

PBDE AND PFOS INVENTORY GUIDANCE FOR THE STOCKHOLM CONVENTION

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Introduction

The Stockholm Convention on Persistent Organic Pollutants (POPs) is an international treaty aimed at protecting human health and the environment from the threats posed by POPs. The Convention goals are to restrict and ultimately eliminate the production, use, release, and storage of POPs. The Convention also establishes regulation on the international trade of POPs and their disposal upon becoming wastes. An initial 12 POPs were listed under the Convention when it was adopted in 2001. The Conference of the Parties (COP) to the Stockholm Convention decided to list nine new chemicals in 2009 and an additional one in 2011¹. These newly listed chemicals are commonly referred to as the new POPs.

To assist Parties in updating their national implementation plans to address the new POPs, a set of guidance documents has been developed by the United Nations Industrial Development Organization (UNIDO) and the United Nations Institute for Training and Research (UNITAR), working in collaboration with the Secretariat of the Stockholm Convention (SSC). These documents aim at supporting Parties in developing strategies to restrict and eliminate the new POPs, by providing guidance on establishing inventories, monitoring the presence of products and articles containing new POPs, and selecting best available techniques and best environmental practices for situations when production, use, and recycling of industrial POPs are allowed by the Convention.

The following guidance documents have been prepared to assist with NIP review and updating:

1. Guidance for Developing, Reviewing, and Updating a National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants
2. Guidance for the inventory of perfluorooctane sulfonic acid (PFOS) and related chemicals listed under the Stockholm Convention on POPs
3. Guidance for the inventory of polybrominated diphenyl ethers (PBDEs) listed under the Stockholm Convention on POPs
4. Guidelines on best available techniques and best environmental practices for the production and use of perfluorooctane sulfonic acid (PFOS) and related chemicals listed under the Stockholm Convention on POPs
5. Guidelines on best available techniques and best environmental practices for the recycling and waste disposal of articles containing polybrominated diphenyl ethers (PBDEs) listed under the Stockholm Convention on POPs
6. Guidance for the control of the import and export of POPs

7. Guidance for strengthening the regulatory framework/voluntary agreements regulating the monitoring of products/articles that contain or may contain new POPs
8. Labelling of products and articles that contain POPs - initial considerations
9. Guidance on calculation of action plan costs for specific POPs

PBDEs listed under the Convention (POP-PBDEs) include commercial pentabromodiphenylethers (major compositions are tetra- and penta-homologues) and commercial octabromodiphenylethers (containing hexa-, and hepta- homologues). PFOS, its salts, PFOSF and PFOS related chemicals include chemicals that contain the perfluorooctane sulfonic acid structural element in their molecular structures including those in the form of polymers. In this presentation, the inventory methods described in the guidance for POP-PBDEs and PFOS, its salts, PFOSF and PFOS related chemicals are elaborated.

Results and Discussion

Two inventory guidance documents were developed for POP-PBDEs and for PFOS and its salts, PFOSF and PFOS related chemicals. The guidance drafting group included experts from industry in the respective field, researchers, governmental authority and UN staff.

The inventory methodologies need to be applicable to all Parties to the Convention, particularly developing countries and countries with economies in transition. Therefore a tiered approach, namely, initial assessment, preliminary inventory and in-depth inventory, was incorporated throughout the guidance. It is expected that the preliminary inventory will be carried out and reported in the form of inventory reports by most of the Parties once the project fund from the Global Environmental Facility is given to eligible Parties for updating the National Implementation Plan.

POP-PBDEs and the developed inventory approach

The production and use of POP-PBDEs are banned subject to specific exemption in the area of recycling of POP-PBDE containing plastic that is valid until 2030. The guidance focuses on the two sectors of (1) electrical and electronic appliance and its waste (EEE/WEEE) and (2) the transport sector for the preliminary inventory. The EEE/WEEE inventory approach adopted a simplified method of the Basel Convention's e-waste assessment approach² and is therefore compatible with the EEE/WEEE inventories developed. The guidance also provides a preliminary method to estimate the inventory of cathode ray tube (CRT) televisions that can be used even in countries with lack of available data.

For POP-PBDEs in CRT

Once the per capita data have been estimated, the POP-PBDE content in CRT casings (TVs and computer monitors) can be calculated considering the following additional data:

- population in the respective country;
- weight of the CRTs: 25 kg per device (estimated average weight of a CRT monitor, either TV or PC monitors; see also Table 4-5);
- polymer content of CRT casings: 30% (estimated average³);
- average c-OctaBDE content of 0.15% for these polymers used in CRT casings (estimated average⁴).

The calculation of c-OctaBDE in CRT devices is done as follows:

$$M_{\text{PBDE}(i)} = [\text{Number of CRTs/capita}_{\text{Region}}] \times \text{population} \times 25 \text{ kg} \times 0.3 \times 0.0015$$

Where:

- $M_{\text{PBDE}(i)}$ is the amount of POP-PBDEs (i) in [kg]

While the main approach of tier 1 (initial assessment) and tier 2 (preliminary inventory) is largely based on gathering of data, the tier 3 (in-depth inventory) can consist partly of screening and analysis of articles or materials in particular where no or too less information on POP-PBDE content is available. During the development of the inventory guidance it was revealed that information on POP-PBDE content in several former key use areas (e.g. vehicles, furniture, construction) for several regions were missing. For the improvement of the accuracy for establishing a detailed inventory for countries in these regions, a screening approach of

potentially PBDE-containing articles by e.g. hand-held equipments like XRF or sliding spark guns for presence of bromine can be combined in combination with confirmation analysis (GC-ECD or GC-MS). Such national or regional monitoring studies might best be conducted in cooperation of responsible ministries and research institutions possibly including international cooperation or with coordination by Stockholm regional centers.

For POP-PBDEs in ELV

The following formula is used to calculate the POP-PBDEs content of vehicles for the different categories (cars/trucks or busses) in different life cycle stages:

Quantity of POP-PBDEs_{Vehicle category} = Number of vehicles_{category} x POP-PBDEs_{category} x F_{regional}

where:

- Number of vehicles_{category} is the number of vehicles (manufactured 1975-2004) present in a category (car, bus or truck) calculated for the different life cycle stages;
- POP-PBDEs_{category} is the quantity of POP-PBDEs in an individual car, truck or bus treated with POP-PBDEs;
- F_{regional} is the regional factor for vehicles. The use of c-PentaBDE depended on the national/regional legislations and production/use patterns. Approximately 90% of c-PentaBDE has been used in the US/North America⁵. Therefore, approximately 200 million cars and other vehicles produced in this region from 1975 to 2004 could have been contaminated with c-PentaBDE. A factor of 0.5 (50% of vehicles impacted) is selected for adjustment for vehicles in/from the US/North America. A factor of 0.05 is suggested as regional adjustment factor for Europe. This factor is derived from measurements of European automotive shredder residues having contained an average of approximately 7 g c-PentaBDE per car around 2000 corresponding to 4.4% impacted car when considering 160 g c-PentaBDE for an impacted car⁶. In vehicles produced in Asia the overall use of c-PentaBDE might be even lower since e.g. Japan discontinued the use of c-PentaBDE in the early 1990s. However since there are some uncertainties in respect to c-PentaBDE production and use in China, also a factor of 0.05 (5% of cars produced between 1975 and 2004 in the Asian region) are considered impacted by c-PentaBDE in/from this region. For vehicles produced in Latin America and the Caribbean regions and for vehicles produced in the African regions no data on POP-PBDE in vehicles are available. Due to the major use of PentaBDE in the United States and the lack of specific flammability standards in these regions also the impact factor of 0.05 is suggested as factor for vehicles produced in this region until data for these regions are available.

PFOS, its salts, PFOSF and PFOS related chemicals

The production and use of PFOS will continue for acceptable purposes. In the inventory guidance, chemical preparations in industrial sectors (e.g. metal/plastic plating, fire-fighting foams and insecticides), and PFOS containing consumer articles (e.g. carpets) are two major prioritized areas for the inventory. The overall estimation at the national level for all production and use can be made by using the following equation.

PFOS in consumer articles and chemical preparations

Annual net consumption of PFOS in [country] = [manufacture + import – export] of PFOS containing products or articles x PFOS content*

*The average content of PFOS in various articles or preparations is given in the guidance.

However, the guidance also provides estimated contents of PFOS for various chemical preparations and consumer articles that could be multiplied with their annual production amount to obtain the approximate consumption of PFOS. Compared to the POP-PBDEs, data related to PFOS are limited and have not been collected successfully to present as a case study. One of the expected challenges during the inventory activity in the field would be the detection of PFOS polymers coated on the surface of consumer articles. The measurement of surface tension angles is proposed as a tool.

Review process of the guidances

To get a comprehensive view from different stakeholders perspectives, guidance drafts were circulated to experts, governmental officers, Stockholm Convention regional centres from developing and industrial countries as well as UN institutions for review and feedback in particular in respect to the overall approach and the practicability.

Pilot testing of POP-PBDEs inventory guidance

Furthermore the inventory method and reporting formats were tested in pilot studies in some countries, e.g. Nigeria and Serbia. For Nigeria an EEE/WEEE inventory was recently developed by the Basel Convention Regional Center Nigeria and Swiss EMPA⁷ This POP-PBDE inventory is compiled in Table 1. The POP-PBDE content in plastic of CRT is currently assessed in a monitoring study using the suggested screening approach and screening data were presented at Dioxin 2011⁸ and analytical data at Dioxin 2012⁹.

Table 1: Commercial OctaBDE and related POP-PBDE (hexaBDE and heptaBDE) in EEE, WEEE (TV/PC CRT) plastic in Nigeria (in kg)

| Homologues | Distribution homologues c-OctaBDE | POP-BDEs in import for inventory year 2010 | POP-BDEs in stocks for inventory year 2010 | POP-BDEs entering the waste stream (WEEE) for inventory year | POP-BDEs in recycled polymers for inventory year 2010 |
|------------------------------|-----------------------------------|--|--|--|---|
| Total inventoried c-OctaBDE* | | 8.9×10^3 | 8.1×10^5 | 3.4×10^4 | 4.5×10^3 |
| hexaBDE | 11% | 9.7×10^2 | 8.9×10^4 | 3.8×10^3 | 4.9×10^2 |
| heptaBDE | 43% | 3.8×10^3 | 3.5×10^5 | 1.5×10^4 | 1.9×10^3 |

*C-OctaBDE contains PBDEs listed (hexa- and heptaBDE) and not listed as POPs (octa-, nona-, and decaBDE), and therefore the sum of hexaBDE and heptaBDE do not correspond to 100% of c-OctaBDE.

It was estimated that approximately 840 tonnes of commercial OctaBDE including 360 tonnes of POP-PBDE is present in Nigeria in approximately 530,000 tons of CRTs in stocks (in use, stored on private and companies/institutions level) and dispose of all over the country. According to this inventory approximately 0.8 % of the total historic c-OctaBDE production (approx. 100,000 tons) is present in stocks and waste in Nigeria. Also a preliminary POP-PBDE inventory for the transport sector focusing on end-of-life vehicles in Nigeria was developed in this pilot study. In total approximately 275 tonnes of POP-PBDEs largely from application of PentaBDE in polyurethane foam from cars and busses. Therefore approximately 0.3 % of the total historic c-PentaBDE production (approx. 100,000 tons) is present in stocks and wastes in Nigeria. This study is presented in another paper at Dioxin 2012¹⁰.

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