexaBDE) and a contamination level of ~62,000 ppm for HeptaBDE. This corresponds to the concentrations in old computer screens and TV exported to third countries.

Waste flows

The current overall waste flow for PBDE is dominated by PUR foam containing upholstery as part of bulky waste (~5 million t/y). Given the fact that C-PentaBDE was the commercial product predominantly used in PUR foams, bulky waste in terms of upholstery is also the major waste stream for C-PentaBDE and for Penta- and TetraBDE as the presominant congener in the commercial product, but also for Hexa- and HeptaBDE although the concentrations are very low. Shredder light fractions from ELV and WEEE represent only low shares (0.7 million t/y and 0.1 million t/y) in comparison. For C-OctaBDE on the other hand shredder light fraction from WEEE is the only waste stream that exists.

The final PBDE concentrations in upholstery bulky waste are expected to be low. With the assumption that 30-40% of the bulky waste is upholstery the concentration for the commercial BDE is 20 ppm and corresponding concentrations for the single congener are 6 ppm (Tetra-), 11 ppm (Penta-), 1.6 ppm (Hexa-) and 0.2 ppm (HeptaBDE).

For ELV shredders the second PUR waste stream – apart of a fraction of vehicles seats directly reused – contamination levels are expected to be about 160 ppm for C-PentaBDE and for the single congener 50ppm (Tetra-), 90ppm (Penta-), 13ppm (Hexa-) and ~1.6ppm (HeptaBDE).

Shredder light fraction of WEEE shredders is the third waste stream relevant for PBDE. Due to existing separate collection schemes this fraction is expected to be composed only of WEEE Directive categories 3 and 4 items. Based on this assumption, the PBDE concentration is ~1,200 ppm for the commercial OctaBDE, ~80 ppm for Penta-, and Hexa- and >400 ppm for HeptaBDE. (Note: due to the composition of c-OctaBDE the congener listed in the Stockholm Convention and the amended EU POP Regulation correspond to less than 50% of the concentration of the commercial product.)
**PFOS**

Based on available data the waste flow for chromium metal plating is dominated in quantity by chromium sludges (~99 kt/y in 2010) with low PFOS contamination (~4 ppm). Apart from this it comprises small quantities (0.3 kt/y) of filter residues (activated carbon and resins) with contamination 900-19,000 ppm, and activated carbon from waste water treatment and vacuum distillate (~2.4 kt/y) with a contamination in the dimension of 240-300 ppm.

The waste flow for the photographic industry is dominated in quantity by X-ray films (~46 kt/y in 2010) with a contamination of C= 13.45 ppm, other films and photographic pictures (together 194 kt/y in 2010) with a low PFOS contamination (~4 ppm). Furthermore, it comprises small quantities (0.0002 kt/y) of photochemicals (C= 41%) and of photo plates (0.2 kt/y) with an average contamination level of 1 ppm.

The waste flow in the semiconductor industry is composed of 0.07 kt/y of Photoresist with a contamination level of C= 600 ppm, 0.0004 kt/y of bottom anti-reflecting doating (BARC) with a PFOS content of 1,500 ppm and 0.06 kt/y of top anti-reflecting coating TARC with a PFOS contamination of 1,000 ppm. For the aviation sector the waste flow consists of 0.7 kt/y of spent fluids with a PFOS concentration of roughly 1,000 ppm.

As regards fire fighting foams, the remaining stocks of PFOS containing foam (c = 1% or 10,000 ppm) are estimated to be roughly 9 kt in 2010. All wastes of the latter three source sectors are directed to hazardous waste incineration.

As regards the waste flows from historically treated leather and textiles current waste flows are as follows:

- **Leather:** The waste flow consists of 71 kt/y of PFOS treated leather furniture with an average PFOS concentration of 80 ppm, which in the light of the overall quantity of leather produced for furniture (including also non treated leather upholstery) corresponds in practice to a waste flow of 2,378 kt/y (relevant bulky waste) with an average concentration of 2.4 ppm. (For further evaluations the latter concentrations has been taken)
- **Textile:** The waste flow for carpets is estimated as accounting to 1,938 kt/y (total waste carpets) with a mixed PFOS concentration of 75 ppm. (Separation of treated and untreated fractions would not change the quantities and concentrations significantly).

The PFOS waste flows are completed by annually 11.6 milion tonnes of sewage sludge with an a contamination level of only 0.98 ppm.
**PeCB**

The waste flow for PeCB is dominated by industrial coal combustion in power production and metallurgical industry (~800,000 kt/y) and sewage sludge (11,600 kt/y) with a low contamination level of in the dimension of <0.0002 – 0.0005 ppm (0.2- 0.5 ppb). A small waste streams of a corresponding contamination level is constituted by domestic burning of solid fuels (including waste burning). Waste flows from MSWI account for roughly 1,000 kt/y with an average contamination of 0.07 ppm, and HWI contributes with ~500 kt/y and a estimated contamination level of 0.01 ppm.

*Coverage waste quantities and need for additional treatment capacity depending of specific limit values.*

Based on the waste flows as listed above, major quantities of the waste flows start to be covered at limits of 10 ppm for Tetra- and PentaBDE, 1ppm for HexBDE and 0.1 ppm for HeptaBDE. Due to the fact that contamination in WEEE and PUR foams is dominated by single congener at different levels these results can not be used directly for the derivation of limit values.

For PFOS relevant waste quantities are covered at 10 ppm, and for PeCB waste is concerned only at potential limits below 5 ppb (0.0005 ppm).

**Prognosis for waste streams under status quo conditions**

PBDE: With the estimated annual consumption of C-PentaBDE in automotive applications, the export data and the average life time of cars (~12 years), the substance flow of C-PentaBDE in automotive products is expected to phase out by 2016 (detailed mass flows see chapter 5).

Similar estimations have been also performed for C-PentaBDE in upholstery applications. It can be summarised that with the assumed lifetime of 10 years all C-PentaBDE in upholstery applications (the predominant waste stream for PBDE) will be disposed of by 2014. As a consequence the concentrations in the final waste fractions by 2015 are estimated to have dropped by a factor of almost 10 compared to 2010 (C-PentaBDE 18 ppm instead of 162 ppm (single congener <10 ppm (Tetra, Penta-) and <1 ppm (Hexa-/Hepta-) for ELV shredder light fluff).

Due to the relatively short lifetime of WEEE products containing C-OctaBDE, (between 7 and 9 years) it is estimated that all C-OctaBDE will be disposed of before 2015 with the concentrations of Penta- to HeptaBDE dropping from >70 ppm (Penta- and Hexa-) and >400 ppm (Hepta-) to almost zero.

PFOS: Based on reduction of PFOS used in the industrial sector (due to substitution with alternatives), the mandatory elimination of PFOS contained in fire fighting foams, the elimination of treated carpets and upholstery, and the expectation that PFOS concentrations in sewage sludges (as secondary source) will also slowly decrease, it is expected that the mass flow will be reduced until 2020 to an amount of ~4 t/y.
For the ten year prognosis of the PeCB mass flow in 2020, it is expected that relatively small changes will occur. PeCB is produced unintentionally due to incineration and combustion processes in the industry as well as in the domestic sector.

**Prognosis for waste streams if derogations and trace contamination levels apply**

PBDE: By derogation in Annex I to the amended POP Regulation, articles partly or fully produced from recycled material could contain the relevant PBDE congeners in concentrations up to 1,000 ppm. If this derogation shall also apply for material produced within the EU, it could be interpreted that also shredder outputs as a basis material would be allowed for recycling up to concentrations of 1,000 ppm.

Given that the derogation in Annex I applies for shredder fractions intended for recycling, the complete remaining stocks of PBDEs in PUR foam and WEEE plastics (roughly 470 t/y for commercial products corresponding to TetraBDE 103.73 t/y, PentaBDE 195.38 t/y, HexBDE 34.64, HeptaBDE 48.65 t/y) could in theory be kept in the recycling cycle, as all concentrations for single congeners in shredder fractions (if mixed with non contaminated items as currently practiced) are well below 1,000 ppm. The trace contamination level of 10ppm (continuous input into the mass flow) on the other hand has to be compared to current concentration levels in the original products of around 40,000 ppm. The permissible contamination in new products hence appears to be negligible compared to the historic load, and will lead to maximum continuous substance flows in a dimension of TetraBDE 25 kg/y, PentaBDE 50 kg/y, HexBDE 10 kg/y, and HeptaBDE 12 kg/y.

PFOS: If comparing the proposed trace contamination (0.1 g/m²) in e.g. carpet and leather with previously used PFOS amounts of roughly 2.4 g/m² for leather and 370 mg/m² for textiles, a continued trace contamination threshold would result in maximum annual discharge via waste of 5g/y via leather upholstery and 1 kg/y via impregnated textiles. This seems to be negligible.

PeCB: No derogations or trace contamination levels are foreseen for PeCB.

**4 Low (LPCL) and maximum (MPCL) POP concentration limits**

In accordance with Article 6 of the Stockholm Convention, the EU POPs Regulation stipulates that wastes containing POPs must be treated in such a way as to ensure that the POP content is destroyed or irreversibly transformed so that the remaining waste and releases do not exhibit the characteristics of POPs. Exemptions of this principle are possible

- if the POP content is below the limit value as of Annex IV „low POP concentration limit (LPCL)“,
in exceptional cases, for specific waste streams from power production, aluminium, lead, copper, zinc and other metallurgical processes, C&D, and thermal waste treatment\textsuperscript{5} listed in Annex V to the Regulation, up to a so called “maximum POP concentration limit” (MPCL).

The latest amendment of the POP Regulation (26. August 2010) lists tetra- to heptaPBDEs, PFOS and its salts, and PeCB. Specific exemption from the ban on marketing and use on intermediate use and other specifications, preliminary trace contamination levels and provisions have been set in Annexes I and III for tetra-, penta-, hexa-, and hepta- PBDE homologues as well as for PFOS and its derivates. In addition, provisional thresholds of 50 ppm and 5,000 ppm have been set for PeCB.

\textbf{Determination of low POP concentration limits (LPCL)}

The approach used in this report is based on the methodology developed for the determination of limit values for the initial 12 POPs, making use of upper and lower limitation criteria for low POP concentration limits (LPCL):

\textit{Lower limitation criteria:}

- A: Analytical potential
- B: Environmental background contamination
- C: Disposal/recovery capacities
- D: Economic feasibility
- Z: Existing limit values already agreed by the European Union (PBDE, PFOS)

\textit{Upper limitation criteria:}

- D: Economic feasibility (PBDE, PFOS)
- X: Precautionary principle
- Y: Worst case scenario for human health risks
- Z: Existing limit values already agreed by the European Union

\textbf{Criterion A (analytical potential)} corresponding to the Limit of Quantification (LoQ) that can be reached with GC/HRMS is about 0.1 ppm for single PBDE congener and PFOS and 1 ppb for PeCB, which is lower than the limitation set by the environmental contamination levels.

\textbf{Criterion B (environmental levels)} shall take into account the fact that any limit value for waste should be significantly higher than average or background levels observed in the environment (namely soil and sediments). “Hot spot” data indicate the factor by which common background values are likely to be exceeded. The limitation values hence is based on highest background data

and an “uncertainty factor” (related to the availability of representative data).

**Criterion C (disposal/recovery capacity)** does not cause limitations because <10% of the D10/R1 capacity existing in 2006 would be needed in addition, even in the worst case situation that all PBDE, PFOS, and PeCB contaminating wastes are covered.

**Criterion D (economic feasibility)** shows to be an upper limitation criterion as regards PBDE and PFOS (use of concerned waste in R1 is economically interesting and beneficiary from the environmental and waste hierarchy point of view), while it constitutes a lower limitation criterion for PeCB (ashes and sewage sludge that would need to be sent to class III or IV landfill in case of being classified as POP wastes).

As regards **Criterion Y (potential health impacts)** there are alternative options for limitations depending on the calculation basis and the level of precaution used for PBDE and PFOS. The higher limitation value for PBDE congener and for commercial products is based on RfDs applied by US EPA. The lower is a result from a recent risk assessment conducted by the Netherlands and is restricted to PentaBDE (applying corresponding standards as for PCDD/PCDF). The higher value for PFOS is based on the TDI and a safety margin one order of magnitude higher than for the other new POPs due to the higher water solubility, whereas the lower limitation value is oriented at the limit values set for agricultural application of sewage sludge in Austria, and hence is restricted to sewage sludge intended for agricultural application and not to be understood as general limitation.

**Criterion Z (existing legislation)** has the function of lower and of upper limitation criterion for PBDE and PFOS due to existing EU legislation. In consequence the LPCL may generally – unless ther are severe arguments in favour to it - not be lower than the value considered as trace contamination in EU law (10 ppm), and should not be higher than the 1,000 ppm considered as limit for placing on the market of products and substances according to ROHS Directive and REACH.

These limitation criteria are to be understood as borderline and not as recommendation for limit values. The precautionary principle is to be applied in addition requesting to chose the lowest feasible level.

The evaluation of lower and upper limitation criteria for the new POPs leads to the results as compiled in Table 4-1 and *** Impacts of limits shall be assessed and alternatives proposed is relevant

Table 4-2.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PBDE (commercial)</td>
<td>1 ppm</td>
<td>1 ppm</td>
<td>*********</td>
</tr>
</tbody>
</table>
### Overview on upper limitations for LPCLs for new POPs

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C-OctaBDE</td>
<td>50 ppm</td>
<td>500 ppm*</td>
<td>500 ppm (criterion Y)</td>
<td>1,000 ppm</td>
</tr>
<tr>
<td>C-PentaBDE</td>
<td>20 ppm</td>
<td>500 ppm*</td>
<td>500 ppm (criterion Y)</td>
<td>1,000 ppm</td>
</tr>
<tr>
<td>TetraBDE</td>
<td>5 ppm</td>
<td>50 ppm*</td>
<td>0.5 ppm*</td>
<td>1,000 ppm</td>
</tr>
<tr>
<td>PentaBDE</td>
<td>10 ppm</td>
<td>50 ppm*</td>
<td>0.5 ppm*</td>
<td>1,000 ppm</td>
</tr>
<tr>
<td>HexaBDE</td>
<td>1 ppm</td>
<td>50 ppm*</td>
<td>0.5 ppm*</td>
<td>1,000 ppm</td>
</tr>
<tr>
<td>HeptaBDE</td>
<td>0.1 ppm</td>
<td>50 ppm*</td>
<td>0.5 ppm*</td>
<td>1,000 ppm</td>
</tr>
<tr>
<td>PFOS</td>
<td>2 ppm</td>
<td>5 ppm*</td>
<td>0.5 ppm*</td>
<td>1,000 ppm</td>
</tr>
<tr>
<td>PeCB</td>
<td>50 ppm*</td>
<td>50 ppm*</td>
<td>50 ppm*</td>
<td>50 ppm</td>
</tr>
</tbody>
</table>

* limited to direct application of waste (sewage sludge) to soil

** R1 advantageous compared to landfill

*** Impacts of limits shall be assessed and alternatives proposed is relevant

### Conclusions for LPCLs for new POPs based on results from upper and lower limitation criteria

<table>
<thead>
<tr>
<th>Product</th>
<th>Lower limitation</th>
<th>Upper limitation I</th>
<th>Upper limitation II</th>
<th>Upper limitation III</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-OctaBDE</td>
<td>1 ppm</td>
<td>50 ppm (crit D**)</td>
<td>500 ppm (criterion Y)</td>
<td>1-50 ppm</td>
<td></td>
</tr>
<tr>
<td>C-PentaBDE</td>
<td>1 ppm</td>
<td>20 ppm (crit D**)</td>
<td>500 ppm (crit Y*)</td>
<td>1-20 ppm</td>
<td></td>
</tr>
<tr>
<td>TetraBDE</td>
<td>10 ppm (crit. Z)</td>
<td>5 ppm (crit D**)</td>
<td>500 ppm (crit Y*)</td>
<td>conflict</td>
<td></td>
</tr>
<tr>
<td>PentaBDE</td>
<td>10 ppm (crit. Z)</td>
<td>10 ppm (crit D**)</td>
<td>0.5 ppm (crit Y*)</td>
<td>1,000 (crit. Z***), conflict</td>
<td></td>
</tr>
<tr>
<td>HexaBDE</td>
<td>10 ppm (crit. Z)</td>
<td>1 ppm (crit D**)</td>
<td>1,000 (crit. Z***), conflict</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HeptaBDE</td>
<td>10 ppm (crit. Z)</td>
<td>0.1 ppm (crit D**)</td>
<td>1,000 (crit. Z***), conflict</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PFOS</td>
<td>1 ppm</td>
<td>0.5 ppm (crit Y*)</td>
<td>2 ppm (crit D**)</td>
<td>1,000 (crit. Z***), conflict</td>
<td></td>
</tr>
<tr>
<td>PeCB</td>
<td>1 ppm</td>
<td>50 ppm (crit Y*)</td>
<td>1 ppm</td>
<td>1-50 ppm</td>
<td></td>
</tr>
</tbody>
</table>
As illustrated in Table 4-3, the range for potential limits seems to be quite clear for PeCB, whereas there are a number of conflict as regards feasible LPCLs for new POPs and a number of alternatives (depending on weighting of limitation factors) that can be used for PBDEs and PFOS.

For PFOS there is a fundamental conflict between lower limitation Criterion Z and upper limitation criterion Y (as based on a national limit for sewage sludge). This conflict could be solved by requesting a specific limit for sewage sludge.

In the assessment of conflicts it has also to be taken into account that some of the limitations relate namely to specific treatments (crit Y), are of limited effect (crit. D as upper limitation limit), or shall be evaluated and assessed (crit. Z). Furthermore time trends for waste streams need to be taken into account.

4.1.1 Impacts of potential limits

Based on the Waste flows and the results of the limitation criteria a number of options for LPCLs has been developed (see Table 4-6), which have different impacts on waste and substance flows of the individual new POPs.

**PBDEs**

With **Option 1 limits** all relevant wastes streams are covered; including PUR foams from upholstery in terms of not further selected upholstery fraction from bulky waste (~6,000 kt/y) with the precautionary principle applied to its full extent. Under such conditions up to 3,800 kt/y of waste currently landfilled would need to be incinerated or used for energy recovery for the next 5-10 year, unless the 1,000 ppm derogation for articles made from recycled material would apply. In the latter case all concerned wastes could be recycled without limitations, if mixed with other uncontaminated material as expected.

Under Option 1 the limits for Tetra-, Hexa- and HeptaBDE would conflict with lower limitation Criterion Z and the limit for HeptaBDE in addition would conflict with the lower limitation criterion B. On the other hand there is a potential conflict between the proposed limits and upper limitation criterion Y (national TDI) for PentaBDE. As PBDE containing waste in general is not prone to agricultural application and the TDI for PentaBDE is opposed by contrary assessments, this conflict does not seems to be an absolute one. PentaBDE being the most critical congener for all PBDE applications, the LPCL limit of 10 ppm for PentaBDE could be considered sufficient to meet the limitations by criterion D and the LPCL for the other congeners could be lifted to 10 ppm without endangering the effectiveness of the Limits.
At **Option 2 limits** WEEE shredder light fraction is expected to be covered, whereas ELV shredder light fluff (based on current measurements and under the assumption that a considerable share of vehicle seats is reused) in general should not be concerned. The decisive congener for WEEE shredder light fraction would be HeptaBDE, whereas PentaBDE would be the decisive parameter for ELV shredder light fraction. Such limits would request alternative treatment for about 680 kt/y of waste currently expected to be landfilled or recycled, corresponding to roughly 10% of all relevant wastes. From the point of view of the PBDE substance flow, a considerable share of the overall flow of Tetra- through HexaBDE would continue to be cycled or “emitted” into the environment by means of landfilling.

Under Option 2 the limits for commercial products would conflict with criterion D, and the limits for Penta- and HeptaBDE would conflict in addition with criterion Y. As PBDE containing waste in general is not prone to agricultural application the conflict with criterion Y can be solved by banning application on agricultural soils. The conflict with criterion D can be reduced by the limitation of the limit to 2016 and a request to tighten it afterwards.

**Option 3 limits** are designed in order to generally not affect shredder light fractions from ELV and WEEE. This includes the situation that ELV shredder light fraction contains all remaining stocks of automotive PUR foam, and that none of the material is separated for reuse. Such limits reduce the cycling of PBDE only via thermal treatment of shredder residues, or if WEEE and ELV dismantlers manage to effectively separate the contaminated PUR foams and ABS plastics, before the shredding process. Due to the fact that the majority of WEEE shredder light fraction is expected to be already currently incinerated or used for energy recovery, the impact of option 3 on the overall PBDE substance flow does not differ to a large extent from option 2. Only for HeptaBDE the share of substance kept in the economic cycling is increased by almost 20%.

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**Table 4-4: Impact of option 2 LPCLs for PBDE congener on overall substance flows**

<table>
<thead>
<tr>
<th>PBDE substance flow in t/y</th>
<th>TetraBDE</th>
<th>PentaBDE</th>
<th>HexaBDE</th>
<th>HeptaBDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continue to be landfilled or reused</td>
<td>70</td>
<td>120</td>
<td>18</td>
<td>2</td>
</tr>
<tr>
<td>Overall substance flow</td>
<td>104.00</td>
<td>196.00</td>
<td>35.00</td>
<td>49.00</td>
</tr>
<tr>
<td>%</td>
<td>67</td>
<td>61</td>
<td>51</td>
<td>5</td>
</tr>
</tbody>
</table>

**Table 4-5: Impact of option 3 LPCLs for PBDE congener on overall substance flows**

<table>
<thead>
<tr>
<th>PBDE substance flow in t/y</th>
<th>TetraBDE</th>
<th>PentaBDE</th>
<th>HexaBDE</th>
<th>HeptaBDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continue to be recycled and reused</td>
<td>70</td>
<td>122</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Overall substance flow</td>
<td>104.00</td>
<td>196.00</td>
<td>35.00</td>
<td>49.00</td>
</tr>
<tr>
<td>%</td>
<td>67</td>
<td>62</td>
<td>56</td>
<td>20</td>
</tr>
</tbody>
</table>

Due to the fact, that existing stocks of contaminated material will continuously diminish, option 2 and 3 limits should be reviewed by 2016 at the latest. The expected impacts do not take into account
changes in shares of treatment methods towards landfilling or recycling e.g. due to the fact that the 1,000 ppm threshold is applied for shredder light fraction as a basis for recycled products.

Under Option 2 the limits for commercial products would conflict with criterion D, and the limits for C-OctaBDE and all single congener would conflict in addition with criterion Y. As PBDE containing waste in general is not prone to agricultural application the conflict with criterion Y can be solved by banning application on agricultural soils. The conflict with criterion D can be reduced by the limitation of the limit to 2016 and a request to tighten it afterwards.

**PFOS**

*With Option 1* (LPCL of 1 ppm) close to 100 % of the PFOS mass flow, comprising wastes from all sectors related to PFOS would be covered, with leather upholstery and carpets in bulky waste constituting the major fractions. Due to the huge quantity of sewage sludge with a low contamination level, this figures however, corresponds to only 33% of PFOS waste flows. Based on current treatment shares roughly 3,500 kt/y of the covered wastes would need additional thermal treatment.

Under Option 1 the LPCL would conflict with lower limitation Criterion 2 and at the same with the stricter alternative of upper limitation criterion Y. The conflict could be solved by limiting the limit for agricultural applications to <0.5 ppm)

*With Option 2 (10 ppm)* the ratio of coverage would drop to 12% in terms of the waste flow but still >90% of the PFOS mass flow would be covered. In this case, leather upholstery, wastes from photographic industry (except x-ray picture waste and photographic fluids) and chromium sludges would not be classified as POP waste. From the covered waste roughly 1,200 kt (carpets and x-ray pictures) would need additional thermal treatment (R1 or D10).

Under Option 2 the LPCL would conflict with the upper limitation criterion Y (both alternatives) and with upper limitation criterion D. The conflict could be solved by fixing the limit for agricultural applications to <5 or <0.5 ppm and by requesting a review of the limit by the year 2016 with the objective to tighten it further.

*Option 3 (100 ppm)* is designed in a way to not cover carpets (almost 50% of PFOS related wastes) the LPCL would need to be lifted at 100 ppm or higher. Less than 1% of all wastes and only about 5 % of the PFOS substance flow would be covered in that case. From the 3.1 kt/y of waste covered by the limit only 1.24 kt/y (waste from the vacuum distillation from the chromium industry) would need additional thermal treatment, whereas the remaining 1.8 kt/y are already treated by incineration.

Under Option 3 the same conflicts occur and the same solutions can be chosen as for option 2.
**PeCB**

At **Option 1** limits (1 ppm) none of the identified waste would be concerned. The limit would correspond to a strict application of the precautionary principle. A lower limit does not appear reasonable due to the limitation criterion related to environmental contamination.

At **Option 2** (LPCL of 50 ppm as set on the amended POP regulation) all of the identified waste would be far from being concerned. A LPCL of 50 does not seem to cause severe health concerns based on the few existing information (Criterion Y). Due to the precautionary principle a lower limit however would be recommended in this case for sewage sludge to be applied on agricultural soils even more as common contamination levels are as low as 5 ppb in average.

If a LPCL with impact on waste management was to be chosen it would need to be set at 3 or 5 ppb. Due to the fact that the large part of environmental contamination is via air emissions and deposition such a limit however, seems to be exaggerated and is not recommended.

Table 4-6: Overview on discussed options for LPCL limits for new POPs

<table>
<thead>
<tr>
<th></th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 2</th>
<th>Option 3</th>
<th>Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-PentaBDE</td>
<td>20 ppm</td>
<td>200 ppm</td>
<td></td>
<td>500 ppm</td>
<td></td>
</tr>
<tr>
<td>C-OctaBDE</td>
<td>50 ppm</td>
<td>500 ppm</td>
<td>Limited to 2016 for upholstery, ELV and WEEE</td>
<td>100 ppm</td>
<td>Limited to 2016 for upholstery, ELV and WEEE</td>
</tr>
<tr>
<td>TetraBDE</td>
<td>5 ppm</td>
<td>50 ppm</td>
<td>Limited to 2016 for upholstery, ELV and WEEE</td>
<td>100 ppm</td>
<td>Limited to 2016 for upholstery, ELV and WEEE</td>
</tr>
<tr>
<td>PentaBDE</td>
<td>10 ppm</td>
<td>100 ppm</td>
<td>Limited to 2016 for upholstery, ELV and WEEE</td>
<td>200 ppm</td>
<td>Limited to 2016 for upholstery, ELV and WEEE</td>
</tr>
<tr>
<td>HexaBDE</td>
<td>1 ppm</td>
<td>50 ppm</td>
<td>Limited to 2016 for upholstery, ELV and WEEE</td>
<td>100 ppm</td>
<td>Limited to 2016 for upholstery, ELV and WEEE</td>
</tr>
<tr>
<td>HeptaBDE</td>
<td>0.1 ppm</td>
<td>100 ppm</td>
<td>Limited to 2016 for upholstery, ELV and WEEE</td>
<td>500 ppm</td>
<td>Limited to 2016 for upholstery, ELV and WEEE</td>
</tr>
<tr>
<td>PFOS</td>
<td>1 ppm</td>
<td>10 ppm</td>
<td>Limited to 2016 With limitation for sewage sludge to 0.1 ppm</td>
<td>100 ppm</td>
<td>Limited to 2016 With limitation for sewage sludge to 0.1 ppm</td>
</tr>
<tr>
<td>PeCB</td>
<td>1 ppm</td>
<td>50 ppm</td>
<td>With limitation for sewage sludge to 1 ppm</td>
<td>50 ppm</td>
<td>With limitation for sewage sludge to 1 ppm</td>
</tr>
</tbody>
</table>
**Determination of maximum POP concentration limits (MPCL)**

For maximum POP concentration limits (MPCL) pursuant to Annex V the following levels are proposed for new POPs:

- PBDE (single congeners): 500 ppm
- PFOS: 50 ppm
- PeCB: 500 ppm

This proposal represents the lower edge of range of possible worst case estimates and is based on a twofold worst case approach to determine the risks from solidified wastes in hazardous landfills to leak into the environment. These values according to legal requirements may only be applied for solidified waste. The calculation is rough and may only give a first indication on the dimension of maximum POP content limit values based on leaching risks. Further studies or modelling work on leaching behaviour (from waste into leachate water) would be needed in order to enable more comprehensive estimates. Alternatively, MPCLs, which are a factor 10 higher (PBDE (single congeners): 5000 ppm, PFOS: 500 ppm, PeCB: 5000 ppm) could be defined without unresponsibly endangering the environment.

5 Impacts and Implications on competing legislation

LPCLs for new POP under the POP Regulation have impacts namely on WEEE and ELV legislation.

In relation to WEEE recycling and implications for brominated flame retardants (BFRs) containing the BDEs, currently Annex II of the WEEE Directive sets out the criteria for the 'Selective treatment for materials and components of WEEE'. Section 1 states that as a 'minimum the following substances, preparations and components have to be removed from any separately collected WEEE and this includes 'plastic containing brominated flame retardants'.

Such substances, preparations and components are permitted to be disposed of or recovered in compliance with Article 4 of Council Directive 75/442/EEC (now repealed). Plastics containing PBDEs above the proposed LPCLs have to be treated as POPs waste, therefore Annex II of WEEE may have to be amended so as to ensure compliance with the POPs Regulation requirements. In addition recycling targets of the WEEE and the ELV directive need to be reviewed in the light of the ban on recycling for POP wastes.

WEEE Reuse & Refurbishment: Reuse of articles containing new POPs in accordance with the waste hierarchy in 2008/98/EC will continue the circulation of elevated levels of PFOS and PBDEs and will contribute to an export of these substances as non-waste outside the EU.

Limit values set for new POPs will hence also have to be taken into account for classification of relevant waste streams under the WSR (1013/2006).
6 Conclusions and recommendations

Based on the evaluation of major substance and waste flows, given the expected trend for remaining stocks of PBDEs and PFOS in used products, and taking into consideration the impacts of potential limit values on the substance flows and potential conflicts with limitation criteria, the project team suggest to chose an amended option 1 (see Table 7) as preferred option for LPCLs for new POPs. This option would correspond to a strict application of the precautionary principle in the light of the objective of the fastest elimination possible. This option in addition takes into consideration the high calorific value of the majority of concerned waste streams and their suitability for thermal treatment - including energy recovery – and adds an additional argument to opt for R1 instead of landfilling as predominant treatment option.

Table 6-1_ Preferred proposal for LPCLs for new POPs

<table>
<thead>
<tr>
<th>Substance</th>
<th>Limit Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-PentaBDE</td>
<td>20 ppm</td>
<td></td>
</tr>
<tr>
<td>C-OctaBDE</td>
<td>50 ppm</td>
<td></td>
</tr>
<tr>
<td>TetraBDE</td>
<td>5 ppm</td>
<td></td>
</tr>
<tr>
<td>PentaBDE</td>
<td>10 ppm</td>
<td></td>
</tr>
<tr>
<td>HexaBDE</td>
<td>10 ppm</td>
<td></td>
</tr>
<tr>
<td>HeptaBDE</td>
<td>10 ppm</td>
<td></td>
</tr>
<tr>
<td>PFOS</td>
<td>10 ppm</td>
<td>Review 2016; With stricter limitation for sewage sludge (0.5 or 5 ppm)</td>
</tr>
<tr>
<td>PeCB</td>
<td>50 ppm</td>
<td>With (potential) limitation for sewage sludge to 1 ppm</td>
</tr>
</tbody>
</table>

Alternatively option 3 limits (see Table 6-2) could be selected for a transitional period of up to 6 years with a recommendation to revise and tighten the LPCLs by 2016 for PBDEs and PFOS; and stricter limits for agricultural use of sewage sludge.

Table 6-2_ Alternative transitional or restricted proposal for LPCLs for new POPs

<table>
<thead>
<tr>
<th>Substance</th>
<th>Limit Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-PentaBDE</td>
<td>500 ppm</td>
<td>Review 2016</td>
</tr>
<tr>
<td>C-OctaBDE</td>
<td>1500 ppm</td>
<td>Review 2016</td>
</tr>
<tr>
<td>TetraBDE</td>
<td>100 ppm</td>
<td>Review 2016</td>
</tr>
<tr>
<td>PentaBDE</td>
<td>200 ppm</td>
<td>Review 2016</td>
</tr>
<tr>
<td>HexaBDE</td>
<td>200 ppm</td>
<td>Review 2016</td>
</tr>
<tr>
<td>HeptaBDE</td>
<td>1000 ppm</td>
<td>Review 2016</td>
</tr>
<tr>
<td>PFOS</td>
<td>100 ppm</td>
<td>Review 2016; With stricter limitation for sewage sludge (0.5 or 5 ppm)</td>
</tr>
<tr>
<td>PeCB</td>
<td>50 ppm</td>
<td>With limitation for sewage sludge to 1 ppm</td>
</tr>
</tbody>
</table>

As regards MPCLs the project team would suggest the lower set of MPCL options as preferred solution, if the preferred proposal for LPCLs is selected by the European Commission and the Member States.

- PBDE (single congeners): 500 ppm
- PFOS: 50 ppm
- PeCB: 500 ppm

Such a solution would represent a maximally precautious approach, taking into consideration concerns that have been raised by certain stakeholders against the MPCL limits for the first 12 POPs.

In case the transitional solution according to option 3 is selected for the LPCLs, the higher set of optional MPCLs with PBDE (single congeners)= 5000 ppm, PFOS = 500 ppm, and PeCB = 5000 ppm should be chosen in order to avoid conflicts between LPCL and MPCL.
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