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QUESTIONNAIRE

"*Study to Support the Review of Waste-related issues in Annexes IV and V of Regulation (EC) 850/2004*"[1]

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[1] Information related to this project on behalf of the European Commission is provided on a dedicated project website at http://pops-and-waste.bipro.de.

Section I – "new POPs"

Decabromodiphenylether (decaBDE); short-chain chlorinated paraffins (SCCPs); Hexachlorobutadiene (HCBD)

Please note that all comments below pertain to decaBDE. We are not aware of any use of SCCPs or HCBD in the plastics industry and consequently their presence in plastic recyclates is not considered.

I. Occurrence of "new POPs" decaBDE, ~~SCCPs and HCBD~~ (articles in use, waste, recycled articles as well as (production) processes and unintentional releases)

1. *a) Please indicate whether your country /company has **stockpiles of decaBDE, ~~SCCPs or HCBD.~~***

*b) **If yes,** please provide information on types, quantity, concentrations, etc.*

a) Plastics recyclers do not store decaBDE as a pure substance. There is however a large amount of decaBDE in articles currently in use, especially in electrical, electronic and automotive applications. These technical plastics can serve as a feedstock for the recycling of plastics.

b) Individual (parts of) articles that are brominated can contain high levels of decaBDE (e.g. 18% in Polystyrene). In small appliances, large appliances and automotive shreds, a fraction of plastics can result in elevated levels of decaBDE, theoretically everywhere between 0 and 20%.

2. *Please indicate any known **occurrence and concentration of the "new POPs" decaBDE, ~~SCCPs and HCBD~~** in different **articles in use, waste** categories **and recycled articles**.*

decaBDE	Specification of waste/article	Concentration [mg/kg]
Articles in use	Small Appliances	0 – 200.000
	Large Appliances	0 – 200.000
	Automotive	0 – 200.000
Wastes (shred)	Small Appliances Shred	0 – 200.000
	Large Appliances Shred	0 – 200.000
	Automotive Shred	0 – 200.000
Waste (from recycling process)	Highly brominated shred	0 – 200.000
Recyclate	PE/PP Compound	<1000
	PS Compound	<1000
	ABS Compound	<1000
Recycled articles		<1000

Plastics recyclers are able to separate brominated from non/low-brominated flakes thanks to the higher density of brominated flakes. In addition, as PE/PP, PS, and ABS have different densities, recyclers can separate these materials. The output of the recycling plant is a highly brominated waste shred and three streams of materials that can be used in new articles.

3. *Please provide **information on quantities of waste containing "new POPs" that are currently generated, then disposed of or recycled***

"new POPs"	Specification of waste	Waste generated (in kt)	Waste disposed of (in kt)	Waste recycled (in kt)
decaBDE				

4. *Please provide i**nformation on wastes containing "new POPs" that are currently recycled** (now or in the near future) and on the extent of recycling. If possible, please specify the types of new articles produced from the recycled material.*

"new POPs"	Types of waste recycled	Recycling rate [%]	New articles produced from recycled material
decaBDE	Mixed Electrical and Electronic Waste plastics fraction	50 – 60%	PP/PE Regrind or Compound ABS Regrind or Compound PS Regrind or Compound

Among other members, PRE represents Technical Plastics Recyclers, who process plastic's fractions of shredded mixed electrical, electronic and automotive waste. The input material of these plastic recyclers is thus typically shredded material from which metal and other non-plastics parts have been removed. This general fraction of plastics is further separated into PP/PE, ABS, and PS. Some recyclers not only mechanically grind materials but have also developed compounding techniques to melt materials and produce plastics pellets. These are easier to process by converters and can be used in more sensitive production's processes.
The recycling rate in the table indicates the fraction of plastics that can be recycled in a new material within this process. The presence of decaBDE is not included in the calculation of the 50-60% recycling rate, but in the fraction of waste the plastic recycler can dispose.
Customers can produce a wide variety of materials from fractions of a polymer (e.g. vacuum cleaners, plant-trays, other electronics, and office equipment).

5. *Please indicate up-to-date (reference) **measurement (analytical) methods** for identifying the presence and levels of the listed "new POPs" in waste.*

To measure decaBDE is relatively expensive because a sample has to be sent to a laboratory, which will perform the following tasks:

- Sample preparation, typically reducing the material to a find powder (e.g. [cryogenic] milling) followed by an extraction with a solvent. The system is typically supplied with energy either in the form of heat or with an ultrasonic bath.
- The solvent and the extractables are then injected into a chromatograph that is coupled with either a mass spectroscopy or a flame ionisation detection.
- The detected signal is compared with signals obtained from standard solutions that have been run over the same chromatography column and detected with the same instrumentation.
- Based on the comparison of signal of the sample and the signals obtained from the standard solutions the concentration in the sample is determined.

In such a procedure, the amount of material included in the analysis is rather low. Hence the need to perform more than one analysis to provide a reliable measurement on a batch of material. For example, one highly brominated PS flake could measure 18,000 mg/kg of decaBDE, but if measured together with 600 non-brominated flakes, the average concentration could be of 300 mg/kg. With 20 flakes collected as samples, there is a major probability for the laboratory to measure 0 mg/kg of decaBDE, and a minor probability of measuring 900 mg/kg.
A solution could be performing more analyses and calculating the average measurement or changing the sampling protocol to instruct analytical laboratories use more materials. In any case this kind of analysis is relatively expensive and cannot be done on each batch without occurring in relevant costs. Such measurement can be used to verify the quality on a regular basis (e.g. monthly) and to check the efficiency of the sorting process.

6. *Please indicate known inexpensive **screening methods** for identifying wastes containing "new POPs"*

X-Ray Fluorescence (XRF) represents the most relevant screening method to determinate the concentration of elemental bromine in materials. With this technology X-Rays are generated and shot at the material. These are absorbed by electrons circulating in the atoms of the material, whereupon the electrons reach a higher energy state. Shortly after the electrons return to their original state, a photon is emitted with a wave length that depends on the specific element. These photons are detected and measured to determine the characterization of the elements included in a given material.
The initial investment in a new XRF system for a recycling company can be between €20,000 and €30,000, although second-hand systems are usually priced €8,000, an option for the smaller operators. Maintenance, calibration and repair

costs are of approx. €3,000/year. With this system, operational costs occur only during the analysis, which is completed in ca. 5 minutes.
As an example, to calculate the presence of decaBDE in a material, the analysis consists of calculating on a given limit (e.g. 1000 mg/kg of decaDBE) the presence of elemental bromine. This is due the fact that decaBDE's molecular mass is made of 83,3% bromine, therefore, if the XRF machine indicates a value of less than 833 mg/kg of total elemental bromine, presence of decaBDE will be within the limits. Nevertheless, even if the levels of elemental bromine are above 833 mg/kg, the limit of 1000 mg/kg of decaBDE can still be respected, as there are many other substances that can cause the same signal (e.g. brominated polystyrene polymer and other polybrominated biphenyls).

XRF technology can be considered a valid screening tool provided that decaBDE limits are not set too low, as both quantification and the presence of other brominated substances would limit the usefulness of the method.

A limit value higher than 1000 mg/kg would allow a constant and efficient recycling of electrical, electronic and automotive waste streams.

7. *Please indicate any known* ***(production) processes using decaBDE,*** ~~***SCCPs and HCBD***~~ *as well as options for the environmental management of their operation and potential related* ***unintentional releases of these POPs*** *into the environment.*

It should be acknowledged that during all industrial processes a percentage of materials is released in the environment and lost. The economic value of these losses represents a financial incentive to reduce the releasing, and many European, national and regional legislations aim at reducing this.

The distinction between (i) air, (ii) wastewater and (iii) waste, is customary in the modelling of environmental emissions of industrial plants. Examples for these releases are provided by the OECD Emission Scenario Document for Plastics Additives[2].
A recycler can perform several operations:

- Mechanical reduction to particle-size (e.g. shredding, grinding, and/or micronisation).
- Separation (e.g. density separation)
- Compounding, i.e. the melting of the plastics material, homogenisation in an extruder and the production of pellets.

(i) Under point 320, volatilisation of decaBDE should not be expected at elevated temperatures (*0.0% at 200 degrees Celsius)*. The release of dust is therefore the only possible release in the environment.

(ii) For wastewater, some considerations have to be made on dust particles released during the size-reduction operations:

- Mechanical reduction in particle-size
  - o The information under point 323 concerns the handling of the additive on raw materials, i.e. the factors described would be relevant only if recyclers would handle 100% pure decaBDE. As we have already stated, material handled by recyclers do not present more than 20% of decaBDE.
  - o The general size of the particle-material handled by recyclers is of >40µm.
  - o Given this, the factor for particles of >40µm corresponding at 0.2% to solid waste/water should be reduced by at least 5, resulting in a release of 0.05% of decaBDE during mechanical reduction.
- Separation
  - o There is no good information in the OECD ESD for PA as it is designed for the virgin production processes.
  - o The release factor under point 333 section 15.2.4.2, could be considered as information for the service-life of organic substances.
  - o In outdoor premises, the service-life of products release 0.16%/year.
  - o In a density-separation process, materials will be in contact with water for up to 30 minutes: a factor of 0.16% * 30/60/24/365 = 1.01E-8% ~ 0.0%
  - o A factor of 0.0% would indicate no release. This can be further supported by migration models where the diffusion coefficient of the substance in the polymer (i.e. how fast can the substance travel through

[2] Emission Scenario Document for plastics additives (OECD, 2004a), online available at: http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env/jm/mono(2004)8/rev1&doclanguage=en

the polymer) is heavily dependent on the molecular weight[3,4]. DecaBDE has an exceptionally high molecular weight for a plastic additive and can therefore be expected not to migrate in any appreciable amount during the processing time (see Figure 1).

- Compounding
  - Usually, compounding would happen only after separation. As the density-separation technology can separate flakes of high bromine content materials there should not be any decaBDE going through this step.
  - For residual decaBDE, the information in point 329 regarding processes partially open is relevant, as most of the processes take place in the extruder and only at the end melted materials undergo a rapid chilling phase in an outside environment.
  - For the low-volatility group the information in point 329 specifies that 0.003% of the material would end in waste water.
  - However, point 328 and 329 explain that for organic flame retardants the material first volatilises and upon subsequent condensation is cleaned from surfaces and where eventually reaches wastewater.
  - As decaBDE do not volatilise before 200 degrees Celsius, it is questionable whether even this 0.003% factor is not overly conservative.

(iii) The information above pertains to plastic recyclers' operations recovering the non-brominated fraction from the brominated one in the plastics waste. The brominated waste fraction needs to be further processed.

[3] Schwope ADG, Rosemary (1990), "Methods for Assessing Exposure to Chemical Substances", in *Methodology for Estimating the Migration of Additives and Impurities from Polymeric Materials*. Vol 11. Washington, D.C.: U.S. Environmental Protection Agency, Office of Toxic Substances.

[4] Brandsch J, Mercea P, Ruter M, Tosa V, Piringer O. (2002), "Migration modelling as a tool for quality assurance of food packaging", Food Addit Contam;19 Suppl:29-41.

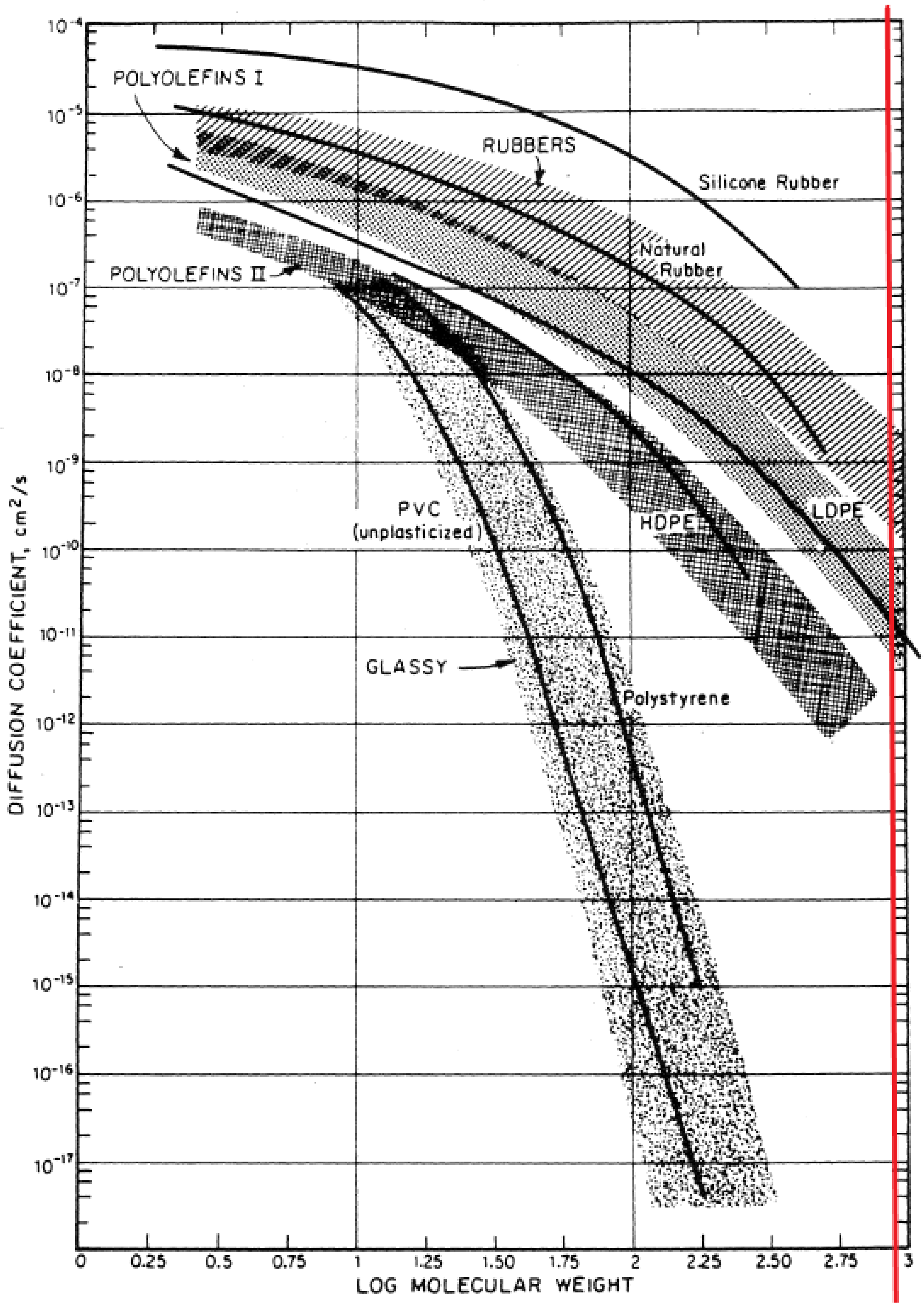

Figure 1 The relationship between the molecular weight of a plastic additive and the diffision coefficient in different polymer matrixes based on emperical data obtained from food contact material testing. The red line indicates the molecular weight of decaBDE. Source: Schwope et al. [1]

II. Waste Management Options/Recycling Operations for "new POPs"

8. *Waste separation for decaBDE, ~~SCCPs and/or HCBD~~ containing wastes: a) How can be* ***distinguished*** *between* ***contaminated and non-contaminated waste****? b) Which* ***separation operations*** *should preferably be used* ***in practice to separate*** *contaminated from non-contaminated waste (please provide further details if available)? c) What should be the preferred* ***waste management options for the contaminated waste fraction*** *(please provide justification and further details if available e.g. related costs)?*

a) For electric, electronic and automotive waste it is not possible to identify non-contaminated streams. It is possible to identify streams when flame retardants were used (e.g. hair driers, as there is significant heat production). It is however not economically feasible to determine in each sub-stream and for each batch whether flame retardants were included to extend the functionality of the material.

b) For shredded or grinded materials, instead, it is possible to distinguish between brominated and non-brominated. This is done thanks to a different density between these two types of materials, with brominated materials being denser. Immerged in water with varying salt content and thus different densities, it is possible to obtain a PE/PP, ABS, PS, and a 'heavy' fraction. Decontamination efficiency is quite high in this case, with only low levels of bromine being detected in PE/PP, ABS, and PS fraction (<1000 ppm).

c) As explained above XRF is able to detect bromine in decaBDE sample within 5 minutes. However, sorting of flakes "in line" cannot be obtain through this technology, because of the of analytical technologies and physics' limitations.

d) XRF can be used on a batch to provide some kind of guarantee to customers on the average levels, and to exclude the possibility that substances are present above a certain limit value. Naturally, the lower the limit value the more frequent testing needs to be performed and the more frequent batches of material need to be discarded to waste operators.

b) **Preferable separation operations**	**Relevant waste / new POP**	**Possible health risks for workers during separation of waste**	**Separation costs / ton of waste**	**Explanation / further information**
1. Density Separation	DecaBDE	None – the substance is embedded in a polymer matrix*	Low	
2. XRF Batch Control	DecaBDE	None from the substance – the substance is embedded in a polymer matrix* Radiation precautions need to be taken.	Manageable	See above
3 Analytical Chemistry quality control	DecaBDE	None – although the substance is forced out of the matrix the quantity is minimal and exposure is expected to therefore be minimal.	Manageable	See above
4. XRF "in line"	DecaBDE	None from the substance– the substance is embedded in a polymer matrix* Radiation precautions need to be taken.	Impossible	See above

* as explained above, decaBDE is a molecular additive with a very high weight and it's migration from the polymer matrix will be extremely limited.

c)

Preferable waste management operations	Relevant waste / new POP	Possible health risks for workers during waste management (e.g. recycling)	Management costs / ton of waste	Explanation / further information
1. Recycling	DecaBDE	None – the substance is embedded in a polymer matrix		Results in a fraction of highly brominated material and a fraction of reusable material
2. Energy Recovery	DecaBDE			After purification of the brominated material through recycling operations the brominated material must be destroyed. Ideally, energy would be recovered from the material.
3. Incineration	DecaBDE			
4. Controlled landfill	DecaBDE			Should be last resort

It should be noted that with the recycling process, only traces of decaBDE are recovered. As there is currently no further process by which the non-brominated material containing decaBDE can be separated, these traces should be destroyed. The waste hierarchy should be respected also in the destruction of these traces: ideally in energy recovery, incineration, and, if not feasible, controlled landfill.

III. Concentration Limits for decaBDE, ~~SCCPs and HCBD~~

e) *Are you aware of **any existing concentration limits for decaBDE in waste?***

There are currently no concentration limits for decaBDE in waste under EU legislation. However, under the REACH restriction on decaBDE a level of 0.1% is set for the reintroduction of substances into the EU (as substances, components in a mixture, and articles). The limits of 0.1% concentration in recycled materials, except for aircraft and automotive spare parts, will be effective from 2 March 2019. Exemptions on automotive spare parts were allowed for repair and reuse of spare parts in vehicles, for aviation, instead, these were allowed for the higher standards characterising the industry components. For the latter case, recycled materials are not foreseen to be used, as a lengthy process to standardize them would be required. Materials containing decaBDE will remain waste, and will be either incinerated or landfilled.

Furthermore, standard EN 50625 specifies that material containing more than 2000 mg/kg elemental bromine needs to be treated in a specialised recycling plant to separate the brominated material. This EN standard is taken up by various national legislations in the EU.

f) *Which **concentration limits for decaBDE in** waste according to the POP Regulation would you recommend? Please justify.*

Plastics Recyclers Europe would recommend a limit value of 1000 mg/kg or more.
The limit value of 1000 mg/kg would be aligned with REACH, which is easier in terms of enforcement.
However, the primary reason for Plastics Recyclers Europe to advocate a limit value of more than 1000 mg/kg is density separation, by far the most efficient way to condensate decaBDE. Condensation, by removing non contaminated materials and materials containing only traces of brominated flame retardants, is able to guarantee that the recovered

material contains at maximum 1000+ mg/kg of decaBDE. By setting higher limits it is possible to achieve a more precise measurement of the quantity of decaBDE present on recycled materials, therefore contributing on defining higher quality characteristics for these secondary raw materials.
Lower limits mean potentially to have other brominated compounds, and the need for other measurement tools such as analytical chemistry to be performed on each batch. Analytical chemistry would require higher cost and a lengthy process during which the batch needs to remain at the recycler's premises with repercussions on logistics and surface required for storage. Any levels lower than 1000 mg/kg would result in a decrease of the recycled output, which if low enough result in the cessation of the recycling of electrical, electronic, and automotive waste.

g) *At which lower concentration limits for decaBDE in waste would you* ***expect relevant impacts*** *(e.g. on recycling industry)? Please justify.*

A limit below 300 mg/kg would make recycling impossible, not because of technical limitations of the sorting process, but because of technical limitations of the laboratories, and more specifically in the sampling and sample preparation processes. Even though some laboratories report detection limits for decaBDE as low as 25 mg/kg, experience shows that repeatable results are not possible below 300 mg/kg. The cause of that is in the fact that the residues of decaBDE are not homogeneously spread over the product. For one single flake with 18% decaBDE (which is the common concentration in HIPS), 600 flakes without decaBDE would be needed to come to a 300 mg/kg concentration. Because laboratories can only work with (very) small samples, large variations occur when the same sample is analysed repeatedly.

On top of that, a limit below 1000 mg/kg would prevent future separation processes for polymers with fillers or additives, or for polymer blends. Several recyclers are already practicing small scale separation of f.i. talc-filled PP (very common in washing machines) or PC-ABS (very common in flat panel TVs and monitors) out of mixed WEEE plastics. These separation processes can no longer be done by density. Other techniques like LIBS and X-ray are needed, which are less accurate because of their technical limitations. However, a further development of these processes is needed to reach the recycling targets set in Directive 2012/19/EU.

h) *Is there a* ***continued need for the derogation provided for POP-PBDEs in articles*** *produced from recycled materials in the POPs Regulation (i.e. level of 1,000 mg/kg or 0.1% by weight) of POP-PBDEs allowed in articles produced partially or fully from recycled materials?*[5] *Please justify.*

Without the current derogation for POP-PBDEs it would not be possible to recycle. Any stricter limits would increase the burden on the recycling industry.
Data available in some studies (e.g. 1. Stoffflüsse im Schweizer Elektronikschrott, 2. Decabromodiphenyl ether and other flame retardants in plastic waste destined for recycling, and 3/ A Further Update of the UK's Persistent Organic Pollutants Multi-media Emission Inventory) show that the concentration of POP-PBDEs is decreasing. In due time, limits could be lowered.

i) *Is an* ***adjustment of existing POP limit values for SCCPs***[6] ***and HCBD***[7]***, as specified in Annex IV and V of the EU POP Regulation,*** *and/or* ***additional measures required*** *(e.g. due to any notable developments)? Please justify.*

No comment. Does not seem to be an issue for plastics recyclers.

j) *Please indicate if, beyond the EU POP Regulation, there are any adjustments to EU legislation needed, resulting from the listing of the "new POPs" decaBDE, ~~SCCPs and HCBD~~ under the Stockholm Convention.*

No Comment.

[5] See Annex I Regulation (EC) No 850/2004
[6] Regulation (EC) 850/2004, Annex IV, concentration limit referred to in Article 7(4)(a): 10 000 mg/kg; Maximum concentration limits of substance listed in Annex IV: 10 000 mg/kg
[7] Regulation (EC) 850/2004, Annex IV, concentration limit referred to in Article 7(4)(a): 100 mg/kg; Maximum concentration limits of substance listed in Annex IV: 1000 mg/kg

k)	*Can you provide any other information or information sources relevant to Section I of this questionnaire on the "new POPs"?*

1. Stoffflüsse im Schweizer Elektronikschrott,
2. Decabromodiphenyl ether and other flame retardants in plastic waste destined for recycling,
3. A Further Update of the UK's Persistent Organic Pollutants Multi-media Emission Inventory,
4. PRE Experts would like to contribute in the form of interviews or specific follow-up questions

[SECTION II is removed as PRE does not have any information to contribute

Section III – "already listed POPs"

Hexabromocyclododecane (HBCD), Polychlorinated Biphenyls (PCB), Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/PCDF)

29. *Are the existing concentration limits in Annex IV and V of the EU POP Regulation* ***for HBCD, PCB and PCDD/F*** *appropriate to ensure a sufficient level of environmental and health protection or is it necessary to adjust* ***them*** *(e.g. due to any notable developments such as new scientific data and technical progress, etc.)? Please justify.*

For the sake of alignment of legislation of brominated flame retardants, the threshold for HBCDD should be set higher than 1000 mg/kg/.

30. *If the existing limit values need to be adjusted, which* ***concentration limits for HBCD, PCB and PCDD/F in waste*** *would you recommend and why?*

See 29

31. *What would be the* ***major impacts from a possible adjustment of existing limit values of Annex IV or V of the EU POP Regulation****? Please justify.*

The analysis of elemental bromine will become sufficient in most cases to make sure that HBCDD is below the limit value. Reducing the need for analytical chemistry and facilitating the recycling of material, while maintaining the