Guidance for the inventory, of Hexabromocyclododecane (HBCD)

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The designations employed and the presentations in this guidance document are possible options, based on expert judgment, for the purpose of providing assistance to parties in undertaking inventories of hexabromocyclododecane, in its identification and substitution, in order to develop, revise and update national implementation plans under the Stockholm Convention. The Stockholm Convention Secretariat, UNEP or contributory organizations or individuals cannot be liable for misuse of the information contained in it. While reasonable efforts have been made to ensure that the contents of this publication is factually correct and properly referenced, the BRS Secretariats, UNEP, FAO or the UN do not accept responsibility for the accuracy or completeness of the contents and shall not be liable for any loss or damage that may be occasioned, directly or indirectly, through the use of, or reliance on, the contents of this publication, including its translation into languages other than English. If there is any inconsistency or conflict between the information contained in this non-binding guidance document and the Stockholm Convention on POPs, the text of the Convention takes precedence.

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Abbreviations and acronyms

ABS	Acrylonitrile-butadiene-styrene
ASR	Automotive shredder residue
BAT/BEP	Best available technologies/best environmental practices
BFR	Brominated flame retardant
c-PentaBDE	Commercial pentabromodiphenyl ether
c-OctaBDE	Commercial octabromodiphenyl ether
COP	Conference of Parties
CRT	Cathode ray tube
DecaBDE	Decabromodiphenyl ether
DSI	Detailed site investigation
EEE	Electrical and electronic equipment
ELV	End-of-life vehicle
EPS	Expanded polystyrene
ESM	Environmentally sound management
EU	European Union
GC/MS	Gas chromatography/mass spectrometry
HBB	Hexabromobiphenyl
HBCD	Hexabromocyclododecane
HIPS	High impact polystyrene
HS	Harmonized Commodity Description and Coding Systems
LCD	Liquid crystal display
LOI	Limiting oxygen index
MCV	Maximum concentration value
MFA	Material flow analysis
NGOs	Non-governmental organization
NIP	National implementation plan
IT	Information technology
PBB	Polybrominated biphenyl
PBDDs	Polybrominated dibenzo-p-dioxins
PBDEs	Polybrominated diphenyl ethers
PBDF	Polybrominated dibenzofurans
PC	Personal computer
PCBs	Polychlorinated biphenyls
PCNs	Polychlorinated naphthalenes
PCP	Pentachlorophenol
POPs	Persistent organic pollutants
POP-PBDEs	Persistent organic pollutants-polybrominated diphenyl ethers
PSI	Preliminary site investigation
PWB	Printed wiring/circuit board
SC	Stockholm Convention
SCCPs	Short chain chlorinated paraffins
SFA	Substance flow analysis
TV	Television
WEEE	Waste electrical and electronic equipment
XRF	X-ray fluorescence
XPS	Extruded polystyrene

1. Introduction

1.1. Hexabromocyclododecane (HBCD) in the Convention

In May 2013, the Conference of the Parties amended the Stockholm Convention on persistent organic pollutants (POPs) to add hexabromocyclododecane (HBCD) to Annex A, with specific exemption (decision SC-6/13; United Nations 2013). Pursuant to paragraph 4 of Article 21 of the Convention, the amendment was communicated by the depositary to all Parties and on 26 November 2014, one year after notification, the amendment listing HBCD in Annex A to the Stockholm Convention entered into force for most parties[1].

Like all POPs, this chemical possesses toxic properties, resists degradation, and bioaccumulates. It is transported through air, water and migratory species, across international boundaries and deposited far from their place of release, where it accumulates in terrestrial and aquatic ecosystems.

Parties to the Convention for which the amendments have entered into force have to meet the obligations under the Convention leading to the elimination of HBCD for the production and uses not exempted. Each Party that has registered for the exemption pursuant to Article 4 for the production and use of HBCD for expanded polystyrene and extruded polystyrene in buildings shall, as per Part VII of Annex A, take necessary measures to ensure that expanded polystyrene and extruded polystyrene containing HBCD can be easily identified by labelling or other means throughout its life cycle.

1.2. Purpose of the guidance

Under Article 7 of the Stockholm Convention, Parties are required to develop and endeavour to implement a plan for the implementation of their obligations under the Convention. This national implementation plan (NIP) has to be updated with information on how Parties, for which the amendments have entered in force, will address obligations arising from amendments to the Convention to list new chemicals, in accordance with decision SC-1/12 of the COP.

Under Article 15 of the Stockholm Convention, Parties are required to report to the Conferences of Parties on the measures they have taken to implement the provisions of this Convention and on the effectiveness of such measures in meeting the objectives of the Convention.

To develop effective strategies that can lead to the elimination of the HBCD and to the environmentally sound management of waste containing HBCD, Parties need to acquire a sound understanding of their national situation concerning this chemical. Such information can be obtained through an inventory of HBCD and materials containing HBCD. By decision SC-2/7 the Conference of the Parties recommended that Parties follow, as appropriate Phase II of the guidance for developing NIPs, entitled "Guidance for Developing a National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants" and if appropriate undertake inventories, not only of the existence of the new chemical, but also the institutional arrangements and infrastructure related to it. The establishment of inventories is thus an important element to consider when developing, revising or updating the NIPs.

For complying with the reporting requirements under Article 15 a range of information needs to be gathered, and therefore the information compiled in an inventory can play important role as information basis.

The main purpose of this document is to provide guidance to Parties of the Convention on the establishment of inventories of HBCD, listed under the Convention in 2013. This document can be of use to national focal points

[1] Amendments shall not enter into force for those Parties that have submitted a **notification** pursuant to the provisions of paragraph 3(b) of Article 22 of the Stockholm Convention. Also, in accordance with paragraph 4 of article 22, the amendment will not enter into force with respect to any Party that has made a **declaration** regarding the amendment to the Annexes in accordance with paragraph 4 of Article 25. Such Parties shall deposit their instruments of ratification regarding the amendment, in which case the amendment shall enter into force for the Party on the ninetieth (90) day after the date of deposit with the Depositary.

for the Convention, the coordinator of the NIP review and update process, and task teams responsible for establishing the inventory. It can also be of interest to other stakeholders concerned with the recycling and/or elimination of HBCD.
Article 6, paragraph 1 (a), of the Stockholm Convention requires each party to develop appropriate strategies for the identification of products and articles in use and wastes consisting of, containing or contaminated with POPs. The identification of HBCD wastes is the starting point for their effective environmentally sound management.

This document can be used in conjunction with Basel Convention documents providing guidance on identification strategies and inventory development in relation to persistent organic pollutants wastes and in particular HBCD wastes:

- General technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants (UNEP 2015a)
- Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with hexabromocyclododecane (UNEP 2015b)
- Methodological guide for the development of inventories of hazardous wastes and other wastes under the Basel Convention (UNEP 2015c).

Information on alternatives to HBCD are compiled in the *Draft guidance on best available techniques and best environmental practices for the production and use of hexabromocyclododecane listed with specific exemptions under the Stockholm Convention* (Secretariat of the Stockholm Convention 2017c) which could support the phase out of HBCD. More information on alternatives and assessment of alternatives is compiled in the publication "POPs in Articles and Phasing-Out Opportunities" (http://poppub.bcrc.cn/)

In response to Decision SC-7/10 with the request made by the Parties to continue updating of the guidance including on the basis of the comments received from Parties and others, thanks to the generous financial support from the European Union, the current guidance document was revised and updated incorporating such inputs.

1.3. Objectives of the inventory

The main objective of the inventory is to obtain information in support of the implementation of Party obligations in the Stockholm Convention. More specifically, such an inventory can serve to:

- Provide the basis for the development of a strategy in the NIP (i.e. identify the economic sectors that should be prioritized and the type of actions required for those sectors).
- Report to the Stockholm Convention COP on progress made to eliminate HBCD.
- Identify areas where financial or technical support is needed (when resources are limited, to fill the gaps in the inventory/fulfil the obligations of the Convention).

The information obtained about HBCD through such an inventory can include the following:

- Past and current uses/production of HBCD at the national level;
- Presence of products and articles containing HBCD in the consumer market;
- Flows (import/export) into a country of products and articles containing HBCD;
- Disposal practices for products and articles containing HBCD when they become wastes;
- Any chemical stockpiles;
- Import/export of HBCD containing waste (see UNEP 2015b);
- Existence of alternative flame retardants to HBCD (see Secretariat of Stockholm Convention 2017c);
- Potential contaminated sites.

Information collected on the above can provide broader understanding of the sources of HBCD, the extent of

their impact and the risks that they pose to human health and the environment in a country. The information can help Parties to evaluate whether they comply with obligations under the Convention regarding HBCD and identify areas where they need to develop effective strategies and action plans for managing the POP and for meeting the obligations. Information collected as part of the inventory can also provide a valuable basis for Parties to report to the COP on measures taken to implement the provisions of the Convention and the effectiveness of such measures (report under Article 15).

The inventory process is usually iterative. In establishing an inventory of HBCD for the first time, Parties will also identify resources and technical capacities needed to further improve the accuracy of their inventory.

1.4. Structure of the guidance

The guidance is divided into seven chapters.
Chapter 1 outlines the purpose of the guidance and the major objectives for undertaking an inventory.
Chapter 2 provides necessary background information on the HBCD for undertaking the inventory.
Chapter 3 outlines the five main steps involved in conducting a general inventory of HBCD. It also provides an overview of considerations that are important for planning the inventory and defining its scope.
Chapter 4 provides the guidance on inventory of HBCD production and import of HBCD.
Chapters 5 and 6 contain specific guidance for the two main sectors of concern for the inventory of HBCD: polystyrene foam insulation in the building/construction industry, packaging and other uses (chapter 5) and the application on textiles for different uses (chapter 6). These are the sectors in which HBCD have been predominantly used[2] and which are likely to be relevant for many countries.
Chapter 7 provides information on minor applications of HBCD that may be relevant for certain countries and gives some guidance on possible inventory approach.
Chapter 8 provides guidance on developing an inventory of potentially HBCD contaminated sites.

Annex A contains sample questionnaires for the major uses of HBCD in EPS/XPS (Annex A1) and in textiles (Annex A2) which can be used for gathering inventory information for these major (former) uses of HBCD. The questionnaires can be adjusted to suit national circumstances.

The key design and content features of this guidance are:

Step by step approach: The guidance is designed to provide a clear step-by-step and a tiered approach that can be followed and implemented by a wide variety of users. A five-step approach is provided for the overall inventory from the planning stage to the preparation of the inventory report (also see chapter 3). The tiered approach provides the opportunity to countries with different capabilities to develop an inventory according to their realities. More detailed and specific guidance on stakeholders, data collection and other points for key sectors can be found in chapters 5 to 7.

Questionnaires and reporting format: Additional information, such as the listing of HBCD, a sample questionnaire, and quality guidelines, is provided in Annexes A1 and A2.

[2] While the use in polystyrene is considerably higher compared to textiles (see chapter 2) the release and exposure from textiles is also relevant and was even considered higher in Europe (Swedish Chemical Agency 2006).

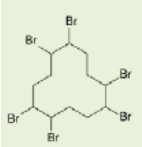
2. Background information on HBCD

2.1. Description of Characteristics of HBCD

Hexabromocyclododecane (HBCD) has a cycle ring structure with Br-atoms attached (see Table 2-1). As a commercially available brominated flame retardant, HBCD is lipophilic, with low water solubility and a high affinity to particulate matter. The molecular formula of the compound is $C_{12}H_{18}Br_6$ and its molecular weight is 641 g/mol. For commercial uses, HBCD usually has three stereoisomers, which consists of 70-95 % γ-HBCD and 3-30 % of α- and β-HBCD, while in theory 16 stereoisomers could be formed (Heeb et al. 2005).

Information about HBCD characteristics are shown in Table 2-1.

Table 2-1: Basic information of HBCD (European Commission 2008, ECHA 2009, UNEP 2010a)

Chemical Properties	**Characteristics of Chemical**
Chemical name (IUPAC)	Hexabromocyclododecane
Identification numbers (CAS number, EC number)	CAS No. 25637-99-4, 1,2,5,6,9,10-hexabromocyclododecane (CAS No: 3194-55-6) and its main diastereoisomers: alpha-Hexabromocyclododecane (CAS No: 134237-50-6); beta-hexabromocyclododecane (CAS No: 134237-51-7); and gamma-hexabromocyclododecane (CAS No: 134237-52-8)." EC number: 247-148-4
Molecular Formula and Structure (general) and molecular weight:	C12H18Br6 (641.7 g/mol) 
Names of the major diastereoisomers identified	alpha-hexabromocyclododecane (CAS No 134237-50-6) beta-hexabromocyclododecane (CAS No 134237-51-7) gamma-hexabromocyclododecane (CAS No 134237-52-8)
Trade name:	Cyclododecane, hexabromo; HBCD; Bromkal 73-6CD; Nikkafainon CG 1; Pyroguard F 800; Pyroguard SR 103; Pyroguard SR 103A; Pyrovatex 3887; Great Lakes CD-75P™; Great Lakes CD-75; Great Lakes CD75XF; Great Lakes CD75PC (compacted); Dead Sea Bromine Group Ground FR 1206 I-LM; Dead Sea Bromine Group Standard FR 1206 I-LM; Dead Sea Bromine Group Compacted FR 1206 I-CM.
Density	2.24 g/cm^3 to 2.38 g/cm^3
Auto flammability	Decomposes at >190 °C
Vapour pressure	6.3·10-5 Pa (21 °C)

2.2. Production of HBCD

HBCD has been on the world market since the late 1960s and is still being produced for use in EPS and XPS in buildings. It has been produced mainly in China, the European Union (EU), and the United States of America. The

total production of HBCD was estimated at around 31,000 tonnes in 2011, of which about 13,000 tonnes were produced in EU countries and in the United States, and 18,000 tonnes in China (UNEP/POPS/POPRC.7/19/Add.1, UNEP/POPS/POPRC.8/16/Add.3). For comparison, in 2001 demand for HBCD was 9,500-16,500 tonnes in Europe, 3,900 tonnes in Asia and 2,800 tonnes in North and South America (additional data are available in UNEP/POPS/POPRC.7/19/Add.1 and UNEP/POPS/POPRC.8/16/Add.3).
Since HBCD has been phase out in textile sector due to Convention obligations and alternatives for HBCD are available for EPS and XPS (Secretariat of the Stockholm Convention 2017c; ECHA 2009; USEPA 2014; Subsport 2013) the future production and use volumes might be expected to decrease in the future (ECHA 2009).

2.3. Uses of HBCD

HBCD is used as a flame retardant additive to reduce ignition of flammable polymers and textiles in buildings, vehicles or electrical and electronic equipment (EEE) (Table 2-2). The main uses of HBCD globally are in expanded and extruded polystyrene foam insulation while the use in textile applications and electric and electronic appliances is smaller (UNEP 2010a).
HBCD has been on the world market since the 1960s. The wider use of HBCD in insulation boards started in the 1980s (European Commission 2008).
The main application (90%) of HBCD is in polystyrene foam that is used in insulation boards, which are widely used in building and construction. Insulation boards with HBCD may also be found in transport vehicles, and in road and railway embankments (UNEP 2010a). These polystyrene foams exist in two forms, as expanded polystyrene (EPS) and extruded polystyrene (XPS) foams, with HBCD concentrations ranging from 0.5% to 2.5%. The manufacture of EPS, XPS and HIPS involves polymerisation and extrusion processes where HBCD is added in the process as one of the additives used (ECHA 2009).
HBCD is used in EPS filling in nursing pillows and bean bags used as easy chairs (UNEP 2010a).
The use of HBCD in EPS in packaging material is considered to be small (UNEP 2010a). However, a first screening of EPS including packaging materials in South Korea revealed that also some packaging material was treated with HBCD or contained recycled EPS/XPS (Rani et al. 2014).
It was assumed that HBCD is not used in food packaging according to the technical report developed in the EU (ECHA 2009). However in a first survey of PS food contact materials HBCD was also discovered in ice box and in fish tray (Rani et al. 2014). HBCD was also detected in water buoy at low levels which also indicate that they have been made from recycled EPS (Hong et al. 2013).

The second most important application is in polymer dispersion on cotton or cotton mixed with synthetic blends, in the back-coating of textiles where HBCD can be present in concentrations ranging from 2.2 – 4.3% (Kajiwara et al. 2009). Back-coating to textiles is applied by adding a dispersion containing a polymer and HBCD among other additives as a thin coating film (ECHA 2009). Treated textiles is mainly used in upholstery fabrics such as upholstery in residential and commercial furniture and vehicle seating upholstery, draperies and wall coverings, interior textiles (roller blinds) and automobile interior textiles (UNEP 2010a).

A further minor application of HBCD is in high impact polystyrene (HIPS).
HBCD-containing HIPS is used in electric and electronic appliances, such as in audio visual equipment cabinets, in refrigerator lining as well as in distribution boxes for electrical lines and certain wire and cable applications (UNEP 2010a).
HBCD may also be added to latex binders, adhesives and paints (Albemarle Corporation 2000, Great Lakes Chemical Corporation 2005).
The concentrations at which HBCD is used depend on the polymer it is used with and the fire safety requirements the product needs to meet (UNEP/POPS/POPRC.7/19/Add.1), resulting in regional differences in the use. In the EU the main use has been in XPS and EPS, and the uses in HIPS and in textiles are each estimated

at 2% (ECHA 2009). In Japan 80% of the consumption of HBCD was in insulation boards (including tatami mat) and 20% in textiles (Managaki et al. 2009).

Table 2-2: Overview of the production and application of HBCD and their release media into the environment (Based on UNEP/POPS/POPRC.6/13/Add.2 and UNEP/POPS/POPRC.7/19/Add.1) (UNEP 2015b)

Group	Source materials /Substance used	Applications /Processes	End Product	Release Media
HBCD CHEMICAL PRODUCTION				
Chemical Production	Cyclododecatriene, bromine	Chemical synthesis	HBCD chemical	• Solid waste • Water • Sludge • Air
HBCD MIXTURE PRODUCTION (Emptied packages of HBCD chemical have been identified as an important source of emissions among first-line users of HBCD and appropriate waste management has reduced emissions significantly				
HBCD mixture production	Styrene, pentane, HBCD and other additives	Production of flameretardant EPS raw materials	PS beads containing a blowing agent for EPS production	• Solid waste • Landfill leachate • Wastewater cleaning • Sludge • Air
	PS, HBCD and other additives	Production of flameretardant XPS HBCD masterbatches	HBCD masterbatch compound for XPS production	
	Surfactants, HBCD, antimony tri-oxide, acrylic adhesive	Production of flameretardant textile backcoatings	Textile back-coating mixture	
	Textiles, HBCD	Production of impregnated textiles	Flame-retardant textiles	
	Polymer, HBCD	Production of flameretardant yarn	Flame-retardant polymer for spinning into textile yarn	
	HIPS pellets, HBCD antimony trioxide,	HIPS	Flame-retardant HIPS pellets	
		Styrene-acrylonitrile plastics	Styrene-acrylonitrile resins	
			HBCD packaging	
		Production of adhesives and paints	Adhesives, paints	
			HBCD packaging	
PRODUCTION OF ARTICLES CONTAINING HBCD (The boxes below include articles that have become wastes. Such wastes may also be generated at production sites, such as leftovers, cutting waste, etc.)				
XPS articles	XPS masterbatches or PS, HBCD and other additives (including blowing agents such as CO_2)	Expansion and Extrusion	Flame-retardant XPS insulation boards: Cold bridge insulation Floors Basement walls and foundations Inverted roofs Ceilings Cavity insulation Composite panels and laminates	• Solid waste • Landfill leachate • Liquid industrial and household cleaning waste • Wastewater • Sludge • Air

EPS articles	EPS beads	Expansion and molding	Flame-retardant EPS insulation, including insulation boards: - Flat roof insulation; pitched roof insulation; floor insulation 'slab-onground' insulation - Insulated concrete floor systems - Interior wall insulation with gypsum board ("doublage") - Exterior wall insulation or ETICS (External Insulated Composite Systems) - Cavity wall insulation boards - Cavity wall insulation loose fill - Insulated concrete forms (ICF) - Foundation systems and other void forming systems - Load bearing foundation applications - Core material for EPS used in sandwich and stressed skin panels (metal and wood fibreboard) - Floor heating systems - Sound insulation in floating floors (to avoid transmission of contact sound) - EPS drainage boards	• Solid waste • Landfill leachate • Liquid industrial and household cleaning waste • Wastewater • Sludge • Air
			EPS concrete bricks, EPS concrete	
			Soil stability foam (for civil engineering use)	
			Seismic insulation	
			Packaging materials made of PS foams (normally not flame)[3]	
			Other molded EPS articles, such as ornaments, decorations, logos, etc.	
Textiles	Flame-retardant textiles (backcoating or fabrics)		Residential and commercial upholstered furniture	• Solid waste • Landfill leachate • Liquid industrial and household cleaning waste • Wastewater • Sludge • Air
			Transportation seating	
			Wall coverings and draperies	
			Protective clothing and other technical textiles	
			Tents etc.	
Electric and electronic equipment	HIPS pellets	Production of casings for electronic and electric equipment	Electric and electronic appliances	• Solid waste • Landfill leachate • Liquid industrial and household cleaning waste • Wastewater • Sludge • Air

[3] EPS packaging is not usually made of flame-retardant EPS unless specifically required or due to logistical reasons, e.g., when the only available EPS raw materials are flame-retardant.

2.4. HBCD stockpiles, recycling and waste flow

Due to the long service-life of products where HBCD has primarily been used, stockpiles and waste management represents a potential increasing source of HBCD releases to the environment. Planning for the current stocks in use and appropriate action towards waste streams will be essential in order to eliminate, reduce and control the environmental load of HBCD from waste management activities (see Figure 2-1).

Once buildings containing EPS/XPS insulation are demolished or articles containing HBCD treated textiles (e.g. vehicles, furniture), as well as plastic waste from electronics and others (see Figure 2-1; Table 2.2) are discarded, they become wastes. Also, by-products generated from the production of HBCD or the use of HBCD in production, such as residues generated during production or use processes. This might also include sludge containing HBCD generated from related waste water treatment and can hence also become a source of wastes containing HBCD. However the levels of HBCD in municipal sewage sludge without the impact of HBCD producing or using industries might be relatively low (Gorga et al. 2013; Xiang et al. 2015).

The major processes where HBCD containing wastes is generated are listed in Table 2-2 and are described in the *Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with Hexabromocyclododecane* developed in the frame of the Basel Convention (UNEP 2015). The Basel guidelines also list possible impacted categories according to Basel Convention categories. Waste generated along the life cycle of HBCD is described in Table 2-3.

Parties could use this as a reference to build a list of their own. The knowledge of end-of-life pathways is essential to the better understanding of target wastes identification and for appropriate environmentally sound management (ESM) of these wastes (see UNEP 2015b).

Wastes containing HBCD include production wastes, insulation boards, building and renovation wastes, and wastes from other applications such as WEEE plastics, textiles and transport vehicles. Insulation boards represent the majority of HBCD containing waste in particular for those countries using insulation for houses. The life span of polystyrene foam insulation in buildings is reported to be 30 to 50 years (ECHA 2009, Plastics Europe 2009, Posner et al. 2010; UNEP 2010a) and could exceed 100 years. The use of HBCD in insulation boards has been increasing since the 1980s, so it is likely that releases from EPS/XPS from waste materials will be more significant in the future; particularly from about 2025 onwards, when an increasing number of buildings containing HBCD will be refurbished or demolished (Li et al. 2016). Most of this material might go to landfill or incineration but a share is at least currently recycled (Rani et al. 2014; Hong et al 2013).-Article 6 paragraph 1 requires parties to take appropriate measures so that such wastes are disposed of in such a way that the persistent organic pollutant content is destroyed, irreversibly transformed or otherwise disposed of in an environmentally sound measure. One option to recycle the polymer might be the separation of HBCD from the polymer.

Exposure of workers to HBCD has been documented at an industrial plant producing expandable polystyrene (PS) or from cutting PS foam (European Commission 2008; Thomsen et al. 2007). Care needs to be taken also in the end-of-life phase regarding human exposure. E.g. there will be some releases of HBCD in dust when buildings with flame retarded insulation boards are demolished. In developing countries, electrical and electronic appliances containing HBCD and other toxic substances are often recycled under conditions which can result in a release of HBCD and other pollutants to the environment and hence to contamination of the sites with possible exposure to humans (Labunska et al. 2014; Tomko & McDonald 2013). Furthermore dump sites and open burning can be a common end-of-life treatment also for HBCD-containing articles including electronic waste.

Solid waste containing HBCD may be scrap materials generated during processing or shredding operations with related particulate releases. Particles might be also released through aging and wear of end products, and disposal of products at the end of their service life. Products and materials in landfill sites will be subject to weathering, releasing HBCD particulates or through leaching primarily to soil and sediments, and, to a lesser extent, to water and air (ECHA 2009, Environment Canada 2010; Remberger et al. 2004). There is little information on the quantities of HBCD in landfill leachates. The presence of surfactants can result in increased

leaching of otherwise low water soluble POPs (Sakai et al. 2000). For incineration the release of HBCD and by-products such as polybrominated dibenzo-p-dioxins and dibenzofurans (PBDD/PBDF) are low for state of art incinerators while they might be high for other incinerators and open burning (Mark et al. 2015; Takigami et al. 2014; Weber & Kuch 2003).

Article 6, paragraph 2 of the Stockholm Convention mandates its Parties to cooperate closely with the appropriate bodies of the Basel Convention on Control of Transboundary Movements of Hazardous Wastes and their Disposal. The Basel COP mandated by its decision BC-11/3, to update the general technical guidelines and the preparation or updating of specific technical guidelines with regard to the chemicals listed in Annexes A, B and C to the Stockholm Convention. In this frame a "T*echnical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with hexabromocyclododecane (HBCD)"* was developed and provide guidance for the environmentally sound management (ESM) of related wastes (UNEP 2015).

For some countries material/substance flow analysis (MFA/SFA) for HBCD and/or other BFRs in materials have been conducted including the assessment of end-of-life (Figure 2.1) which is considered a comprehensive approach for an overview on the life cycle of materials and chemicals and related inventory efforts (European Environmental Agency 2007) and have been applied for HBCD or POP-PBDEs (Babayemi et al. 2016, 2014; Li et al. 2016; Managaki et al. 2009; Morf et al. 2008).

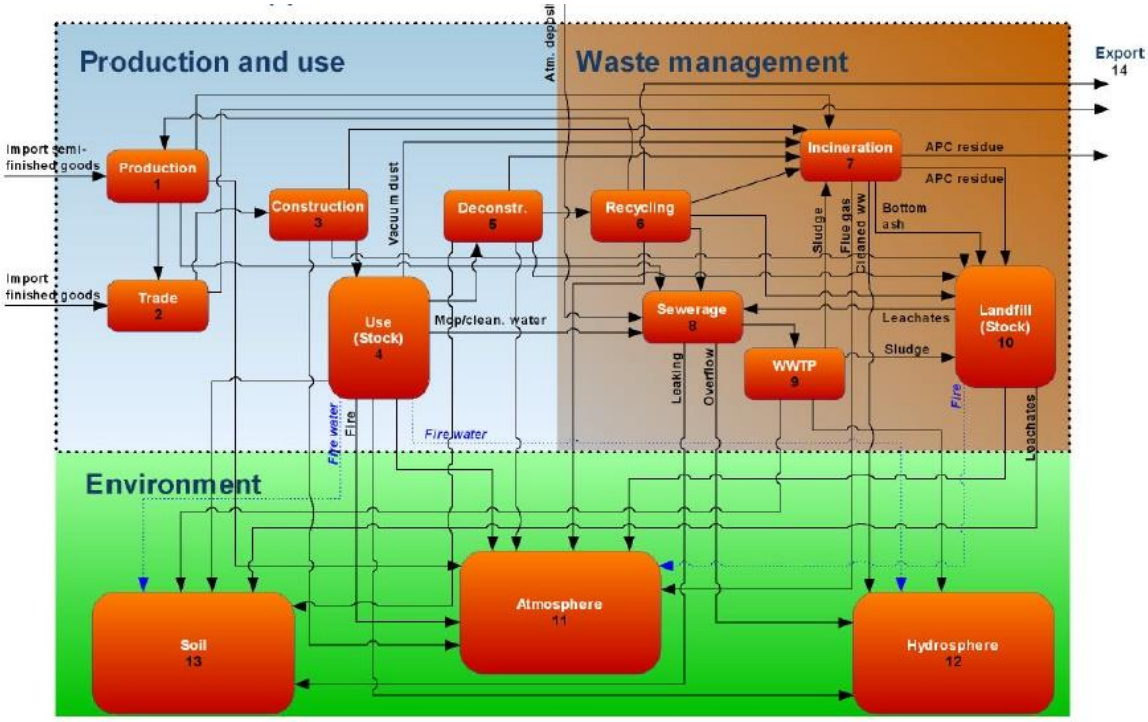


Figure 2-1: Material and substance flow of HBCD in construction and impacted materials in production/use and waste management and related releases to the environment (Morf et al. 2008)

Table 2-3: Source and release of HBCD and its by-products to the environment in the life cycle

Source	Released media	Examples of waste types	Contaminants
1. HBCD Manufacture			
1.1. Production process	Solid waste, off-gas, waste water	Dusts, products residues, wastewater treatment sludge, waste products, discarded waste filter cloth, wastes from filtration	HBCD
1.2. Products and packaging process	Solid waste (Dust) particles	Waste products, packaging wastes	HBCD
2. HBCD use (Process)			

Source	Released media	Examples of waste types	Contaminants
2.1. Building materials production	Waste gas, waste water and solid waste	Dust, production residue, wastewater sludge, waste products, packaging wastes	HBCD
2.2. Textile production	Waste gas, waste water and solid waste	Dust, production residue, wastewater sludge, waste products and packaging, wastes clothing	HBCD
2.3. Production of High Impact Polystyrene (HIPS)	Waste gas, waste water and solid waste	Dust, waste residue and sludge, waste products and packaging wastes	HBCD
2.4. Minor uses	Waste gas, waste water and solid waste	Dust, production residue, wastewater sludge, waste products and packaging wastes	HBCD
3. Consumer Use			
3.1. Leaching and evaporation from products	Waste gas, waste water and solid waste	Dust/particles, waste residue	HBCD
3.2. Fires	Waste gas, waste water and solid waste	Waste residues, contaminated soil, contaminated sites	HBCD and PBDD/PBDF
4. Waste recycling and disposal			
4.1. Building material waste recycling	solid waste	HBCD containing EPS and XPS; wastes from recycling or from separation of HBCD from polymer	HBCD and other chemicals
4.2. Waste plastic recycling	solid waste	Waste HIPS, and other plastics Electrical and electronic plastic shells, circuit boards, wire and polyurethane foams which will not be recycled after dismantling	HBCD and other chemicals
4.3. Incineration	Exhaust, Solid Waste, Wastewater	Solid residues (ash, flue gas cleaning residues); Exhaust gas	HBCD and PBDD/PBDF*
4.4. Landfill	Solid waste and Leachate; air releases (fires)	Leachates; fumes from open burning	HBCD and other chemicals; PBDD/PBDF

* The quality of incineration determines the levels of HBCD and PBDD/PBDF with low levels in state of art incinerators (Mark et al. 2015; Weber & Kuch 2003).

2.5. Potentially HBCD contaminated sites

All sites where HBCD have been produced or used, for any of the activities outlined in sections 2.2 to 2.4, could be potentially contaminated with HBCD. For some HBCD productions and also for industrial operations using HBCD such contamination has been documented (Allchin & Morris 2003; Morris et al. 2004; Li et al. 2012, Rüdel et al. 2012; Eljarrat et al. 2005; Eljarrat et al. 2011; Remberger et al. 2004; Sellstroem et al. 1998; Zhang et al. 2013).

Also landfills where HBCD containing wastes have been landfilled can be considered similarly with related releases in leachates (Remberger et al. 2004). There is little information on the quantities of HBCD in landfill leachates. The presence of surfactants can result in increased leaching of otherwise low water soluble POPs (Sakai et al. 2000).

Users of this guidance document can utilize the information provided in chapters 8 for developing an inventory

on potentially HBCD contaminated sites (as well as considering information from chapter 3 to 7). The inventory will identify all the sectors involved in the life cycle of HBCD, manufacturing locations and locations of uses and storage, wastes being disposed as well as methods and locations of waste disposal and treatment. Also investigating general and hazardous solid waste practices in their countries will contribute to an inventory of contaminated sites.

3. How to conduct a HBCD inventory

This chapter outlines five broad steps for planning and carrying out a national HBCD inventory. The national focal point of the Stockholm Convention or national project coordinator could be responsible for initiating the inventory process. The existing Steering Committee on POPs that was formed for the original NIP development could be re-established for updating the NIP and become involved in the planning of the inventory.

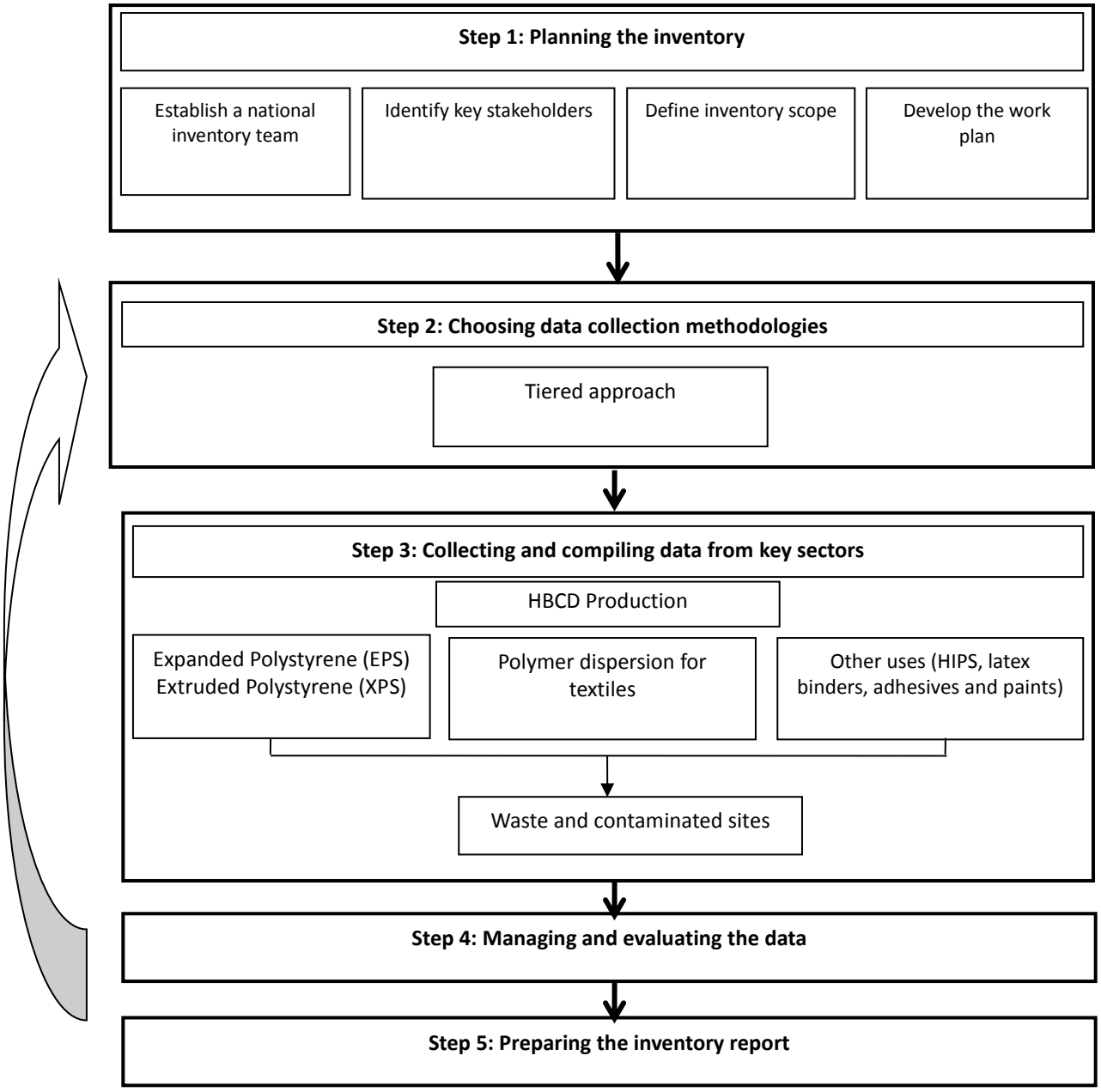


Figure 3-1: Overview of the national HBCD inventory development process.

The inventory process might not be conducted in an entirely linear fashion. The inventory team may need to repeat certain activities in earlier steps depending on how the inventory proceeds and which sectors are

involved. For example, although the identification of stakeholders is shown in step 1 (figure 3-1), there may also be a need to identify additional stakeholders at different points during data collection in step 3.
The arrow going from step 4 (Managing and evaluating the data) back to step 2 (Choosing data collection methodologies) in figure 3-1 indicates that steps 2 to 4 can be repeated until the data quality and coverage of the inventory reach a satisfactory level.
The inventory team will decide on the complexity of the methodology as appropriate for their particular situations, taking into account their financial and technical capabilities. For a number of countries, it could be evident at the beginning of the process that a complex monitoring (within a Tier III approach) (see section 3.2) would be out of reach. Others could decide after evaluating the results of the initial inventory to undertake more in-depth data collection (and move to a higher tier) in the future, including such activities as a task within the action plan in their NIP.

3.1. Step 1: Planning the inventory

The first issue to consider in developing a national inventory is to define the scope of the inventory and target the national relevant sectors for HBCD. Since more than 90% of HBCD has been used in EPS/XPS with major use in construction which has also been exempted, the related inventory development would be one priority.
The development of a national inventory of products and articles containing HBCD requires cooperation with the relevant authorities in charge of manufacturers of HBCD and manufacturers, users, suppliers and retailers.
Furthermore the customs services, other relevant authorities and organizations might be included as stakeholders. It is important to clearly define the responsibilities for developing the inventory. Parties are advised to establish a multi-stakeholder national inventory team for the task.

3.1.1. Establish a national inventory team

The national focal point of the Stockholm Convention could establish and/or lead a multi-stakeholder national inventory team to acquire the necessary competences and access to the relevant inventory information. The inventory of HBCD can be combined with the inventory of other POPs when certain sectors (i.e. WEEE plastic, transport sector, construction, furniture and textiles) are likely to be the same. If such a POP inventory has already been developed then selected members of this inventory team with some additional members and stakeholders might compile the HBCD inventory. Such a team would comprise among others government ministries with a mandate for chemicals and waste management, the national customs service, the private sector, non-governmental organizations (NGOs), and academics and researchers from universities and research institutes working on old and new POPs, waste management and possibly material flows, among others (see table 3-1). National POP or waste management consultants and material flow experts, knowledgeable in these issues, could also be engaged to facilitate the work of the team.
The national focal point and/or the consultants would brief and educate the team on the Stockholm Convention's mandates, its obligations and the new POPs.

3.1.2. Identify key stakeholders

The first meeting of the national inventory team provides the opportunity to assess the available information in the various stakeholder organizations and to debate on how to best proceed with the inventory exercise.
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The inventory development requires cooperation between relevant government authorities and official agencies, producers, importers and distributors, manufacturers, fabricators, community-based organizations and NGOs, organized labour and trade unions, industrial enterprises, other private-sector organizations, the waste

management and the recycling sectors, and users and owners of articles possibly containing HBCD. Representatives from the key sectors could be included in the inventory team, while others could simply be asked to provide data/information.

Due to the major use and potential continuing use of HBCD in EPS/XPS insulation foam (chapter 4) the related potential stakeholders (see table 3.1) would be contacted in an early stage to get an initial idea of the relevance of this use in the country. The use of insulation foams might have less relevance in countries in hot climate. However due to activities of energy saving in buildings also these countries might have started the use of insulation foams.

Also for the minor use of HBCD in textiles (chapter 5) potential stakeholders would be contacted in an early phase. Since the HBCD use has largely phase out in the textile industry in recent years, in particular the historic use in the textile sector and treated textiles in use would be a major target.

Table 3-1: Sectors and stakeholders involved in the use or impact of HBCD (indicative list)

Use	Stakeholders
For all uses	• **Ministry of Environment;** • **Ministry responsible for waste management;** • **Ministry of Industry** • **Ministry of Labour** • **NIP coordinator and steering committee;** • **Basel Convention focal point (and stakeholders in Basel);** • **Customs authorities;** • **Authorities in charge with fire safety requirements** and official agencies**;** • **Industry producing HBCD or importing/exporting HBCD** • **NGOs working on POPs wastes; NGOs working on POPs;**
Expanded Polystyrene (EPS) Extruded Polystyrene (XPS) in construction and buildings and in packaging	• Authorities granting construction permits; • Industry producing EPS and XPS and related associations; • Construction industry (in particular related to insulation); • Importers and exporters of HBCD containing articles/products; • Importers and exporters of HBCD waste; • Retailers of insulation boards; • Potential recyclers of HBCD containing articles/products; • Other relevant stakeholders in the country.
Polymer dispersion for textiles in treated applications (minor use)	• Association of importers and exporters of impregnated textiles; • Retailers of impregnated textiles; • University groups working on textile material flows; • Other relevant stakeholders in the country.
Other minor uses (HIPs, latex binders, adhesives and paints)	• Importers and exporters of electric and electronic appliances, adhesives and paints; • Retailers of electric and electronic appliances, adhesives and paints; • Other relevant stakeholder in the country.
Contaminated sites	• Government organizations and impacted district/city • Producers of HBCD; • Manufacturers using or having used HBCD; • University or research institute working on contaminated sites; • Engineering offices specialized in contaminated sites; • Community-based organizations (CBOs) and NGOs; • Labour and trade unions;

Making preliminary contact

Making contact with stakeholders at the beginning of the inventory exercise can give them a better understanding of the background, scope and objectives and provide them with an opportunity to exchange their

views and questions. This initial feedback can contribute to making the inventory more effective by targeting the relevant areas of national use.

General tools that can be used to identify and contact stakeholders (Face-to-face interviews; telephone interviews; Postal communication, mail/Web-based information sourcing, national registers).

Consulting with a small number of relevant stakeholders

During the inventory planning stage, it may be more efficient to contact and consult only a small number of relevant stakeholders such as manufacturers of HBCD and EPS/XPS and other (former) HBCD users, national industrial associations dealing with insulation of buildings and construction and the customs service. Gap analyses conducted in the evaluation of the initial assessment or the preliminary inventory could result in the necessity to contact some of these stakeholders again to solicit more information or identify other stakeholders to be contacted to help fill in the information and data gaps.

Holding stakeholder group meetings

There may be a range of stakeholder groups involved depending on the use categories:

- Insulation (EPS/XPS) in building and construction,
- EPS packaging
- Performance textiles for transport sector, furniture and functional clothing (fire fighters, military),
- Electrical and electronics, transport,
- Management of related waste categories.

3.1.3. Define the scope of the inventory

Defining the scope of the inventory involves identifying the relevant national sectors to be investigated further. This can be achieved by consulting key stakeholders (see Table 3-1) and paying special attention to the use categories and life cycle stages discussed in chapter 2. Since the major uses of HBCD (sections 2.3) are polystyrene foam insulation in the building and construction industry, and polymer dispersion for textile back-coating on cotton or cotton mixed with synthetic blends, these two applications are likely to be the main targets of the inventory.

Main information to be collected includes:

- Past and current production and use of HBCD at the national level;
- HBCD containing articles in use (in particular EPS/XPS insulation and certain textile application);
- Presence of products and articles[4] containing HBCD on the consumer market;
- Flows (import/export) into a country of products and articles containing HBCD;
- Disposal practices for products and articles containing HBCD when they become wastes;
- Any chemical stockpiles;
- Import/export of HBCD containing waste;
- Alternative flame retardants to HBCD and alternative materials;
- Potentially contaminated sites.

The following criteria are important in defining the scope of the inventory:

- Obligations for HBCD under the Stockholm Convention (see chapter 1);
- Objectives of a HBCD inventory (see chapter1);

[4] Article is an object which during production is given a special shape, surface or design, which determines its function to a greater degree than does its chemical composition. UNEP uses in their “chemical in products” the expression product synonymously for articles. Under some legal frameworks specific definition for product might exist. In this guidance article and product is used as synonym.

- Existing resources and capacities;
- National priorities.

The extent and depth of the inventory can be defined by consulting the sections below on data methodology (section 3.2), data collection (section 3.3) and the tiered approaches described in chapters 4 to 8, whilst taking into account the resources needed for an inventory in the relevant national sectors by selecting the appropriate tier for the individual sector. Minor uses (chapter 7) should be considered in the inventory only if information indicates that those uses might be relevant and capacities and resources are available.

3.1.4. Develop the work plan

The core inventory team is expected to develop a work plan for the inventory, which can be discussed with the stakeholders. Key elements of the plan will include:

- Inventory strategy on what needs to be done to identify the sectors (see chapter 4, 5 and 6);
- Methodologies to be applied (see section 3.2);
- Activities needed and assignments;
- Resources allocation including responsibilities and budget;
- Timeline and milestones.

The inventory team may need to extend and revise the work plan as the inventory proceeds.

3.2. Step 2: Choosing data collection methodologies

The next step is to choose appropriate methodologies for data collection, using a tiered approach.

3.2.1. Tiered approach

The tiered approach to collecting data in a HBCD inventory is illustrated in figure 3-2. The suggested methodologies for data collection in the three tiers are described in section 3.2.1 and further described in each chapter related to the individual inventory sectors. This approach provides flexibility to a wide range of Parties with varying priorities and capacities. Each tier represents a level of methodological complexity. Moving from lower to higher tiers implies that a Party is opting for approaches which are progressively more demanding in terms of complexity and data requirements and, therefore more resources may be needed. Tier I methods usually rely on readily available statistics in combination with estimates for key parameters (provided in this guidance). Higher tiers methods involve more resource-intensive data collection activities and possibly country-specific measurements but should also yield more accurate results.

Parties should endeavour to use methods that provide a robust level of confidence, especially when for example the preliminary inventory concludes that HBCD could pose high human health and environmental risks in the country, and more accurate data are needed to prioritize risk reduction measures and estimate their costs, while making efficient use of available resources and taking into account available technical capacities. The initial assessment (tier I) provides the inventory team with a general understanding of where the problems may lie and, more importantly, which sectors require further investigation and addressing information gaps. The tier I outputs may be rather qualitative (section 3.2.1) or require (subsequent) verification. The (preliminary) inventory (tier II) applies on the major sectors and generates (semi)quantitative data. The in-depth inventory (tier III) uses in depth assessment and possibly include analytical measurement methods to obtain precise data on the relevant sectors.

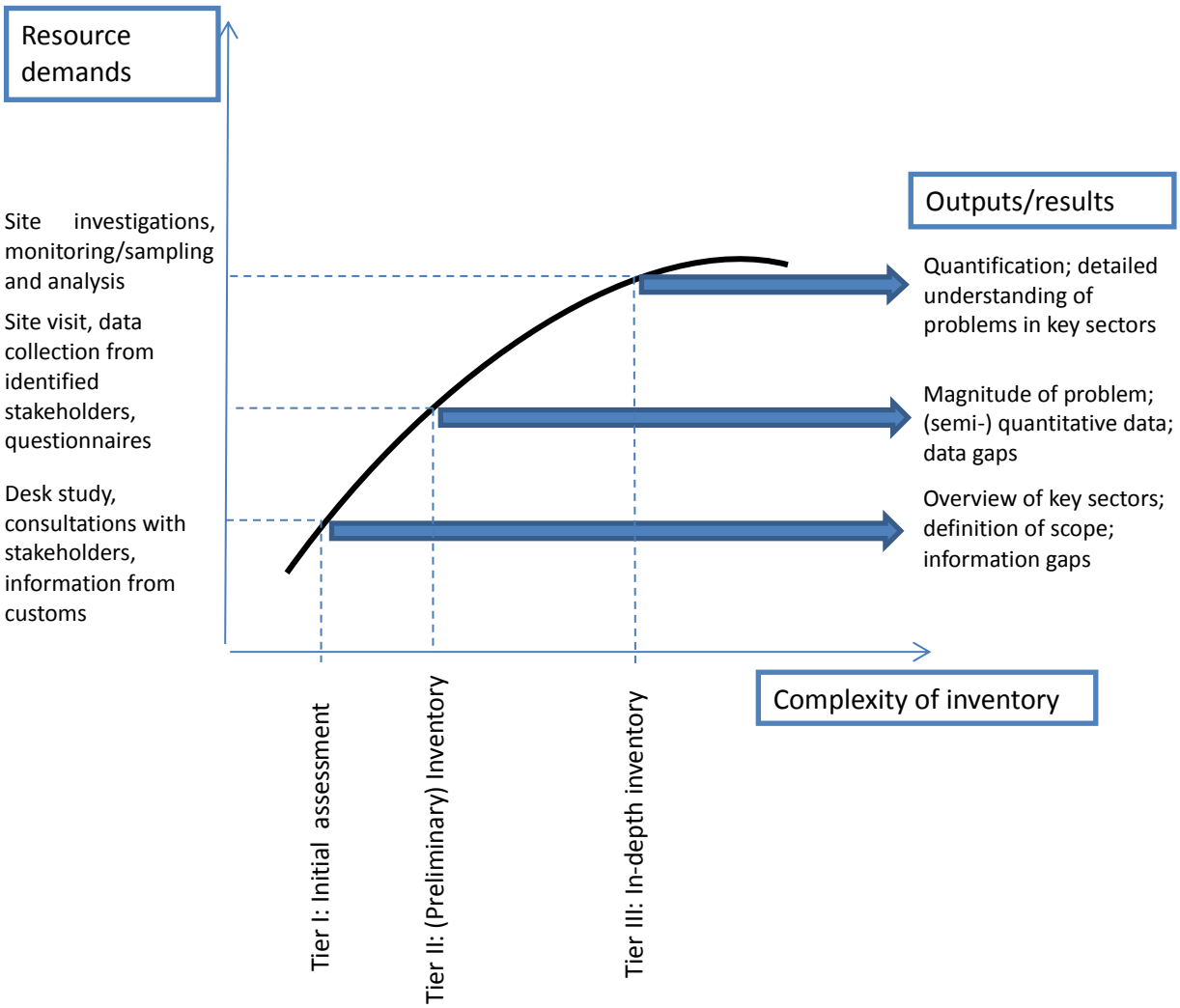

Figure 3-2: The tiered approach to the inventory of HBCD

Tier I: Initial assessment

The initial assessment generally relies on desk studies, interviews etc., i.e. methods that do not require expensive on-site visits or elaborate data collection activities (the team may decide to conduct the interviews on-site). First, the team gets an overview of the former use of HBCD in articles and waste/recycling flows:

- Production of HBCD (section 2.2.; Chapter 4);
- Use of HBCD (section 2.3: Chapter 5 to 7);
- HBCD in waste and recycling (section 2.4);
- Understanding the life cycle of HBCD and potential for emissions (Figure 2-1);

Next, the team collects information about existing past and present national data on the import and use of HBCD and articles containing HBCD from major stakeholders including:

- Ministry of Industry;
- Customs services, the National Bureau of Statistics and the National Central Bank;
- Industry sector associations (in particular EPS/XPS manufacturer; construction; textile);
- Published literature in scientific journals;
- Technical reports or notes, commissioned research reports and development assistance study reports;
- Desk study and online research;
- Responses to the inquiries and interviews.

The team may have to revisit step 1 to include other relevant stakeholders (or increase number of stakeholders in one category), redefine the original scope and refine the work plan before deciding to move on to the next tier.

Tier II: (Preliminary) Inventory

The preliminary inventory generally focuses on specific sectors, as shown in figure 3-2. It involves surveys and site visits to better estimate national data that were identified as missing in the initial assessment/Tier I.
Possible applications (Table 2-2) and target locations can be identified, followed by site visits including:

- Current and former production sites of HBCD;
- Users of HBCD and HBCD containing products;
- Waste collection centres and recyclers;
- Waste management facilities;
- End-of-life vehicles treatment facilities;
- Storage and disposal locations of materials containing HBCD.

Tier III: In-depth inventory

The in-depth inventory—may be undertaken if the preliminary inventory concludes that HBCD could pose high human health and environmental risks in the country and more accurate data are needed to prioritize risk reduction measures and to estimate their costs. Data collection within this tier relies on the use of analytical methods that may include monitoring using the X-ray fluorescence (XRF) screening and possibly additional measurements with instrumental analysis (see Guidance on screening POPs in products (Secretariat of the

Stockholm Convention 2017a). It may also involve detailed inspections of sites mentioned in tier II above and in the inventory chapters below.

3.2.2. Indicative, qualitative and quantitative methodologies

A number of different methodologies can be used for gathering information about HBCD. The methodologies can be divided into three groups:

- **Indicative method:** provides initial information for further planning of the inventory depending on the amount of resources (i.e. manpower and financial situation). This method is quick and does not require significant manpower and financial resources. Activities include desk research on existing information, workshops, and interviews. This method is normally used in the initial assessment.
- **Qualitative method**: might use questionnaires (see Annex A) or detailed literature surveys to obtain more specific data. Data management is based on estimations from known levels of quantities of HBCD used and total production volumes in production processes, and manufacture of products and articles. Workshops and interviews (and existing legal mechanisms) may also be helpful in obtaining data from the industry. This method is normally used in the initial assessment and preliminary inventory.
- **Quantitative method**: provides accurate and specific numerical information, but needs to be carried out by experts or involve experts in the relevant fields of HBCD usage and the sectors of investigation. This is an advanced stage of the inventory that includes detailed interviews with industry and associations where also questionnaires (Annex A) can support the survey and possibly site inspection.

  The quantitative methods might also use sampling and analysis for some areas where the extent of HBCD use is not known (e.g. EPS and XPS in packaging). Such investigations might be extensive and labour intensive. If screening technologies like X-ray fluorescence (XRF) equipment are available such investigations might not be costly, but XRF analysis is limited to the detection solely of bromine in products, without any capability to identify the type of brominated flame retardant (BFR) compound. Only if chemical analysis (GC/FID, GC/MS or HPLC/MS) is involved such an assessment would become expensive. These methods are normally used in the in-depth inventory.

Four approaches that can be used for data collection are discussed briefly in the next sections.

Desk study of existing information

The desk study involves gathering information about existing past and current national data on former production and use of HBCD, and on articles containing HBCD. This information can be obtained from the customs services, national bureau of statistics, and national central bank; published literature data in scientific journals, technical reports or notes from industry and industry associations, commissioned research reports, and Internet searches. The information should be collated, evaluated and verified if possible, and a gap analysis of the data could be undertaken as well. Such an approach is typically used in the Tier I assessment (see below).

National awareness raising/inventory workshop on Stockholm Convention and new POPs including HBCD

This national workshop involves major stakeholders from all sectors and groups in which products and articles containing HBCD have been used or are still being used. The importance of their cooperation in the inventory exercise to meet the Country's commitments to eliminate POPs would be emphasized to participants. If confidential business information is involved agreements should be reached with respective concerned parties such that the information required can obtained, and appropriately shared e.g., in aggregate (without specifying individual names) or in ranges. Breakout sessions and group meetings can be organized during the workshop to

ensure that all sectors in which HBCD has been used are adequately covered as well as to get consensus on how best to collect and compile data.

Questionnaire surveys

Questionnaire surveys might be valuable instruments for primary data collection in inventory programs. Based on preliminary contact and consultation meetings with stakeholders, questionnaires with explanatory notes can be developed and sent to the relevant stakeholders to gather the information needed to compile data for a Tier II or Tier III assessment (see below).

Questionnaires can be administered through various outreach mechanisms, including electronic distribution, postal distribution; supply chain distribution; distribution via trade unions, NGOs, local governments and community leaders. Questionnaires might also be used for one-on-one interviews or in the frame of a stakeholder workshop.

Site inspection, sampling and analysis

Samples of products and articles can be collected during on-site visits of relevant storage facilities, recycling locations, and waste disposal/storage facilities.

The screening and analysis of POPs and HBCD containing articles and products is described in the *Draft Guidance on Sampling, Screening and Analysis of Persistent Organic Pollutants in Products and Articles (*Secretariat of the Stockholm Convention 2017a). Parties may look to documented studies for examples: An initial screening of HBCD has e.g. been performed in Japan for curtains[5] (Kajiwara et al. 2008, 2009) and textiles in vehicles (Kajiwara et al. 2014). A preliminary monitoring of HBCD in EPS and XPS has been performed in South Korea for packaging (Rani et al. 2014) and for buoy (Hong et al. 2013) detecting HBCD at different levels[6].

3.3. Step 3: Collecting and compiling data from key sectors

The inventory team needs to investigate if the following activities exist in the country:

- Production of HBCD;
- Industries currently and formerly using HBCD;
- Products and articles containing HBCD in use such as: expanded and extruded polystyrene, polymer dispersion for textiles and other uses;
- HBCD in waste and how is managed;
- Articles containing HBCD that have been recycled, the possible extent of recycling, and the types of articles produced from recycling, including the life cycle of HBCD and its potential for emissions;
- Stockpiles and wastes from current and former production and use in industries (countries that produced/produce HBCD or used/use HBCD in industries);
- Sites/locations where activities have occurred that could have potentially contaminated the locations or wider environment with HBCD.

It is desirable to collect and compile the following numerical data in the inventory:

- Quantity of HBCD produced and used in history and quantity which is still produced and used in current newly manufactured products and articles including XPS and EPS in construction (exempted use) and in other non-exempted uses (packaging, textile, other uses);
- Quantities of HBCD present in articles and products such as in EPS and XPS in use in building and construction and possibly in packaging and other uses (e.g. furniture, buoy);
- Quantities of HBCD in use in textiles;

[5] The life span of quality curtains is more than 20 years (Wrey's 1997). Therefore HBCD in curtains treated the last decades are to a considerable share still in use.

[6] The levels were partly below HBCD levels used for flame retarding PS (Rani et al. 2014; Hong et al. 2013) indicating that some of the PS were produced from recycling.

- Possibly quantities of HBCD in use in other applications;
- Quantities of HBCD in stockpiles and wastes.

Data collection approaches will vary from country to country based on the data gathered in steps 1 and 2; these may be by estimations, using statistical data or possibly measurements. Estimations of HBCD quantities in a country for major HBCD former use sectors are provided in chapters 5 and 6. Measurements could be performed by analytical screening on representative samples (see Annex A below and the *Guidance on Screening and Analysis of POPs in Articles and Products (Secretariat of the Stockholm Convention 2017a)*).
The focal sectors to be investigated in the national inventory fall under five key areas:

- HBCD production and import (chapter 4);
- Building and construction sector (chapter 5);
- Textile sector (chapter 6);
- Minor uses such as in electrical and electronic equipment (EEE), paints, coatings and glue (chapter 7);
- Potential contaminated sites (chapter 8).

In addition, data collected for the first three key areas will form the basis for the preliminary inventory of the contaminated sites and hot spots.

3.4. Step 4: Managing and evaluating the data

3.4.1. Data management

Since Parties have different designs and levels of legal framework, political organization and economic support for environmental management, different methodologies will be applied in the data gathering process as described in section 3.2. The management of the collected data should be done as consistently and as transparently as possible. During the data processing, all the assumptions and conversion factors adopted as a result of expert judgment, where needed, should be noted/recorded and referenced when the results are presented.
Before the inventory starts, all the data formats including questionnaire survey formats should be determined to ensure the consistency of the data collection as much as possible. If some data conversions and estimations are done by stakeholders, the inventory team shall provide training on how to estimate the amount of HBCD and how to fill out the questionnaire. This will reduce the possibility of errors during the data management activities.
Estimations will be needed to provide the total quantities in a country. Estimations are a valuable tool for providing the data needed when resources are limited. Since direct measurements of HBCD in products and articles are resource intensive, a preliminary inventory could be fully based on estimations in many cases (see section 3.2). However, estimations should not be the method of choice when robust information can be gathered from industry and other stakeholders or direct measurements can deliver more accurate data.

3.4.2. Mechanism for evaluation of the inventory

Some challenges may still exist at the end of the inventory including a lack of detailed information on certain activities and applications. An evaluation of the process, strategy used and information collected can take place along with a decision on what further actions are needed to make the inventory more complete.
The evaluation includes identification of the following:

- Gaps and limitations;
- Need for validation of the information compiled in the inventory;

- Actions needed to meet the requirements of the Stockholm Convention.

Important elements in this evaluation step are to identify any gaps and limitations, and the measures needed to make the inventory more complete. Other ways to involve the stakeholders and other data collection strategies (see steps 2-4) could then be considered. A gap analysis in the evaluation of the initial assessment or preliminary inventory could result in the need to contact some of the stakeholders again to get more information or identify other stakeholders to be contacted to help fill the gaps.
For inventory sectors with limited information, information campaigns and stakeholder meetings or workshops may be a necessary measure. In some cases, government regulations may be required to ensure that stakeholders report their holdings, cooperate with the national authorities and engage in the national inventory. To be noted that drafting a regulation and making it come into force can sometimes require a long time (a year at a minimum in some places).

Gaps, limitations and necessary actions to complete the inventory will also be valuable information for the NIP, especially for developing countries with need of financial support for their inventory. It is important for developing countries to identify whether and what kind of technical and financial support will be necessary to complete the inventory. Even if the inventory is very incomplete, the NIP is expected to provide information on gaps and the limitations of a country's resources and capabilities — information that is useful to identify appropriate technical and financial needs.

It is also important to identify whether the current situation meets the requirements of the Convention, including the actions needed to fulfil the obligations in the NIP, i.e. elimination of HBCD without specific exemption or recycling of HBCD containing materials. Information on BAT/BEP measures will be needed. Information on the environmentally sound management of HBCD is provided in the *Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with hexabromocyclododecane* (UNEP 2015).

The inventory might also require revision at a later stage when the action plan is updated. This can also be done using the strategies described in this guidance.

3.5. Step 5: Preparing the inventory report

The final step for the inventory team is to prepare the HBCD inventory report. This report will include the inventories of all sectors investigated by the country (see chapters 4, 5, 6, and 7), but also information on potential contaminated sites (chapter 8) all compiled in a single document. Although its aim is to support the development of the NIP, the report, though there is no obligation, can also be used for other purposes such as feeding into Article 15 reporting, developing post NIP projects, and developing effective strategies and action plans for managing HBCD to meet the obligations under the Convention.
The essential elements of the report are:

- Objectives and scope;
- Remit of the inventory team;
- Description of data methodologies used and how data were gathered, including all the assumptions and conversion factors adopted as a result of expert judgment;
- Final results of the inventory for each sector considered a priority for the country (using a format to be provided in this guidance, as such or adapted from that format);
- Results of the gap analysis and limitations identified for completion of the inventory;
- Further actions (e.g. stakeholder involvement, data collection strategies) to be taken to complete the inventory and recommendations.

Other information (e.g. stakeholder list) could be included in the report depending on the national requirements.

4. Production and import/export of HBCD

4.1. Production of HBCD

Parties to the Stockholm Convention shall prohibit and/or eliminate the production of HBCD, except if they have notified the Secretariat of their intention to use for the time-limited specific exemption for production and use of EPS and XPS in buildings, as provided in Annex A of the Convention. In addition, a number of countries might continue production of HBCD for any purpose until their ratification. Information on production of HBCD under the exemption and the status of parties' ratification of amendments can be found on the register for specific exemptions on the website of the Stockholm Convention (www.pops.int).

HBCD has been and is possibly still produced only in a few countries (China, the European Union and United States). Countries where HBCD production takes or took place would compile data on current (and historic) production and possibly current stockpiles, taking into account ruling to treat confidential business information.

Also information on the amount of production waste and the historic management and deposition of waste from these productions would be collected in the inventory.

Considering HBCD contamination has been detected around HBCD production sites (Li et al. 2012; Morris et al. 2004, Rüdel et al. 2012) during the inventory development information on contamination at and around production sites and/or associated landfills and surface water would also be gathered (see chapter 8 on contaminated sites).

The information to be gathered would include data on current and former production of HBCD and related exports. If available also the uses of the produced HBCD would be compiled. All relevant information would be included in the inventory report and selected information in the NIP.

4.2. Import and Export of HBCD

HBCD is often exported and imported as powder or pellets, as masterbatches, as HBCD containing EPS beads and high impact polystyrene (HIPS) pellets downstream into the production chain for the manufacturing of end-products for further professional use or sales to consumers (UNEP 2010a). Several imports of HBCD as a pure compound or in products have been reported within POPRC assessment: Canada (100-1,000 tonnes), Australia (<100 tonnes), Poland (500 tonnes), Romania (185 tonnes) (UNEP, 2010a).

Information on imports of HBCD might be available from custom services or HBCD using industries or related industry associations of HBCD using industries (in particular industries producing polystyrene insulation foam and packaging; textiles and EEE plastic materials). Here information would be gathered on current imports and on historic imports. When collecting the information on current/historic imports of HBCD also information on the related uses would be asked.

For information retrieval from customs, HS codes are normally not specific enough to gather information on a specific chemical or chemical in products/articles in import or export (Korucu et al. 2014). Therefore HS codes can currently not be utilized for assessing imports of HBCD or HBCD containing products or articles. For the pure chemical, CAS numbers and trade names might be useful for the search (see Table 2-1).

The information and detailed data on imports and exports of HBCD and the related HBCD containing materials would be compiled in the inventory report.

The information on the amount of imported HBCD can be compared with inventory data on the use of HBCD by the industry. Care should be taken that no double counting of imported HBCD and the further used HBCD in products manufactured by industry is done in the inventory process.

5. Inventory of HBCD in XPS and EPS

XPS and EPS have been the major uses of HBCD in the world market. The use of HBCD in XPS and EPS depends on the application and on the region. For example, in Western Europe approximately 70 % of this EPS is flame retarded while in East Europe about 99% of EPS in construction is flame retarded (Seppälä 2013).

5.1. Use of EPS and XPS and related HBCD uses

5.1.1. EPS and XPS in the construction sector

As described in Chapter 2, the major use of HBCD (approx. 90%) has been and is in EPS and XPS in the building and construction sector. Also insulation foam in buildings is the only use exempted in the Stockholm Convention (United Nations 2013). If HBCD continues to be used in insulation in buildings in a country (after registration for exemption) then the EPS/XPS containing HBCD needs to be easily identifiable by labelling or other means and separated from other EPS/XPS (considering Annex A, Part VII of the Stockholm Convention).

There is a large variety of uses in the construction sector (Table 2-2; Table 5-1). Depending on the flammability standards in a country and on production policies all or only some of these materials might be flame retarded. In some countries with flammability standards requirements, all EPS/XPS applications in construction require flame retardants (e.g. Germany, Netherland, UK). While e.g. Finland only require flame retardants in PS for wall and ceiling insulation, while PS in ground and frost insulation does not require flame retardants. In some other countries legislation does not require the use of flame retardant in PS in construction but other protection measures against fires (e.g. Sweden, Norway) (Seppäla 2013; Troitzsch 2008).

Therefore a first step of the inventory of the construction sector should clarify which specific EPS/XPS applications in the country are/have been in use (see table 2-2 and table 5-1) and in which of these applications HBCD is used or has been used. For these applications then the total historic use of the HBCD treated materials in construction would be compiled and the current stock of HBCD and related XPS/EPS in buildings and constructions calculated (see below). Total volumes of EPS/XPS use might be available from national statistics or from industry associations and related stakeholders.

HBCD is applied in EPS at a typical loading of 0.5 - 1.0 % by weight and in XPS at a typical loading of 0.8 – 2.5 % in XPS by weight (UNEP 2011). These concentrations can be applied when calculating the HBCD amount from the used insulation foam in the country. For an inventory also the total volume of XPS and EPS in current use would be noted since these are the materials which finally need to be addressed.

Table 5-1: EPS and XPS uses in buildings and construction (UNEP 2015b)

Type of PS	Uses
EPS	Flame-retarded EPS insulation, including: - Flat roof insulation - Pitched roof insulation - Floor insulation 'slab-on-ground' insulation - Insulated concrete floor systems - Interior wall insulation with gypsum board ('doublage') - Exterior wall insulation or ETICS (External Insulated Composite Systems) - Cavity wall insulation boards - Cavity wall insulation loose fill - Insulated concrete forms (ICF) - Foundation systems and other void forming systems - Load bearing foundation applications - Core material for EPS used in sandwich and stressed skin panels (metal

	and wood fibreboard) - Floor heating systems - Sound insulation in floating floors (to avoid transmission of contact sound) - EPS drainage boards
EPS	EPS concrete bricks, EPS concrete
EPS	Soil stability foam (for civil engineering use)
EPS	Seismic insulation
EPS	Packaging materials made of PS foams*
EPS	Other moulded EPS articles, such as ornaments, decorations, logos, etc.
XPS	- Flame-retarded XPS insulation boards: - Cold bridge insulation Floors - Basement walls and foundations - Inverted roofs; ceilings; cavity insulation - Composite panels and laminates

* EPS packaging is usually not made of flame retardant EPS unless specifically required or due to transportation and logistical reasons.

HBCD containing materials from construction in the waste and recycling flow

The largest use and stock of HBCD is found in various building and insulation materials in construction which will end up as waste. Therefore, the analysis of end-of-life issues related to insulation materials containing HBCD is given as an example since insulation boards will represent the majority of waste containing HBCD (Figure 2-1). The way in which a product is handled after use contributes to its environmental and human health impacts. There are several end-of-life pathways for insulation products including reuse, recycling, landfilling or incineration.

For insulation materials, the end-of-life scenario usually occurs when the building is refurbished, demolished, or even burned down. During demolition, HBCD may be released in the dust (European Commission 2008; Sall 2010). Today common demolition techniques include implosion with explosives, use of a crane and wrecking ball, or deconstruction of the structure (European Commission 2008). Construction and demolition debris will increase in future (Dajadian & Koch 2014; Monier et al. 2011). The amount of XPS and EPS insulation in construction and demolition waste is not known. In Europe, HBCD use in insulation began in the 1980s; with a service life of 30 to 50 years, the volume of waste containing HBCD is expected to increase after 2025, when buildings containing insulation flame retarded with HBCD are refurbished or demolished (Sall 2010). The waste management determines the releases into the environment (Figure 2-1; Table 2-3).

Additionally, in some cases, insulation used on or under the soil may be left in the environment after the use-phase. As such, polystyrene insulation may be used under parking decks, rails, roads, or exterior insulation of cellars (European Commission 2008). Insulation used for these purposes can remain in the ground after its intended use is over (European Commission 2008).

Granulated EPS waste is also used to improve the texture of agricultural and horticultural soil (UNEP 2010a). The share of HBCD containing EPS in this (recycling) application has not been reported or assessed.

5.1.2. EPS and XPS in packaging

Applications of polystyrene foam in packaging generally would not require the use of HBCD or other flame retardants (European Commission 2008). Therefore EPS packaging is not usually made of flame-retardant EPS unless specifically required or due to logistical reasons, e.g., when the only available EPS raw materials are flame-retardant (UNEP 2015b). First screening of XPS and EPS in an Asian country revealed the use and/or

recycling of HBCD containing EPS in packaging (Rani et al. 2014).For regions with high share of flame retardant use like in East Europe (99%) a particular risk for other EPS/XPS use (e.g. packaging) might exist.

Since the use of HBCD in packaging might be different in different regions, in a step of the inventory it needs to be clarified to what extent the packaging materials in a country or region contain HBCD for logistic and transportation reasons (i.e. because a formulator in the region only produces HBCD containing XPS and EPS) due to imports or to recycling of HBCD containing EPS or XPS into packaging.

5.1.3. XPS and EPS in furniture and nursing pillows

According to country information, HBCD treated XPS and EPS has also been minor used in furniture and nursing pillows (UNEP 2010a). The extent of this use has not been documented yet. Also it is not clear if all EPS and XPS used in furniture (e.g. child seat) or nursing pillows are flame retarded and if there are regional differences. Such information would be gathered by detailed interviews in the Tier II approach or by monitoring in a Tier III approach (see below).

5.1.4. EPS in ornaments and decoration

EPS is used for ornaments and decorations to some extent. If production activities or products are on the marked, an assessment if they contain HBCD would be made. In case they contain or contained HBCD these products would also be considered in the inventory.

5.1.5. EPS in disposable drinking cups and plates

EPS is used for disposable cups and dishes. As for packaging, HBCD is normally not used for this application. The use of HBCD in food contact materials is not allowed in a number of countries (e.g. EU, Japan, China, US). However since EPS and XPS is recycled also such products might become impacted. Therefore also for these uses the presence of HBCD might have to be assessed. Such information would however probably need a Tier III approach involving some monitoring and only be done by countries with respective capacity (however a XRF screening might be sufficient for such a screening (Schlummer et al. 2015).

5.1.6. Recycled PS plastic from EPS/XPS recycling

According to the Stockholm Convention provisions, the recycling of articles/products containing HBCD above the low POP limit is not exempted. However this may happen in the case of countries which are not Parties to the Convention or have not ratified the HBCD amendment.
A first screening of XPS and EPS in an Asian country has revealed the use and/or recycling of HBCD containing PS in packaging (Rani et al. 2008) and buoy (Hong et al. 2013)[7]..
In the packaging sector, depending on the presence or the absence of HBCD in the packaging the EPS/XPS can be further recycled. If some of the packaging in the country contains HBCD then it could be separated before recycling. Technologies for separation could be XRF screening ((Secretariat of the Stockholm Convention 2017a)). However simple XRF analysis is limited to the detection solely of bromine in polymers, without any capability to identify the type of brominated flame retardant (BFR) compound and need a specific XRF screening approach to describe between HBCD and brominated PS polymer (Schlummer et al. 2015)).
The industry has advanced by developing processes which may recycle EPS into polystyrene and achieve bromine recovery whilst destroying HBCD (Tange et al. 2016). In the example of HBCD containing polystyrene foam, such processes are expected to allow the recovery of approximately > 99.5% of used flame-retardant additive (http://www.creacycle.de/en/the-process.html; http://www.synbra.com/en/39/187/raw_materials.aspx).

[7] Buoy made from PSare abundantly used in aquaculture farms and along the coasts and could be a source of HBCD in the marine environment (Hong et al. 2013).

5.2. Step 1: Planning the inventory of HBCD in EPS/XPS and identifying stakeholders

This first step focuses on defining the scope of the inventory and developing a work plan (see section 3.1.).

Considering the information above, the inventory of HBCD in EPS and XPS is expected to address the following:

- HBCD in current EPS and XPS production for building & construction, packaging and furniture (depending on the legislative status);
  - HBCD containing EPS and XPS in use and stock in building and construction;
  - HBCD containing EPS and XPS in use and stock in packaging[8], furniture and other uses;
  - HBCD in EPS and XPS in recycling and end-of-life.

Appropriate members of the inventory task team need to be selected to conduct the inventory of this sector. Specific stakeholders for the inventory of HBCD are listed in Table 3-1 and are selected according to country situation. The inventory task team could be extended as appropriate. The NIP coordinator or task team leader can decide which stakeholders would be included in an inventory team and which stakeholders would just be contacted for an interview or with a questionnaire (A sample questionnaire for HBCD in EPS and XPS is provided in Annex B1).

5.3. Step 2 and 3: Choosing data collection methodologies and collecting data

5.3.1. Tier I: Initial assessment of HBCD in EPS and XPS

The aim of the initial assessment is to find out the possible uses and stockpiles of HBCD in the country. For this information it is appropriate to assess if any inventory data on XPS and EPS use in construction, packaging, furniture and other uses are already available in the country or in the region.

In the first step the inventory team can screen the available literature and information from the institution compiling national statistics, the national central bank, published literature in scientific journals, technical reports or communications from industry and industry associations, commissioned research reports, and internet searches. The information should be collated, evaluated and verified if possible, and a gap analysis of the data could be undertaken to feed as well into a Tier II assessment.

In a second step the inventory team could contact major stakeholders to get initial information if XPS and EPS are being used in the construction sector. Also the ministry of environment and the ministry in charge of industry and/or construction could be contacted and asked for available information.

Countries with very limited resources and capacities might decide to focus on the two major uses of HBCD (XPS/EPS in the construction and the textile sectors see chapter 6) in particular when considering that the use of HBCD in casings of electronics is already covered to some extent by the inventory of POP-PBDEs[9].

In Tier I also a first assessment of whether recycling activities of EPS and XPS are present in the country could be considered (e.g. by internet search or first contact to plastic association or major company).

If reasonable information on the total use of XPS and EPS in the country has been found by the Tier I survey then

[8] EPS packaging is not usually made of flame-retardant EPS unless specifically required or due to logistical reasons, e.g., when the only available EPS raw materials are flame-retardant.

[9] In WEEE plastic without specific separation, the POP-PBDEs are more relevant POPs pollutants compared to HBCD (Waeger et al. 2010). For addressing POP-PBDE in WEEE plastic currently full scale separation technologies can only separate bromine containing plastic from other plastic (Secretariat of the Stockholm Convention 2017b) which also would address the HBCD containing plastic. Developing countries (and most industrial countries) have only limited separation capacity for separating bromine containing WEEE plastic. However if a country has companies separating on different plastic types from WEEE then the HBCD in HIPS plastic could be addressed (see chapter 7).

a preliminary inventory of HBCD in this sector might be done by using the total volume of EPS and XPS in building & construction and the related HBCD contents (0.5 to 1.0 % for EPS and 0.8 to 2.5% for XPS). In the Tier I approach all EPS and XPS in construction might be considered flame retarded with HBCD for a first conservative estimate. However if information on the share of HBCD-free and of non HBCD containing EPS and/or XPS is available then this can be considered in the calculation.

5.3.2. Tier II: (Preliminary)[10] Inventory of HBCD in EPS and XPS

In the Tier II assessment detailed quantitative information on the current and overall use of XPS and EPS in the building and construction sector should be collected by gathering detailed information from the concerned industry sectors (EPS/XPS industry; construction industry), from industry associations, importers, retailers and other stakeholders. This activity would build on the information gathered in the Tier I assessment including the related gap analysis.

5.3.2.1. Gathering information and calculating the HBCD amount and related volumes of EPS/XPS in construction

The information gathered would include the amount of (potentially) HBCD containing XPS and EPS currently used in new buildings and construction for the respective inventory year and also the total amount of HBCD in current EPS/XPS use/stockpile in buildings and construction (considering that the use of HBCD in EPS and XPS started in the 1960s) (Potrykus et al. 2015). In the survey therefore detailed information would be needed on the historical use of HBCD in industry. Since the alternative flame retardants in XPS/EPS are only available since recently all flame retarded foam until 2014 can be considered to be treated with HBCD.

In the Tier II approach also the availability and use of XPS/EPS using alternative flame retardants and other materials approaches for fire safe insulation with EPS/XPS without flame retardants in construction (see e.g. Babrauskas et al. 2012) or other alternative materials (See chapter 9) is important to be compiled. This information will be also important to decide if an exemption of HBCD use in insulation in construction would be needed and would then be registered. In the in depth discussion with the construction sector this would be evaluated in detail with a possible time frame for HBCD phase out for new constructions considering that the specific exemption is only for 5 years and then the COP will decide based on requests.

With the information on the total amount of EPS and XPS present in building and construction in the country the total maximum amount of HBCD and volume of materials could be calculated. If information on the share of HBCD and non-HBCD treated EPS and XPS is used, this calculation can be further refined. As mentioned in Tier I, the total amounts of HBCD in XPS and EPS can be calculated (see Table 5-2) by using the total volumes of EPS and XPS in building and construction and the related HBCD contents (0.5 to 1.0 % for EPS and 0.8 to 2.5% for XPS) and the total volume of XPS in construction and the related HBCD content (0.8 to 2.5 %).

[10] Depending on the quality of information and the uncertainties the inventory developed in Tier II might become a robust inventory with sufficient information for further steps in this sector (action plan development) or the information has large gaps and might need to be called “preliminary”.

Table 5-2: Sample calculation of the amount of HBCD in EPS/XPS used and present in the construction sector

Total amount of EPS used in the construction sector	**HBCD content (weight - %)**	**Total amount of HBCD in EPS in the construction sector**
Amount of EPS* newly used in construction in the inventory year …….tonnes	0.5 to 1.0 %	Amount of EPS* used x 0.5 to 1.0 % = ……. tonnes of HBCD
Total amount of EPS* present in construction …….tonnes	0.5 to 1.0 %	Amount of EPS* used x 0.5 to 1.0 % = ……. tonnes of HBCD
Total amount of XPS* used in the construction sector	**HBCD content (weight-%)**	**Total amount of HBCD in XPS* in the construction sector**
Amount of XPS* newly used in construction in the inventory year …….tonnes	0.8 to 2.5 %	Amount of XPS* used x 0.8 to 2.5 % = ……. tonnes of HBCD
Total amount of XPS* present in construction ……. tonnes	0.8 to 2.5 %	Amount of XPS* used x 0.8 to 2.5% = ……. tonnes of HBCD

* If only a share of EPS or XPS in construction contains HBCD then only this share would be considered in the calculation of HBCD.

With the information of the current share of XPS/EPS in the construction sector using HBCD, the share of using alternative flame retardants and the share of EPS/XPS not treated with flame retardants the current amount of HBCD used in the inventory year can be calculated. In this survey it should be noted if the different EPS/XPS with and without HBCD can be distinguished and in particular how the HBCD containing foam is labelled for future identification and environmentally sound management.

Assessment and inventory of end-of-life management from EPS and XPS

Within Tier II it is also expected that the total volume of waste generated for the respective inventory year is assessed and calculated (see Table 5-3). Such information might also be available from statistics. Detailed information on the amount of HBCD treated EPS/XPS foam in the end-of-life management would be noted. These would include the amount of EPS/XPS from demolishing and refurbishing buildings as well as waste from new constructions and insulations. Also if there are companies producing EPS and XPS in the country the related waste would be included in the inventory.

In the detailed evaluation of the EPS/XPS in end-of-life also detailed information on the end-of-life management of HBCD containing XPS and EPS including recycling, reuse, treatment, destruction and disposal of HBCD containing EPS/XPS polymers would be gathered. Since recycling of HBCD containing EPS/XPS is not allowed according the Stockholm Convention listing (United Nations 2013), specific technologies might be needed for

material recycling of the polymers which destroy HBCD whilst achieving bromine recovery (Tange et al. 2016).[11] Also this information would be compiled in the inventory.

For the assessment of EPS/XPS generated in the future a rough validation could be carried out within Tier II by considering the current stock of EPS/XPS in buildings and a use of 30 to 50 years taking in account when the EPS/XPS have been applied. For a refined assessment a dynamic substance flow analysis could be developed (see Tier III) (European Environmental Agency 2007; Li et al. 2016).

In the discussions with the EPS and XPS producing and applying industries also any initial plan of these industries on managing the HBCD containing EPS/XPS stockpiles in the construction sector for the coming decades can be initially discussed for formulating an activity in the action plan.

Table 5-3: Sample Calculation of the amount of HBCD in EPS*/XPS* in end-of-life from the construction sector

Total amount of EPS entering the waste stream, in the inventory year	**HBCD content (weight-%)**	**Total amount of HBCD in EPS entering into the waste stream in the construction sector, in the inventory year**
Amount of EPS going to landfill Amount of EPS going into thermal treatment Amount of EPS going into recycling[5]	0.5 to 1.0 %	Amount of HBCD in EPS going to landfill x 0.5 to 1.0% = ……..tonnes of HBCD Amount of EPS going into thermal/ treatment x 0.5 to 1.0% = ……tonnes of HBCD Amount of EPS going into recycling[5] x 0.5 to 1.0% = ……..tonnes of HBCD
Total amount of XPS entering the waste stream, in inventory year	**HBCD content (weight-%)**	**Total amount of HBCD in XPS entering into the waste stream in the construction sector, in the inventory year**
Amount of XPS going to landfill Amount of XPS going into thermal treatment Amount of XPS going into recycling[5]	0.8 to 2.5 %	Amount of XPS going to landfill x 0.8 to 2.5% = ……..tonnes of HBCD Amount of XPS going into thermal/ treatment x 0.8 to 2.5 = ……tonnes of HBCD Amount of XPS going into recycling[5] x 0.8 to 2.5% = ……..tonnes of HBCD

*If it is not possible to assess EPS and XPS separately then a combined calculation for EPS/XPS might be conducted with a determined average HBCD content.

5.3.2.2. Gathering information and calculating the HBCD amount and related volumes of EPS/XPS in packaging and furniture

Within tier II information on the total volume of EPS used in packaging and in furniture (and possibly in disposable cups and dishes) would be gathered and compiled with related information on HBCD use and

[11] While recycling of HBCD containing waste is not allowed, there are technologies to separate HBCD and the polymer which might allow recycling of the polymer and appropriate end of life management of HBCD (e.g. http://www.creacycle.de/en/projects/recycling-of-expanded-poly-styrene-eps.html).

presence (see Table 5-4). For this information direct interviews or questionnaires would be used to collect information on the use and presence of HBCD in packaging, furniture and disposable cups and dishes with the related sectors (EPS/XPS industry, packaging industry, furniture industry and retailers). Since the use of HBCD in packaging is considered minor in most regions only a fraction of these EPS and XPS might contain HBCD. However monitoring revealed the use of HBCD containing EPS in packaging including food packaging (Rani et al 2014). For the XPS/EPS produced in the country or regions the presence or absence of HBCD can be initially assessed in Tier II by in-depth discussions with the producers and importers of EPS and XPS.

A large amount of EPS and XPS is normally imported with packaged goods. For these materials the assessment by interviews and questionnaires might be difficult and useful results might need some monitoring (see Tier III below). When chemical legislation is updated in respect to HBCD, the use and import of HBCD in EPS/XPS would be restricted for others than those listed in an exemption. Also the national legislation would be assessed and revised to stop package goods containing HBCD to be imported.

Depending on the presence or absence of HBCD in the packaging sector then this EPS/XPS can be further recycled. If some of the packaging in the country is known to contain HBCD then it should be separated before recycling. Technologies for separation could be XRF screening recognising that XRF analysis is limited to the detection of bromine in polymers, without capability to identify the type of brominated flame retardant (BFR) compound and need some additional approach for distinguishing HBCD and bromine containing polymer (Schlummer et al. 2015).

Also for EPS/XPS in furniture the presence of HBCD would determine the recyclability[12].

In these surveys also the end-of-life management of EPS and XPS in packaging and furniture would be assessed and documented.

Table 5-4: Sample Calculation of the HBCD amount in XPS and EPS in packaging in use and entering into the waste stream (an adapted table could be used for calculating HBCD in furniture)

Total amount of EPS in packaging, in the inventory year	**HBCD content in packaging (weight %)****	**Total amount of HBCD in EPS in packaging, in the inventory year**
Amount of EPS in packaging* in use Amount of EPS in packaging* entering the waste stream	To be determined through Tier II or by monitoring activities in Tier III	Amount of EPS in packaging* in use resp. amount of EPS in packaging entering the waste stream x x weight %** HBCD = …… tonnes of HBCD (in use) = ……tonnes of HBCD (entering waste stream)
Total amount of XPS in packaging, in inventory year	**HBCD content in packaging (weight %)****	**Total amount of HBCD in XPS in packaging* in the inventory year**
Amount of XPS in packaging* in use Amount of XPS in packaging* entering the waste stream	To be determined through Tier II or by monitoring activities during Tier III	Amount of XPS in packaging* in use resp. amount of XPS in packaging entering the waste stream x weight % HBCD* = …… tonnes of HBCD (in use) = ……tonnes of HBCD (entering waste stream)

* Or for furniture (this would be a separate calculation)

** This would include the share of HBCD impacted packaging and the average HBCD concentration in these packaging and would be described in the report

5.3.2.3. Gathering information and calculating the HBCD amount and related volumes of EPS/XPS in recycling and related waste

Paragraph 1(d)(iii) of Article 6 of the Convention requires each Party to take appropriate measures such that wastes consisting of, containing or contaminated with a chemical listed in Annex A, B or C are not permitted to be subjected to disposal operations that may lead to recovery, recycling, reclamation, direct reuse or alternative uses of persistent organic pollutants. Since not all EPS/XPS is treated with HBCD these untreated EPS/XPS can be recycled without restriction. Furthermore the separation of HBCD from EPS/XPS might become possible (see e.g. http://www.creacycle.de/en/the-process.html) and could possibly be used for the recycling of EPS containing HBCD and bromine recovery whilst destroying HBCD (Tange et al. 2016).

If recycling activities of EPS and XPS are present in the country then further assessment on the extent of EPS and XPS recycling would be performed by interviews with the respective industries and site visits. Here an assessment would be made if HBCD is likely present in recycling (e.g. if EPS/XPS insulation foam from construction is recycled) or if e.g. only EPS/XPS from packaging is recycled which might contain HBCD depending on the country (see Rani et al. 2014). Companies recycling EPS or XPS might already have measurements or might know the bromine content from screening, although such activities started only recently in a few countries.

All this information would be compiled in table 5-5. If from the recycling companies no information on HBCD or bromine content is available then a Tier III assessment with bromine screening or HBCD analysis might be needed to fill table 5-5 (see Tier III below and Annex A below).

Table 5-5: Listing of the amount of HBCD present in EPS* and XPS* in recycling and related wastes

EPS materials used in recycling (tonnes)	**HBCD present or absent and content (ppm)**	**Products made from recycling (tonnes)** **Related HBCD content (ppm)**	**Waste generated during recycling (tonnes)** **Related HBCD content (ppm)**
XPS materials used in recyling (tonnes)	**HBCD present or absent and content (ppm)**	**Products made from recycling (tonnes)** **Related HBCD content (ppm)**	**Waste generated during recycling (tonnes)** **Related HBCD content (ppm)**

5.3.3. Tier III: In-depth inventory of HBCD in XPS and EPS

The in-depth inventory can consist of a field survey with detailed assessment of the share of HBCD containing materials in the different applications. This might include the screening of XPS and EPS for bromine or HBCD (Schlummer et al. 2015).

As mentioned above the amount of HBCD use in packaging is not well documented with regional differences and an inventory of this sector might only lead to reasonable data by involving monitoring approaches. Such monitoring could be performed by screenings with handheld XRF equipment to screen the bromine content (see

e.g. *POP-PBDEs BAT/BEP Guidance*[12] (Secretariat of the Stockholm Convention 2017b) and *Draft Guidance on Screening and Analysis of POPs in Articles and Products*). Bromine positive samples of XPS/EPS (packaging and furniture and minor uses) can be considered to contain HBCD, since HBCD was until 2014 the main brominated flame retardant used in EPS and XPS. Handheld XRF equipment has been purchased by a range of developing countries in the frame of the NIP update and therefore also these countries would be able to do a national (or even regional) assessment.

Also not all EPS and XPS applications in buildings and construction might contain HBCD (see above chapter 5.1). Therefore the information gathered in Tier I and Tier II might have to be validated, confirmed or refined by XRF screening for bromine content of the different applications of EPS and XPS in the construction sector (see Table 5-1). Since currently HBCD is being substituted by other brominated flame retardants, the bromine screening of current newly used EPS and XPS in the construction sector might not be sufficient to determine the presence of HBCD. Because currently used EPS and XPS in construction bromine positive tested samples could either contain HBCD or the alternative bromine containing EPS/XPS systems. This would require further clarification with the producer or supplier. As listed in part VII of Annex A per decision 6/13, parties that have registered for the exemption to use HBCD in XPS and EPS in buildings shall take necessary measures to ensure that EPS and XPS insulation treated with HBCD can be easily identified by labelling or other means which currently might not already be implemented in all cases. However all of EPS and XPS which has been produced and used before 2014 and contain bromine is most likely containing HBCD since the alternative only recently entered into the market in larger scale.

In the Tier III screening also sensitive EPS uses such as food contact materials (e.g. disposable drinking cups and plates) might be screened for their bromine content. Bromine positive tested samples most probably would contain HBCD and might indicate recycling of HBCD-containing PS or use of HBCD treated EPS depending on the bromine content detected. For concentration of 5000 mg/kg and higher the HBCD most probably would stem from intentionally added HBCD, while concentrations of less than approx. 3000 mg/kg might indicate that these products have been produced from recycled EPS since the lowest amount of intentional added HBCD to EPS is considered 5000 mg/kg (0.5%) (Table 5-2 and Table 5-5; UNEP 2015b). Low HBCD content in EPS and XPS in sensitive uses has e.g. been detected in the study on EPS in packaging including food packaging indicating such recycling into sensitive uses (Rani et al. 2014).

The results of XRF screening would be described in the inventory report and shortly in the NIP report. After Tier III assessments have been done, the tables 5-2, 5-3 and 5-4 can be filled or refined (instead of using only the information from Tier II assessment).

Another possible Tier III approach could be the development of a material and substance flow analysis of HBCD containing EPS/XPS (see e.g. Li et al. 2016; Morf et al. 2007, 2008; Managaki et al. 2009). Material and substance flow analysis can support waste management and material recovery. Dynamic material and substance flow analysis can be used to predict the generation of waste volumes in future (see e.g. Li et al. 2016; Morf et al. 2007, 2008).

The inventory development of POP-PBDE in transport sector and in WEEE/EEE plastic in Nigeria from Basel Conventional Regional Center has shown that also developing countries are able to use the material and substance flow analysis approach in the frame of Stockholm Convention inventory development (Babayemi et al. 2012, 2014) using the free software for substance flow analysis from Vienna University (http://www.stan2web.net/). These or similar approaches could be considered in the development of an in-depth inventory.

[12] This draft guidance document is under revision in accordance with decision SC-6/10.

5.4. Step 4: Managing and evaluating data

In the data evaluation step the data need to be assessed for completeness and plausibility, possibly including a comparison with data from other countries in the region. Data gaps may (partly) be filled by extrapolation of available statistical data. If the quality of the data is considered unsatisfactory, additional data collection or screening (Tier III) might be undertaken.

When a country enhances the inventory of the EPS/XPS use over time, the data quality will become better and more reliable. Countries (or cities) might establish and update inventories of their buildings and construction sector for further waste management planning and overall material recovery planning purposes (e.g. for urban mining purpose; Brunner 2011; U.S. General Service Administration, 2015). This could result over time in robust sector inventories of buildings.

When developing a comprehensive inventory of contaminants in buildings, also other POPs contamination (PBDEs, PCBs, PCNs) and asbestos (see Wagner et al. 2014; Secretariat of the Stockholm Convention 2017d) should be considered. While this is beyond the scope of the HBCD inventory, it might be a useful strategy for the larger frame of assessment of POPs and relevant pollutants in buildings and construction).

If buildings with HBCD containing XPS/EPS are individually registered then this information could be managed in an appropriate national database (or at municipal level) on contaminants in buildings (together with other pollutants~~)~~ for further planning when buildings are demolished or refurbished. Such a database could be valuable for the (waste) management of construction and demolition waste (which will be a major waste flow in future for many countries). This could be made available to a governmental body responsible for waste and resource management (e.g. ministry of environment, ministry of industry or other responsible ministries) and possibly to the competent authority of the Basel Convention.

5.5. Step 5: Preparing the inventory report

The final information and data for HBCD use and presence in XPS and EPS in the country would be accompanied by the methodology used and the detailed calculations as well as assumptions made in the calculations as an audit trail in a separate chapter of the HBCD inventory report. All country-specific adjustments and estimates would be noted and described.

To provide an overview on the presence of HBCD at the national level, as well as on the amount of the HBCD impacted volumes of EPS/XPS materials and of packaging to be managed during the NIP implementation phase, the information which could be included in dedicated NIP paragraphs may include a brief summary on:

- Overall use of EPS/XPS in the building and construction sector and the amount of HBCD in these uses.
- Amount of (potentially) HBCD containing XPS and EPS currently used in new buildings and construction and availability and use of XPS/EPS using alternative flame retardants or other approaches for fire safety insulation in construction.
- Regulations on flammability standards in the country requiring and determining flame retardant use in the building and construction sector.
- Amount of HBCD in current EPS/XPS use/stockpile in buildings and construction (considering that the use of HBCD started in the1960s (Potrykus et al 2015)).
- Amount of HBCD impacted packaging materials.
- End of end-of-life management of HBCD containing XPS and EPS including reuse, recycling[13], treatment, destruction and disposal of HBCD containing EPS/XPS polymers. For compiling this information also consult the related Basel Convention guidelines (UNEP 2015)

While several of these pieces of information can be generated from a Tier I and Tier II inventory, some of the listed information might only be included if a Tier III inventory approach has been used.

Also further activities suggested for assessing and managing the use of HBCD in EPS and XPS would be included in the NIP.

[13] Please note that the recycling of HBCD containing materials is not exempted in the Stockholm Convention.

6. Inventory of HBCD in textiles

The second most important application of HBCD was in polymer dispersion on cotton or cotton mixed with synthetic blends or synthetic, in the back-coating of textiles (Table 2-2; UNEP 2010a). Since the use of HBCD in textiles is not exempted under the Convention, the major HBCD use can be assumed until approx. 2013/2014 and therefore textiles produced from 2015 onwards might not contain HBCD. The information on the phase out of HBCD in the textile should be gathered as basis for an appropriate inventory approach. HBCD might still be used in textiles in countries having not ratified the Stockholm Convention or which have not yet ratified the HBCD amendment and where industry have not yet switched to alternative flame retardants since Parties might have not yet set the respective regulatory frame. Other flame retardants have been used in textiles including POP-PBDEs (commercial PentaBDE) and decaBDE (recommended for listing but not yet included in the Convention, UNEP 2017a). Today other flame retardants are used.

While the total use volume of HBCD in textiles was considerably lower than for XPS/EPS, the environmental releases of these two applications were similar in Europe (ECHA 2009).

Back-coating to textiles is applied by adding a dispersion containing a polymer and HBCD among other additives as a thin coating film (ECHA 2009). The flame retardant can be introduced to the textile by impregnation/spraying or by spinning flame-retarded polymer into textile yarn.

HBCD can be present in flame retarded textiles at concentrations ranging from 2.2 % – 4.3 % (Kajiwara et al. 2009) or even up to 15 % (UNEP 2010a).

Textile applications for HBCD include (European Commission 2008; UNEP 2010a; UNEP 2015b):

- Residential and commercial upholstered furniture;
- Seating and other textile interior in transportation (trains, air planes, ships);
- Automobile interior textiles;
- Wall coverings and draperies;
- Interior textiles e.g. roller blinds and curtains;
- Bed mattress ticking;
- Protective clothing and other technical textiles;
- Tents;
- Other treated textiles.

The different textile applications treated the last approximate 40 years have partly already entered the end-of-life treatment and ended in landfills, incinerators and possibly in recycling. Due to the long lifetime of some of these uses (in transport seating; other automobile application, curtains, tents) a considerable share of these textiles might be still in use.

The application of flame retardants in textiles depends on the flammability standards in the respective country (Horrocks 2013; Shaw et al. 2010). Flammability standards define for which application specific material requirements in respect to ignitability is made which trigger the use of flame retardants and can determine which type of flame retardants are needed. For example the German DIN 4102/Class B1 standard can be fulfilled by the use of HBCD or other brominated flame retardants (Zinser 2009). These standards depend on the respective uses and are different in different countries or regions (Horrocks 2013; Shaw et al. 2010) and some have not been triggered by scientific evidence (Chicago Tribune 2012). Therefore textile-related fire regulations between different nations may offer an overall confusing picture in terms of the items regulated and the applications covered by them but, in general, regulations fall into one of several categories depending on whether they apply: to a normal consumer living in a domestic environment; a member of the public in a public environment (e.g., hotel, airport, public building (including hospitals and prisons)); in the workplace for worker

protection; for personal protection in the emergency and military services and in transport (Horrocks 2013).

It can be assumed that HBCD has been used until recently in major applications (for EPS and XPS see chapter 2.1 and chapter 5) including textiles and might still be used. Although it has been reported that the share of use in the textile sector has decreased the last years (UNEP 2010a) still significant volumes could be used in this application in some regions.

POP-PBDEs such as c-PentaBDE and DecaBDE (recommended for listing as POP but not yet included in the Convention) have been used in the textiles sector until recently (UNEP 2017a; Kajiwara et al. 2014). In the POP-PBDE inventory development, the textile sector was considered a minor application (Secretariat of the Stockholm Convention 2015). If textiles are addressed within the HBCD inventory then also the POP-PBDE could be addressed if this has not been done within the POP-PBDE inventory (Secretariat of the Stockholm Convention 2015)).

6.1. Uses of textiles possibly containing HBCD

6.1.1. HBCD use in textiles in transport seating and other textile/synthetics use in transport sector

Textiles in transport are, in general, associated with seating, floorcoverings, roof-lining fabrics and other furnishings within the vehicle or vessel interior (Horrocks 2013). In most of transport applications in which safety is an issue, there are national or international regulations that govern their fire-safety. Therefore materials which meet a defined required level of flame resistance or materials with flame retardants are used in different textile application in transport including public transport, air planes, ships and cars[14].

In aircraft, all internal textiles such as seating, internal décor and blankets require defined levels of flame or fire resistance to internationally recognized standard levels. Therefore particular flammability standards exists e.g. for airplanes (e.g. UK Civil and US Federal Aviation Authorities' requirement for fire-resistant seating materials in all passenger aircraft) (Horrocks 2013) with related flame retardant use. In a first monitoring study high levels of flame retardants (including HBCD) were detected in dust in commercial airplanes (Allen et al. 2013).

Also for railways a range of flammability standards on national or regional (e.g. European Directive 2008/57/EC) exist which require fire safety for materials used (Horrocks 2013). Therefore also for this transport sector HBCD (and other flame retardants) have most likely been used in relevant volumes. However there has not been any monitoring of HBCD in trains.

In the transport sector, HBCD, POP-PBDEs, decaBDE (recommended for listing in the convention (UNEP 2017a)) but also other flame retardants are used for different fabrics. Up to now only one specific screening of HBCD and PBDE in individual parts of cars has been conducted (in Japan) including HBCD (Kajiwara et al. 2014). In this study HBCD was detected in 50% of the analysed floor covering (n=4) but has not been detected in any of the analysed seat fabric (n=16) but instead PBDEs were detected in textiles[15] (Kajiwara et al. 2014). HBCD has also been detected in door trim fabrics in this study. The car manufacturer or the year of manufacture of the respective cars was not documented in this monitoring (Kajiwara et al. 2014).

Therefore it is not documented in detail for which textile applications in the transport sector HBCD has been mainly used and e.g. which car manufacturers have used HBCD for which years and until when HBCD was used in this application or if HBCD is still used in this sector e.g. in countries which have not yet ratified the amendment.

[14] The use of flame retardants in cars have been linked to the levels of PBDEs in human blood serum in a study in the US (Imm et al. 2009) and also the highest HBCD exposure in United Kingdom via dust were determined to cars (Abdallah & Harrad 2009).

[15] More than 60% of the bromine containing seat fabric contained PBDE as flame retardant (5500 to 78000 mg/kg) but it was not reported to which extent these were POP-PBDEs. In 6 of the 16 seat fabrics HBCD was detected at a concentration between 0.15 to 50 mg/kg (Kajiwara et al. 2014). These HBCD levels can be considered a secondary contamination (e.g. from related floor covering with up to 13,000 mg/kg HBCD). Such secondary indoor POP contamination has been well documented for PCBs (Bent et al. 2000).

Please note: HBCD is also used in insulation panels in transport sector and has likely been substituted 2013 to 2015 after alternatives flame retardants were available for polystyrene insulation.

6.1.2. HBCD use in textile applications used indoor

A range of textile application in residential homes, public buildings (including hospitals and prisons), air ports or hotels are flame retarded. This might include curtains, textile upholstery of furniture, bed mattress ticking, wall coverings and draperies (UNEP 2010a; Horrocks 2013). It has been concluded that indoor contamination with HBCD is a relevant exposure pathway to humans (Harrad et al. 2010b)[16].

Also for furniture application the national flammability standards (e.g. in the United States an UK) trigger the use of flame retardants, as documented for POP-PBDEs (Secretariat of the Stockholm Convention 2015; Shaw et al. 2010, Stapleton et al. 2012; Chicago Tribune 2012). Such national flammability standards most probably also trigger the use of HBCD or other flame retardants in such applications and would be assessed within the inventory.

Only a few studies on HBCD in home textiles have been performed. A preliminary screening of HBCD in curtains in Japan revealed a relevant use of HBCD in this application (Kajiwara et al. 2008, 2009). From 10 curtains tested positive for bromine, 9 curtains contained HBCD in a concentration between 2.2 % to 4.3 %. This revealed the high usage of HBCD in this application for this country or possibly region.

6.1.3. HBCD use in textile clothing

HBCD was also used in textile clothing but has most likely been phased out after the listing of HBCD in the Convention in 2013. In particular specific personal protective equipment (PPE) clothing (e.g. for fire fighter and military uniform; other technical textiles) can contain HBCD or other flame retardants.

Also for nightwear and other clothing flammability standards exist in some countries (e.g. British Standards (BS) 54 Update on Flame Retardant Textiles 5722) which have resulted in the use of flame retardants even in children sleepwear (Blum & Ames 1977). If and to which extent HBCD has been used in such private clothing has not been documented and the former use might be of lower relevance and be considered only for a Tier III inventory. Flammability standards do however not necessarily need the use of flame retardants but can be met by fibres with a high Limiting Oxygen Index (LOI) (e.g. wool has high resistance to flammability with an LOI of 25 (Adivarekar & Dasarwar 2010). . Also some standards require only the labelling of fire risk for clothing (e.g. in Australia or New Zealand Standards Association of Australia (2003), Australian Government 2007).

Table 6-1: Selected national and international nightwear fire regulations (Horrocks 2013)

Country	Regulation
UK	The Nightdress (Safety) Regulation, Statutory Instrument S.I. 839:1967 and The Nightwear (Safety) Regulations S.I. 2043:1985, HMSO, London, UK.
Netherlands	Netherlands The Nightwear (Safety) Regulations 1985; from 2008 all clothing must meet minimum burning requirements.
EU	EU General Product Safety Directive (2001/95/EC); European Standard (EN) 14878:2007. Textiles – Burning Behaviour of Children's Nightwear – Specification, 2007.
Unite States	USA Standard for the Flammability of Children's Sleepwear, Title 16, Code of Federal Regulations (CFR), 16 CFR Parts 1615 and 1616 (recodified from Department of Commerce to Consumer Product Safety Commission at 40 FR 59917, 30th December 1975). Standard for the Flammability of Clothing Textiles, 16 CFR 1610, 02/2007.
Australia and New Zealand	Australian Government: Trade Practices (Consumer Product Safety Standards) (Children's Nightwear and Paper Patterns for Children's Nightwear) Regulations 2007.

[16] An assessment of the temperature dependent emission rate of HBCD from a curtain showed measurable releases to air above 80 °C and the human exposure risk was considered small (Miyake et al. 2009). In this study the (long-term) releases of HBCD by the release of fibers and related exposure was however not considered and assessed.

	Product Safety Standards (Children's Nightwear and Limited Daywear Having Reduced Fire Hazard) Regulations, 2008 (declares AS/NZS 1249:2003 as the standard with variations stated in Amendment A 2008).

6.2. Step 1: Planning the inventory of HBCD in textile and identifying stakeholders

This first step focuses on defining the scope of the inventory and developing a work plan (see section 3.1.).

Considering the information above, inventory of HBCD in textiles is expected to address the following:

- HBCD in textile used in transport sector in current use and in related end-of-life;
- HBCD in textile used indoor in current use and in related end-of-life;
- HBCD in textile clothing in current use and in related end-of-life.

Appropriate members of the inventory task team would be selected to conduct the inventory of this sector. Specific stakeholders for the inventory of HBCD are listed in Table 3-1. The core inventory team could be extended as appropriate. The NIP coordinator or task team leader can decide which stakeholders would be included in an inventory team and which stakeholders would just be contacted for an interview or with a questionnaire.

6.3. Step 2 and 3: Choosing data collection methodologies and collecting data

6.3.1. Tier I: Initial assessment of HBCD in the textile sector

The aim of the initial assessment is to find out the possible uses and stockpiles of HBCD in the country. In this case it should be assessed whether information or inventory data on HBCD use in textiles are already available in the country and/or in the region.

In the first step the inventory team can screen the available literature and information from national statistic institutions, published literature in scientific journals, technical reports or notes from industry and industry associations, commissioned research reports, and internet searches.

In this step also an initial assessment of flammability standards for different applications in textiles (e.g. transport seating, curtains) would be compiled.

In a second step the inventory team could make first contact with major stakeholders to inform them that HBCD will not be allowed for use in these applications, as well as to obtain initial information on whether HBCD has been used or is still being used in the textile sector. Also the ministries of environment and ministry in charge of industry could be contacted and asked for available information.

The first compilation of information on the use of HBCD in the textile sector in the country (or region) or information on certain possibly impacted textile applications that has been found present in the country by the Tier I survey could result in a preliminary or robust list of applications and products which might contain or probably contain HBCD in textiles. But this assessment will be rather qualitative. In this stage the information might not be sufficient to do any quantitative estimate on the share of different applications impacted or possibly impacted by HBCD and therefore the amount of HBCD used.

For some applications a first rough estimate might be conducted on e.g. the total volume of textiles in the transport sector or textiles from certain protective clothing (fire fighters or military) or specific applications (e.g. curtains) to get the order of volume magnitude of this application. However in Tier II and Tier III further information might be gathered on potential use of HBCD in textiles to estimate the share of HBCD treated products and articles in the respective sector. This assessment on total volume can also lead to a prioritization of efforts in Tier II and possibly Tier III.

The information should be collated, evaluated and verified where possible, and a gap analysis of the information would be undertaken to feed into Tier II assessment.

6.3.2. Tier II: (Preliminary)[17] Inventory of HBCD in textile applications

In Tier II assessment semi-quantitative information and for some application possibly quantitative information on the current and historic use of HBCD in the textile sector in the country should be compiled by gathering detailed information from industries producing the products and articles (textile industry; furniture industry, car and other transport industry), from related industry associations, importers, retailers and other stakeholders with related information. This would build on the information gathered in the Tier I assessment and the related gap analysis. Also the Regional Stockholm Convention Center might be contacted for information on HBCD use in the region.

6.3.2.1. Gathering information and calculating the HBCD amount and related volumes of HBCD containing materials in textiles and associated materials in the transport sector

To gather robust information industries producing, importing or using textiles for the different transport (vehicles, trains, air planes and ships) sector would be contacted by direct interviews or by questionnaire survey. This contact could be combined with informing these sectors that HBCD is listed in the Stockholm Convention and will not be allowed to be used in new products as well that the treated textiles will need an appropriate environmentally sound management (UNEP 2015) when the vehicles, trains, air planes or ships will reach their end-of-life or when seats or other textile applications containing HBCD will be refurbished.[18]

Since POP-PBDEs have also been used in this application as minor uses they also can be included in the assessment if they have not been addressed before (see chapter 6 POP-PBDE inventory guidance; Secretariat of the Stockholm Convention 2015). In the screening of upholstery in vehicles, PBDEs have been detected in even higher concentrations compared to HBCD while in the vehicle floorings HBCD were detected at higher levels (Kajiwara et al. 2014).

In the discussion or questionnaire approach with the respective industries and authorities flammability standards for the individual transport sector would be gathered. While for some sectors this might be regulated by international law (e.g. air planes and ships) (Herrock et al. 2013) for other transport sector (vehicles like car, trucks and busses as well as trains) it might rather be regulated on national level. The requirements of the respective standards would be assessed in respect to the possible (former) use of HBCD in related textile applications.

In the discussion or questionnaire survey with the individual stakeholders the current and former use of HBCD for the different transport sectors would be clarified as well as the total volume of HBCD currently and historically used in the respective sector. Here also the total volume of textiles which are treated or possibly treated would be noted.

Assessment and inventory of end-of-life management from HBCD containing textiles and polymers in transport

Other information which would be gathered is the related end-of-life treatment of textiles treated or possibly treated with HBCD (see also UNEP 2017b). Here information on the former and current end-of-life treatment (including recycling, reuse, treatment, destruction and disposal of HBCD containing textiles) would be gathered including the volumes of possibly HBCD treated materials. Also it would be clarified if these textiles can be

[17] Depending on the quality of information and the uncertainties the inventory developed in Tier II might become a robust inventory with sufficient information for further steps in this sector (action plan development) or the information have large gaps and might nee to be called “preliminary”.

[18] The related Basel Convention draft technical guidance can be given to the stakeholders.

removed from other materials or if e.g. for seats and other upholstery materials the materials cannot be separated or are normally not separated. This would increase the volume of materials which would finally need to be managed in an environmentally sound manner. Since a major application of POP-PBDEs is in the polyurethane foam and textiles in transport, HBCD and POP-PBDE containing waste could be inventoried together (see chapter 5 and 6 of POP-PBDE inventory Guidance). Also polymer wastes from vehicles (entire seat with textile and PUR foam or entire light shredder fraction) would likely contain HBCD and POP-PBDEs (and possibly PCB and PFOS) and here these POPs could be managed together in a synergistic manner (see chapter 6 in the PBDE BAT/BEP guidance (Secretariat of the Stockholm Convention 2017b) and the related Basel Convention technical guidance (UNEP 2017b). Here also detailed information on the end-of-life treatment of fractions containing or possibly containing HBCD would be gathered. This would include the information on the amount of materials currently recycled, landfilled or treated in incinerators or cement kilns or by other means. In Tier II at least a rough estimate of the share of individual end-of-life treatments could be done, similarly as e.g. was done for China for HBCD in EPS/XPS (Li et al 2016) or for Nigeria for the assessment for their POP-PBDE containing polymers in the transport sector (Babayemi et al. 2017).

In the discussions with the respective HBCD using and applying textile industries also the initial plan of these industries on managing the HBCD containing EPS/XPS stockpiles in the construction sector for the coming decades can be initially discussed for formulating an activity in the action plan.

In this survey also information on alternatives available or currently already applied or planned to be applied in the uses sectors of HBCD in textiles in transport (alternative materials and alternative flame retardants) would be gathered and noted to support the switch to appropriate alternatives in the phase out of HBCD in the textile sector in the country. Information on alternative on POPs in current use has been compiled by a POPs phase out publication (http://poppub.bcrc.cn/) and further information coming from countries could be included in the update of this publication.

From the information gathered in Tier II the total amount of HBCD in textiles in the transport sector would be estimated. The inventory team would decide depending on the situation in the country and the available capacity what transport sectors would be addressed (cars, busses, trains, ships, air plane). Here the total amount of textiles treated with HBCD or possibly treated with HBCD should be compiled and then multiplied by the range of HBCD concentrations reported for textiles of 2.2 % to 15 % (UNEP 2010a; Kajiwara et al. 2009). This would include an estimate of current use/stocks of HBCD in these sectors, the amount of HBCD imported in the respective inventory year and the amount of HBCD and HBCD containing materials which have entered the end-of-life in the transport sector for the inventory year (and if data are available also the historic amount of HBCD containing waste in this application). Since the use of HBCD is prohibited in textiles an HBCD use might be assumed until approximately 2014 and vehicles produced from 2015 onwards might not contain HBCD. This might be assessed within a tier III inventory.

It is most likely that still information gaps will exist. If these gaps are large then a useful compilation of table 6-2 might not be possible. In this case the information gathered in tier II would be compiled in the inventory report without filling table 6-2. These gaps might be addressed within a Tier III inventory or formulated as activities in the NIP (see below).

Table 6-2: Sample Calculation of the amount of HBCD in textiles and associated materials, in use/stocks and in end-of-life in the transport sector

Total amount of textiles treated with HBCD or possibly treated with HBCD, in the transport sector*	**HBCD content in textiles (weight %)**	**Total amount of HBCD in textiles in transport sector*, in the inventory year**
Amount of textiles in transport sector in current use/stocks likely containing HBCD.	2.2 % to 15 %	Amount of textiles in transport sector in current use/stocks in the market x 2.2% to 15% = …….kg of HBCD*
Amount of HBCD treated textiles in transport sector imported to the country in the inventory year.**	2.2 % to 15 %	Amount of textiles in transport sector in current use/stocks in the market x 2.2% to 15% = …….kg of HBCD
Amount of textiles in transport sector* entering the waste stream:	**HBCD content in textiles (weight %)**	**Total amount of HBCD in textiles in transport sector* entering end of life**
Amount of HBCD treated textiles going to landfill …….tonnes Amount of HBCD treated textiles incinerated …….tonnes Amount of HBCD treated textiles going into recycling[19] …….tonnes	2.2 to 15 %	Amount of HBCD in textile going to landfill = ……..kg of HBCD Amount of HBCD in textile going into thermal/ treatment = ……kg of HBCD Amount of HBCD in textile going into recycling[5] = ……..kg of HBCD

* Depending on the type of transport (cars, buses, trains, ships, plains) the table can be refined and individual transport sectors listed individually

[19] The recycling of HBCD containing materials is prohibited by the convention

6.3.2.2. Gathering information and estimating the HBCD amount and related volumes of HBCD containing materials in textile applications used indoor

As mentioned above, a range of textile application in residential homes, public buildings (including hospitals and prisons), air ports or hotels are flame retarded. This might include curtains, textile upholstery of furniture, wall coverings and draperies (UNEP 2010a; Horrocks 2013).

Since POP-PBDEs have also been used in this application as minor uses they also might be included in the assessment if they have not been addressed before (see chapter 6 of POP-PBDE inventory guidance; Secretariat of the Stockholm Convention 2015). In the screening of furniture (couches) PBDEs have been detected in PUR foam (Stapleton et al. 2012).

To gather robust information, industries producing, importing or using textiles in these sectors (textile upholstery of furniture, curtains, bed mattress ticking, wall coverings and draperies), retailers and institutions using these materials (hotels, institutions like hospitals) would be contacted by direct interviews or by questionnaire survey. This contact could be combined with informing these industries and other stakeholders that HBCD is listed in the Stockholm Convention and will not be allowed to be used in new products in these uses.

In the discussion or questionnaire survey with the individual stakeholders, the current and former use of HBCD for the different uses would be clarified as well as the total volume of HBCD currently and historically used in the respective sector. Here also the total volume of textiles which are treated or possibly treated would be noted.

In the discussion or questionnaire approach with the respective industries and/or authorities, flammability standards in the individual uses would be gathered. The requirements of the respective standards would be assessed in respect to the possible (former) use of HBCD in related textile applications.

Assessment and inventory of HBCD containing textiles in end-of-life

Other information which would be gathered is the related end-of-life treatment of textiles treated or possibly treated with HBCD. Here information on the former and current end-of-life treatment (including recycling, reuse, treatment, destruction and disposal of HBCD containing textiles) would be gathered including the volumes of possibly HBCD treated materials.[20] Also it would be clarified if these textiles can be removed from other materials or if e.g. for furniture the materials are difficult to be separated or are normally not separated. This would increase the volume of materials which would finally need to be managed in an environmentally sound manner.

Here also detailed information on the end-of-life treatment of fractions containing or possibly containing HBCD would be gathered. This would include the information on the amount of materials currently recycled, landfilled or treated in incinerators or cement kilns or by other means. In Tier II a rough estimate of the share of individual end-of-life treatments could be done, similarly as e.g. done in Nigeria for the assessment for their POP-PBDE containing polymers in the transport sector (Babayemi et al. 2016).

In the discussions with the respective HBCD using and applying textile industries also the plans of these industries on managing the HBCD containing stockpiles in textiles can be initially discussed for formulating an activity in the action plan.

In this survey also information on alternatives available or currently already applied or planned to be applied in the uses sectors of HBCD in textiles (alternative materials and alternative flame retardants) would be gathered and noted to support the switch to appropriate alternatives in the phase out of HBCD in the textile sector in the country. Information on alternative on POPs in current use has been compiled by a POPs phase out publication (http://poppub.bcrc.cn/) and further information coming from countries could be included in the update of this publication.

[20] The related Basel Convention draft technical guidance can be given to the stakeholders.

After compilation of the information in Tier II on current and former uses in these applications the total amount of HBCD in these applications would be calculated considering a 2.2 % to 15 % HBCD content in textiles (Kajiwara et al. 2009; UNEP 2010a) or the (average) content which have been applied from the industries for these applications according to the current survey. If only the information that flame retardants have been used in respective applications are used then this should be noted and the estimate then marked as maximum volume of HBCD and HBCD containing materials. This would include an estimate of current use/stocks of HBCD in these sectors, the amount of HBCD newly introduced in the marked for the respective inventory year and the amount of HBCD and HBCD containing materials which have entered the end-of-life in the transport sector for the inventory year (and if data are available also the historic amount of HBCD containing waste in this application).

It is most likely that still information gaps will exist. If these gaps are large then a useful compilation of table 6-3 might not be possible. In this case the information gathered in tier II would be compiled in the inventory report without filling table 6-3. These gaps might be addressed within a Tier III inventory or formulated as activities in the NIP (see below).

Table 6-3: Sample calculation of the amount of HBCD in textiles applications used indoor, in use/stocks and in end-of-life

Total amount of textiles used indoor* treated (or likely treated) with HBCD	**HBCD content in textiles (weight %)**	**Total amount of HBCD in textiles used indoor***
Amount of textiles used indoor in current use/stocks likely containing HBCD. …….tonnes	2.2 % to 15 %	Amount of textiles indoor in current use/stocks x 2.2% to 15% = …….kg of HBCD*
Amount of textiles used indoor* entering end-of-life	**HBCD content in textiles (weight %)**	**Total amount of HBCD in textiles used indoor* entering end-of-life**
Amount of HBCD treated textiles going to landfill …….tonnes Amount of HBCD treated textiles incinerated …….tonnes Amount of HBCD treated textiles going into recycling[21] …….tonnes	2.2 to 15 %	Amount of HBCD in textile going to landfill = ……..kg of HBCD Amount of HBCD in textile going into thermal/ treatment = …….kg of HBCD Amount of HBCD in textile going into recycling[5] = ……..kg of HBCD

* The individual HBCD containing textiles (e.g. curtains, mattress ticking) present in the country can be listed individually.

[21] The recycling of HBCD containing materials is prohibited by the convention

6.3.2.3. Gathering information and estimating the HBCD amount and related volumes of HBCD containing materials in textile clothing

As mentioned above, HBCD was used in textile clothing along with other flame retardants in particular specific personal protective equipment (PPE) clothing (e.g. for fire fighter and military uniform; other technical textiles). In some countries with specific flammability standards for nightwear clothing, these textiles might require the use of specific materials or labelling on the use of flame retardants.

To gather robust information, industries producing or importing such personal protective textiles, retailers and institutions using these textiles (fire fighters or military) would be contacted by direct interviews or by questionnaire survey. This contact could be combined with informing these industries and other stakeholders that HBCD is listed in the Stockholm Convention and will not be allowed to be used in new products in textiles.

In the discussion or questionnaire survey with the individual stakeholders, the current and former use of HBCD for these uses would be investigated as well as the total volume of HBCD possibly currently and historically used in the respective application. Here the total volume of textiles which are treated or are possibly treated would also be noted.

In the discussion or questionnaire approach with the respective industries and/or authorities, flammability standards in the individual uses would be gathered. The requirements of the respective standards would be assessed in respect to the possible (former) use of HBCD and alternatives in related textile applications.

Assessment and inventory of end-of-life management from HBCD containing textiles

Other information which would be gathered is the related end-of-life treatment of textiles treated or possibly treated with HBCD. Here information on the former and current end-of-life treatment (including recycling, reuse, treatment, destruction and disposal) of HBCD containing textiles would be gathered including the volumes of possibly HBCD treated materials.[22] Also it would be clarified if these textiles can be removed from other materials or if e.g. for furniture the materials are difficult to be separated or are normally not separated. This would increase the volume of materials which would finally need to be managed in an environmentally sound manner.

Here detailed information on the end-of-life treatment of fractions containing or possibly containing HBCD would also be collected. This would include the information on the amount of materials currently recycled, landfilled or treated in incinerators or cement kilns or by other means. In Tier II a rough estimate of the share of individual end-of-life treatments could be done, similarly as e.g. done in Nigeria for the assessment for their POP-PBDE containing polymers in the transport sector (Babayemi et al. 2016).

In the discussions with the respective (formerly) HBCD using and applying textile industries, the initial plan of these industries on managing the HBCD containing stocks in textiles can also be initially discussed for formulating an activity in the action plan.

In this survey information on alternatives available or currently already applied or planned to be applied in the uses sectors of HBCD in textiles (alternative materials and alternative flame retardants) could also be gathered and noted to support the switch to appropriate alternatives in the phase out of HBCD in the textile sector in the country. Information on alternatives on POPs in current use has been compiled by a POPs phase out publication (http://poppub.bcrc.cn/) and further information coming from countries could be included in the update of this publication.

After compilation of the information in Tier II on current and former uses in these applications the total amount of HBCD in these applications would be calculated considering a 2.2 % to 15 % HBCD content in textiles (Kajiwara et al. 2009; UNEP 2010a) or the (average) content which have been applied from the industries for these

[22] The related Basel Convention draft technical guidance can be given to the stakeholders.

applications according to the current survey. If only the information that flame retardants have been used in respective applications are used then this should be noted and the estimate then marked as maximum volume of HBCD and HBCD containing materials. This would include an estimate of current use/stocks of HBCD in these sectors, the amount of HBCD newly introduced in the marked for the respective inventory year and the amount of HBCD and HBCD containing materials which have entered the end-of-life in the transport sector for the inventory year (and if data are available also the historic amount of HBCD containing waste in this application).

It is most likely that still information gaps will exist. If these gaps are large then a useful compilation of table 6-4 might not be possible. In this case the information gathered in tier II would be compiled in the inventory report without filling table 6-4. These gaps might be addressed within a Tier III inventory or formulated as activities in the NIP (see below).

Table 6-4: Sample calculation of the amount of HBCD in textiles clothing, in use/stocks and end-of-life

Total amount of HBCD treated clothing*	**HBCD content in textiles (weight %)**	**Total amount of HBCD in clothing in use***
Amount of HBCD treated clothing* in current use/stocks. …….tonnes	2.2 % to 15 %	Amount of HBCD treated clothing* in current use/stocks x 2.2% to 15% = …….tonnes of HBCD*
Amount of HBCD treated clothing* entering end-of-life	**HBCD content in textiles (weight %)**	**Total amount of HBCD treated clothing* entering end-of-life**
Amount of HBCD treated textiles going to landfill …….tonnes Amount of HBCD treated textiles incinerated …….tonnes Amount of HBCD treated textiles going into recycling[23] …….tonnes	2.2 to 15 %	Amount of HBCD in textile going to landfill = ……..tonnes of HBCD Amount of HBCD in textile going into thermal/ treatment = …….tonnes of HBCD Amount of HBCD in textile going into recycling[5] = …….tonnes of HBCD

* The individual HBCD containing clothing (e.g. fire fighter uniform, military uniform, others) present in the country might be listed individually.

6.3.3. Tier III: In-depth inventory of HBCD in textile sector

The in-depth inventory can consist of a field survey with detailed assessment of the share of HBCD containing materials in the major applications of HBCD in textiles. This might include the physical screening of textiles for bromine and HBCD.

As mentioned above the amount of HBCD used in the different textile applications is not well documented and most likely have regional differences due to different use volumes in the regions (UNEP 2010a) and national differences due to e.g. differences in national flammability standards. Furthermore the share of HBCD containing products might also depend on flammability standards in the producing/exporting countries. Therefore an inventory of this sector might only lead to reliable and detailed data by involving some monitoring efforts. Such a monitoring could be performed by screenings the bromine content of articles with a handheld XRF equipment

[23] The recycling of HBCD containing materials is prohibited by the convention

(see e.g. *POP-PBDEs BAT/BEP Guidance*[24] (Secretariat of the Stockholm Convention 2017b) and *Draft Guidance on Screening and Analysis of POPs in Articles and Product* (Secretariat of the Stockholm Convention 2017a). Handheld XRF equipment has been purchased from a range of developing countries in the frame of the NIP update and therefore also these countries would be able to do a national (or even regional) assessment using the XRF screening approach.

According to a first survey, bromine positive tested samples of curtains likely contain HBCD (in Japan 9 out of 10 bromine positive tested curtains contained HBCD as flame retardant) (Kajiwara et al. 2008, 2009). For other applications such as textiles in upholstery in transport considerable amount of PBDEs have been used (Kajiwara et al. 2014). However there might be regional differences in the use of brominated flame retardants. If countries only have XRF as screening tool then the share of bromine positive tested applications might be considered to possibly contain HBCD as a conservative estimate and it should be noted in the inventory report and in NIP report that this might also include textiles containing PBDEs or other brominated flame retardants.

If instrumental analysis is available for the measurement of HBCD in the country then the XRF positive tested samples could be further analysed for HBCD for confirmation (GC/MS, GC/ECD or HPLC/MS[25]).

The results of XRF screening (and possibly the confirmation analysis) would be described in the inventory report and would be used for determining national (or regional) impact factors for calculating the share of HBCD containing materials in the individual screened applications. If only XRF analysis has been conducted it would be noted that also other brominated flame retardants (e.g. PBDEs) might have contributed to the bromine positive fraction (see e.g. Kajiwara et al. 2014). Therefore this would be noted in the inventory and suggested for a possibility for refinement in further inventory update.

After Tier III assessments have been done, the tables 6-2, 6-3 and 6-4 can be filled or refined (instead of using only the information from Tier II assessment).

Another possible Tier III approach could be the development of a material and substance flow analysis of HBCD containing textiles (see e.g. Morf et al. 2007, 2008; Managaki et al. 2009). Material and substance flow analysis can support waste management and material recovery. Dynamic material and substance flow analysis can be used to predict the generation of waste volumes of HBCD containing textiles (see e.g. Morf et al. 2007, 2008). The inventory development of POP-PBDE in WEEE/EEE plastic in Nigeria from Basel Conventional Regional Center has shown that also developing countries are able to use the material and substance flow analysis approach in the frame of Stockholm Convention inventory development (Babayemi et al. 2012, 2014) using the free software for material/substance flow analysis from Vienna University (http://www.stan2web.net/). Such or similar approaches could be used in the development of an in-depth Tier III inventory.

6.4. Step 4: Managing and evaluating data

In the data evaluation step the data need to be assessed for completeness and plausibility, possibly including a comparison with data from other countries in the region. Data gaps may (partly) be filled by extrapolation of available statistical data. If the quality of the data is considered inadequate, further data collection or screening (Tier III) can be undertaken. Otherwise the gaps would be noted in the inventory.

When a country improves the inventory of the HBCD use over time, the data quality will become better and more reliable. Since different countries/Parties will develop HBCD inventories results in other countries from the region might be assessed and information exchanged and inventories improved by additional information.

Also the regional Stockholm and Basel Convention Centres might be contacted to evaluate if regional information on HBCD use in textile applications is available in the region.

[24] This draft guidance document is under revision in accordance with decision SC-6/10.
[25] Only the HPLC/MS is capable to analyse the individual diastereomers (which is not required for the inventory).

6.5. Step 5: Preparing the inventory report

The final information and data for HBCD use and presence in the different textile applications in the country would be accompanied by the methodology used and the detailed calculations and assumptions done in the calculations as an audit trail in a separate chapter of the HBCD inventory report. All country-specific adjustments and estimates would be noted and described.

To provide an overview on the presence of HBCD at the national level, as well as on the amount of the HBCD impacted volumes of textile materials to be managed during the NIP implementation phase, the information which could be included in dedicated NIP paragraphs may comprise of a brief summary on:

- Key information gathered on the use of HBCD in the different textile applications (transport sectors, different indoor uses and clothing).
- Estimated likely total amount of HBCD in the individual textile sector and volume of possibly HBCD containing textiles;
- Monitoring efforts done during inventory development;
- Gaps in these data;
- Amount of (potentially) HBCD containing textiles currently entering the market (please note that this is not allowed if HBCD use has entered into force for the country);
- Regulations on flammability standards in the country requiring and determining flame retardant use for certain textile applications;
- Alternatives available and used for the different textile applications;
- End of end-of-life management of HBCD containing textiles including reuse, recycling[26], treatment, destruction and disposal of HBCD containing textiles. For compiling the information also the *Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with hexabromocyclododecane* would be consulted (UNEP 2015b).

While some of these information can be generated from a Tier I and Tier II inventory, some of the listed information might only be included if a Tier III inventory approach has been used.

Also further activities suggested for assessing and managing the use of HBCD in the different textile applications would be included in the NIP.

[26] Please note that the recycling of HBCD containing materials is not exempted in the Stockholm Convention in case that the levels are above the low POPs content.

7. Inventory of HBCD in minor uses

There is a range of other uses of HBCD which, however, are considered rather minor uses. These uses – HIPS in EEE and paints, latex binder and glues - are shortly introduced in this chapter with some considerations on possible inventory activities which have likely a lower priority.

7.1. HBCD use in electrical and electronic equipment (EEE) and related wastes

HBCD has also been used as a BFR in high impact polystyrene (HIPS) in casings of electrical and electronic equipment (EEE) (UNEP 2010a). Therefore HIPS plastic casings or parts of electronics as well as WEEE plastic fractions from recycling might contain HBCD. In a Swiss survey of individual EEE equipment (IT equipment and TVs) approximately 18% of IT equipment and 3% of TV housings made from HIPS contained HBCD (Wolf 2001; Waeger et al. 2010).

A first comprehensive screening of BFRs in mixed WEEE plastic from shredders of the major WEEE categories in several European countries, however, did not detect HBCD with a detection limit for HBCD of 200 mg/kg plastic (200 ppm) (Waeger et al. 2010; Waeger et al. 2012). Therefore it seems that the average HBCD concentration in European WEEE plastic is below this concentration. Since a large share of European WEEE plastic originates from Asian imports of EEE this might also indicate that the average HBCD concentration in WEEE plastic from Asia might in average be below 200 mg/kg.

Also in a survey on the occurrence of brominated flame retardants in black thermo cups and selected kitchen utensils purchased on the European market no HBCD was detected[27] (Samsonek & Puype 2013). Also this study indicates that the overall level of HBCD in flame retarded waste plastic recycled into (such) products seems low.

Therefore currently no emission factors can be given for HBCD in mixed WEEE plastic but this is probably below 200 mg/kg which was the detection limits in a monitoring study (Waeger et al. 2010). Therefore the overall relevance of HBCD in WEEE plastic is considered to be low and no specific inventory activity is recommended. Since for POP-PBDE the major inventory activity is normally for WEEE polymers (see POP-PBDE inventory guidance (Secretariat of the Stockholm Convention 2015)), this material flow and related management of POP-BFRs in WEEE plastic are normally addressed within the action plan of POP-PBDEs.

If a country decides to develop a HBCD inventory in WEEE plastics within a Tier III inventory then it is recommended to do measurements of HBCD (and other POP-BFRs) in the HIPS WEEE plastic fraction where the major use of HBCD in plastic took place and to measure average content for the country or region considering e.g. the approach of Waeger et al. (2010) (Secretariat of the Stockholm Convention 2017a) however with lower detection limits for HBCD in WEEE plastics (e.g. 10 or 20 mg/kg which need a robust analytical methodology).

Also if a country has a WEEE recycling sector with separation of different plastic fractions and types then the HIPS fraction could be assessed for HBCD content.

Then based on these measurements a HBCD inventory in WEEE plastic and in the HIPS plastic fraction can be developed.

7.2. HBCD use in paints, coatings, glues and latex binders

The use of HBCD in paints/coatings, latex binders and glues has been reported (Albemarle Corporation 2000, Great Lakes Chemical Corporation 2005). However these were minor uses and have not been confirmed for different regions (European Commission 2008). Therefore it is recommended to address these uses only if a detailed Tier III inventory is being developed.

For these uses, producers of HBCD might directly be contacted to find out more details on these uses and on

[27] The BFR detected were decabromodiphenyl ether (decaBDE) suggested for listing in the Convention (UNEP 2017a) and other not listed BFRs such as tetrabromobisphenol A (TBBPA), tetrabromobisphenol A bis(2,3-dibromopropyl), ether (TBBPA-BDBPE) and decabromodiphenylethane (DBDPE) were identified (Samsonek & Puype 2013)

possible regional uses. Alternatively also producers of paint and latex binders could be contacted and asked for HBCD or general flame retardants in these applications.

If assessment and inventory activities of HBCD use in paints/coatings and latex binders are developed then it might be useful to assess all POPs use in these applications in a more comprehensive synergistic manner.

The most prominent POP formerly used in paints and coatings were PCBs which still have relevance for human and food exposure due to the durability of these paints and coatings (Secretariat of the Stockholm Convention 2017d; Jartun et al. 2009; Wagner et al. 2014, Zennegg et al. 2014). Also PCNs have been used in paints and coatings (Secretariat of the Stockholm Convention 2017d) and have been substituted in these applications partly by short chain chlorinated paraffins (SCCPs) which are recommended to be listed in the Stockholm Convention in May 2017 (UNEP 2017b). Furthermore pentachlorophenol (PCP) has been used in wood paints and impregnations (Secretariat of the Stockholm Convention 2017e)[28].

Therefore if a HBCD inventory team decides to assess HBCD in paints/coatings and latex binders then this should be combined with an assessment of other POPs in these uses. Related inventory guidance documents for PCNs and PCP have been developed (Secretariat of the Stockholm Convention 2017d,e).

[28] Also lead in paints is addressed by the Global Alliance to Eliminate Lead Paint including UNEP.

8. Inventory of contaminated sites containing HBCD

8.1. Scope and background information

In accordance with the provisions of Article 6(1)(e) Parties shall endeavour to develop appropriate strategies for identifying sites contaminated by chemicals listed in Annex A, B or C. Therefore, creating and maintaining a public inventory of HBCD-contaminated sites may be useful for a regulatory agency in formulating a contaminated site management strategy. A contaminated site database is vital as a country develops, its population grows, land is redeveloped and land uses changes and has relevance for several Sustainable Development Goals such as food security (Goal 2), sustainable management of water (Goal 6), safe and sustainable cities (Goal 11) and for the promotion of sustainable use of land including soils (Bell et al. 2016).
This chapter aims to give guidance for the identification of HBCD-contaminated sites for the inventory. In doing so, the inventory team should also consider the step-by-step approach in UNIDO's *Persistent Organic Pollutants: Contaminated Site Investigation and Management Toolkit* (UNIDO, 2010), which contains the identification of POP-contaminated sites (not specifically covering HBCD sites), assessing related risks and setting priorities.
The inventory would compile and report information collected during the site investigation from Module 2, preliminary site investigation, stage 1 and/or stage 2, of the Toolkit. This information includes the site profile, past and present activities, spill releases, and site owners.
As for other POPs, contaminated sites might be generated in the entire lifecycle of the respective POP including in this case production of HBCD, the production of products containing HBCD, the use of these products, recycling and the end-of-life treatment of these products. Also for HBCD landfills represent are one ultimate destination of HBCD-containing materials, in particular in countries without destruction capacities. Brominated flame retardants including HBCD and POP-PBDEs and can to some extent be released from these materials by landfill leachate or from landfill fires (Danon-Schaffer et al. 2014; Gullett et al. 2009; Odusanya et al. 2009; Weber et al. 2011, Remberger et al. 2004).

To carry out the contaminated site inventory, the team is expected to also utilize information provided and gathered in chapters 3 to 7 and the outcome of the related inventories for tracking potential, whilst also examining the solid waste management/practice of the individual HBCD producers, users and the uses in the country.

A step-by-step guidance for the inventory of HBCD contaminated sites also considers a Tiered approach is given below.

To be noted: A site is generally considered contaminated by POPs when the concentration of one or more contaminants exceeds the regulatory criteria or poses a risk to humans and/or the environment. Since currently no regulation limits for HBCD in soil exist, contamination can currently be compared to background levels. Background levels in soils e.g. in East China were below 0.025 ng/g (Tang et al. 2014) and in the UK in rural area were below 0.1 ng/g (Harrad et al. 2010a) and also in cities without point source levels were below 0.1 ng/kg (Desborough 2011). Therefore background levels might somewhat differ in countries/regions but seems below 1 ng/g. Levels in soil in contaminated areas are several orders of magnitude higher e.g. at a formulator/compounder plant in the UK (18,700 – 89,600 ng/g; Dames and Moore 2000) or at a XPS production facility in Sweden (140 – 1300 ng/g; Remberger et al. 2004). Also levels in the London city were up to 420 ng/g with increasing levels in soil close to buildings (Harrad et al. 2010a; Desborough 2011).

8.2. Step 1: Planning the inventory

Information from the identified relevant sectors (chapter 3 to 7) could be used to identify potential HBCD-contaminated sites and then set priorities for remediation. A list of potentially contaminated sites is compiled in Table 8-1.

This first step focuses on defining the scope of the inventory and developing a work plan (see section 3.1.).

An inventory of HBCD contaminated sites would include an assessment of releases and related contamination along the life cycle (see Table 8-1):

- Production sites;
- HBCD containing EPS and XPS in stocks/use in buildings and construction;
- HBCD containing EPS or XPS in use and stocks in packaging, furniture and other;
- HBCD in EPS and XPS in recycling and end-of-life.

Appropriate members of the inventory task team need to be selected to conduct the inventory of this sector. Specific stakeholders for the inventory of HBCD are listed in Table 3-1. The core inventory team could be extended as appropriate. The NIP coordinator or task team leader can decide which stakeholder should be included in an inventory team and which stakeholder should just be contacted for an interview or by means of a questionnaire.

Identification of stakeholders

Identification of stakeholders could consider all those listed in Table 3-1, in addition to personnel from local government such as municipal wastewater treatment plants, those responsible for disposal of biosolids, farmers, landfill owners, and the general public.

- Authorities and other stakeholders that might provide valuable information on identified contaminated sites, that might contain HBCD:
    - Environmental protection agencies;
    - Municipal authorities;
    - Ministries of environment;
    - Ministries of industry;
    - Producers of HBCD;
    - Stakeholders of identified industrial use;
    - Urban and city planning authorities;
    - Industry (to be contacted to gather information);
    - Users;
    - Property development companies.

Environmental contamination from releases from processes and deposits can affect air, water/sediments and land as well as biota including food (Dames and Moore 2000; Morris et al. 2004; Li et al. 2012, Remberger et al. 2004; Rüdel et al. 2012; Eljarrat et al. 2005; Eljarrat et al. 2011). Therefore, the investigation is necessary to identify the relevant sectors involved, manufacturing and wastes being disposed, biosolids application, methods of waste disposal or treatment, and recycling and related waste disposal locations and related releases. Potential HBCD-contaminated sites are listed in Table 8-1 below. The step-by-step approach in the *Contaminated Site Investigation and Management Toolkit* (UNIDO 2010) can then be followed to systematically identify the - HBCD contaminated sites, keep records, develop a registration system, and then perform risk assessment/prioritization on the HBCD contaminated sites.

8.3. Step 2 and 3: Choosing data collection methodologies and collecting data

8.3.1. Tier I: Initial assessment of potentially HBCD contaminated sites

The expected output of the initial assessment includes:

- List of relevant stakeholders in the country;
- Compilation of information on HBCD contaminated sites;

- List of locations of potentially HBCD contaminated sites;
- Compilation of gaps from Tier 1 assessment to be addressed by Tier II.

Gathering information on HBCD contaminated sites

In the first step an overview information on HBCD contaminated sites (internet and literature survey). There are already a range of studies published on environmental contamination from HBCD production and use and related releases. There are already a wide range of publications and reports on HBCD contaminated sites which might be consulted as a first step:

- Contamination at/around HBCD production sites (Allchin & Morris 2003 ; Morris et al. 2004; Li et al. 2012, Rüdel et al. 2012);
- Contamination from HBCD using industries (plastic, textile, etc.) and micronizing of HBCD (Eljarrat et al. 2005; Eljarrat et al. 2011; Morris et al. 2004; Remberger et al. 2004; Rüdel et al. 2012; Sellstroem et al. 1998; Zhang et al. 2013);
- Recycling of HBCD containing wastes (Gao et al. 2011; Tomko & McDonald 2013);
- Landfills and dump sites (Remberger et al. 2004; Weber et al. 2011);
- Application of highly contaminated industrial sludge from (industrial) waste water treatment[29].

Table 8-1: Potential HBCD-contaminated sites

Life cycle stage; Sector	Activities	Locations
HBCD production	(Former) Production	Production site
	(Former) Destruction of production waste	Sites where production waste has been destroyed
	Disposal of waste from production	Landfills related to waste from production
	Former water discharge	River sediment and banks related to releases from production site
Sites where HBCD were used in EPS and XPS production and in textile and related industries	EPS/XPS industry (formerly) using HBCD	Site of production; Landfill site of related wastes; Impacted surface waters (sediment and flood plains)
	Textile industry and other industries (formerly) using HBCD Factories micronising HBCD	Site of production; Landfill site of related wastes; Impacted surface waters (sediment and flood plains)
Use of HBCD	Sites where EPS and XPS is used	Soil impacted from buildings/city[30]
	Accidental fire in building	Soil/environment around fire accidents with HBCD XPS/EPS
End-of-life treatment	Recycling area of HBCD containing materials	Recycling areas and landfills with deposited wastes
	Deposition of HBCD-containing waste	Landfill and surrounding from leachate from HBCD- wastes

[29] The contamination pathway via sewage sludge has been documented for other POPs production (Washington et al. 2010; Oliaei et al. 2013)

[30] The comparison of HBCD in soils in UK cities compared to rural environment revealed higher levels in cities with elevated concentration in some city soils (Harrad et al. 2010a). For one house a transec study found decreasing HBCD levels in soils with increasing distance from the house which were below 1 mg/kg (0.29 mg/kg at 3 m; 0.12 mg/kg at 5 m, 0.035 mg/kg at 7 m and 0.015 mg/kg at 12 m distance, Desborough 2011).

	Open burning or non-BAT incineration of HBCD-containing waste[31]	Related sites and sites were residues/ashes are disposed
	Application sites of HBCD impacted sludge	Agriculture land

8.3.2. Tier II: (Preliminary) Inventory of potentially HBCD contaminated sites

The expected output of the initial assessment of HBCD contaminated sites includes:

- Gathering information on individual site type in the country;
- Detailed locations of potentially contaminated sites (GIS);
- Information by site visits of selected potentially contaminated sites;
- Information on the potentially HBCD contaminated sites allowing prioritisation;
- Information on possible human exposure (e.g. if HBCD measurement of fish exist (see e.g. Rüdel et al. 2012) or levels in chicken eggs around the site);
- Compilation of gaps from Tier II assessment to be possibly addressed by Tier III.

Gathering information on potentially HBCD contaminated sites

Information would be collected by direct contacts, by questionnaire approaches or by site visits from (selected) sites listed in Table 8-1.

Site investigation, comprising preliminary site investigation (PSI) and detailed site investigation (DSI), provides valuable information on a site, including:

- The nature and location of contaminants with respect to the soil and groundwater table;
- Potential pathways for contaminant migration;
- The location of nearby sensitive receptors;
- Potential for direct human exposure to the contaminants;
- Potential of food and feed contamination.

It is suggested to carry out the PSI stages 1 and 2 for those locations of potential HBCD contamination listed in Table 8-1 for the purposes of the inventory.

The objective of PSI stage 1 is to gather sufficient information to estimate the likelihood of HBCD POP contamination that may be present at a site. Sampling relevant environmental media and investigations of subsurface conditions are not required at this stage.

A PSI stage 1 includes the following activities:

- **Historical review:** review of a site's historical use and records to determine current and past activities or uses. This would include information such as:
  - How long has HBCD been produced or used at the site?
  - What other polluting processes or chemicals were and are present?
  - Information on accidents and spills;
  - Practices and management relating to potential contamination at the site and at adjacent sites (including related landfills or thermal treatment of wastes);
  - Waste water treatment;
  - Possible releases to surface water.

[31] The combustion of HBCD-containing waste in state of art incinerators does not lead to relevant releases of HBCD or PBDD/F (Mark et al. 2015; Weber et al. 2003).

- **Site visits:** one or more walk-through site visits to verify and complete the information gathered during the literature review for indicators or presence of contamination; in these site visits the possible exposure to livestock, fish and humans in the vicinity would also be noted.
- **Interviews:** interviews to verify and complete information by asking current or former owners, occupants, neighbours, managers, employees, and government officials who can, with reasonable attempts, be contacted about information on activities that may have caused contamination.

It should be noted, however, that while the information that is required in PSI stage 1 might be accessible in industrial countries, it is not always available or accessible in developing countries.
One outcome of the Tier II assessment would also be a gap assessment of further information needed for selected sites and a prioritization of possible Tier III assessment of selected sites (in particular considering the source strength of sites and the risks to humans).

8.3.3. Tier III: In depth inventory of potentially HBCD contaminated sites

Tier III would include PSI stage 2 assessments and possibly measurements of HBCD contamination if such studies can be conducted.

PSI stage 2 would be conducted only if stage 1 indicates that there is a likelihood of HBCD/POP contamination at the site or if there is insufficient information to conclude that there is no potential for HBCD/POP contamination. The objective of stage 2 is to confirm the presence or absence of the suspected contaminants identified in stage 1 and to obtain more information about them. To achieve this objective, site investigators would carry out the following activities:

- Development of a conceptual site model;
- Development of a sampling plan;
- Sampling of relevant environmental media laboratory or field instrumental analysis of sampled and selected environmental media for substances that may cause or threaten to cause contamination.

Key elements of a conceptual site model may include:

- Site history and setting;
- Potential contaminants of concern – contaminant properties and behaviour;
- Potential areas of environmental concern (Source Zones);
- Geology and stratigraphy;
- Regional and local;
- Overburden – sedimentary, glaciology, depositional processes;
- Bedrock – fracture networks, representative elementary volume;
- Hydrogeology and surface waters;
- Aquifers and aquitards;
- Groundwater levels and elevations;
- Hydraulic gradients and velocities;
- Boundaries;
- Plumes and pathways;
- Groundwater and vapour;
- Environmental transport and attenuation processes;
- Receptors and risk.

8.4. Step 4: Managing/evaluating data

The information on the different potentially HBCD contaminated sites would be compiled and evaluated. The compilation would best be done according to the life cycle of HBCD (Table 8-1).

The contaminated sites data would best be included in a national contaminated site database if there is one, or combined with a database of other POPs contaminated sites (e.g. PCBs, PFOS, PCDD/Fs).

Based on the data collected, a conceptual site model (CSM) can be developed to establish the relationship between the contaminants, exposure pathways and receptors (see figure 8-1). The CSM, which would be developed at the very beginning of PSI stage 2, identifies the zones of the site with different contamination characteristics (i.e., whether contaminants in the soil are likely to be at the surface or at deeper levels, distributed over an entire area or in localized "hot spots"). Releases from some HBCD productions or use industries have been high () while the releases from insulation foams are rather low but might also result in elevated HBCD levels close to houses but still below 1 mg/kg (Desborough 2011)[30]. Exposure pathways and receptors would be identified, where appropriate, for both current and future uses of the site. The CSM is based on a review of all available data gathered during stage 1, and would be continuously modified as more information becomes available during stage 2 and the detailed site investigation.

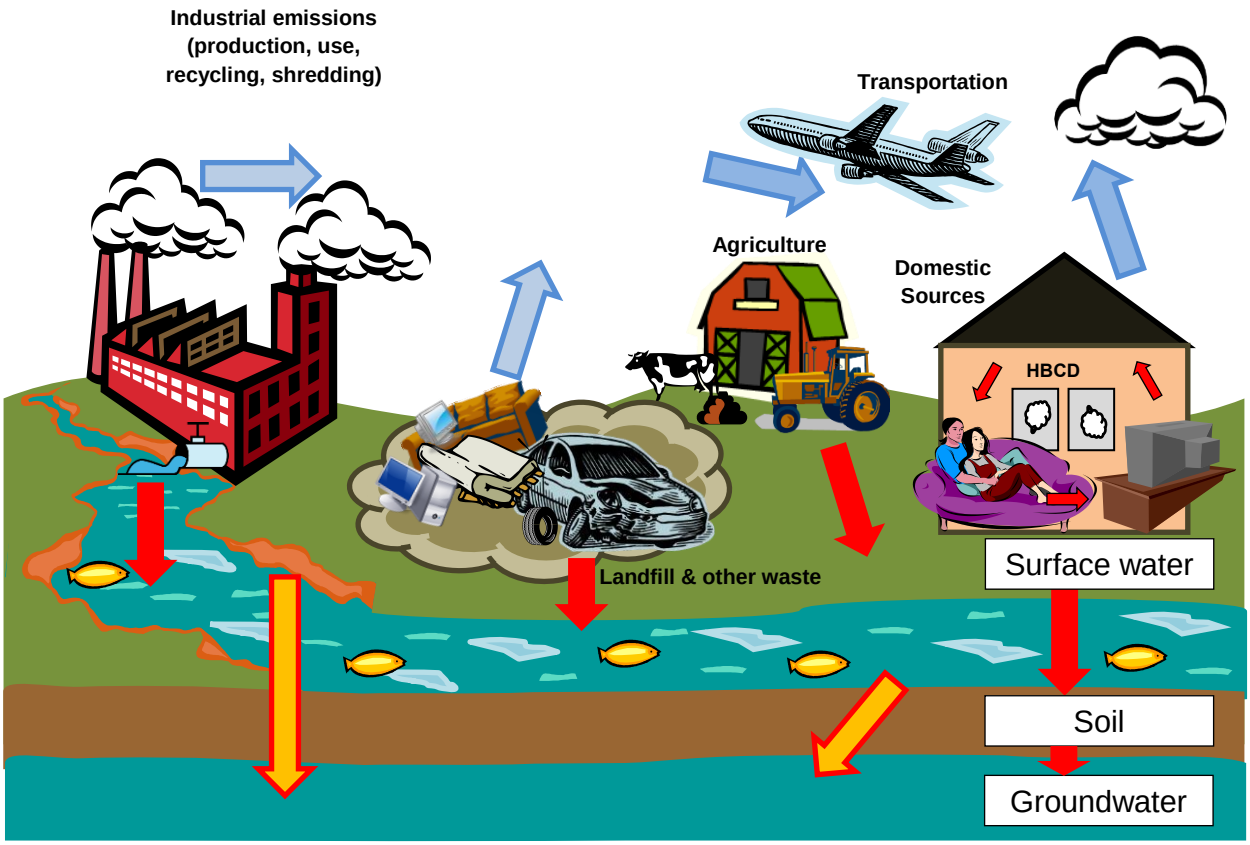

Figure 8-1: Routes of contamination migration

Clearly, the accuracy of the information gathered and analysed during the investigation is vitally important because it forms the basis for the risk assessment phase, for making decisions on the need for, and type of, remedial action and, eventually, for the design and implementation of necessary actions.

During a site investigation, every item of information collected should be recorded properly in words, along with photographs of the site and the surrounding area, with a radius of about 50-100 m (depending on the size of the

site). Reporting is essential for each stage of the investigation as site-specific information is invaluable to decision makers in their efforts to protect the environment.

It is suggested that contaminated site inventories would be established on national level. Data collection and compilation, data management, and evaluation could refer to the *Contaminated Site Investigation and Management Toolkit* (UNIDO 2010).

8.5. Step 5: Reporting of potential HBCD-contaminated sites

Reporting is essential for each stage of the investigation as site-specific information is invaluable to decision-makers in their efforts to protect human health and the environment and to understand the related risks.

Relevant findings would be included in the national contaminated sites database and in the NIP report. Also further activities needed for assessing and possibly securing or cleaning of contaminated sites would be included in the NIP.

Information which might be compiled for individual (relevant) contaminated sites would be included in the inventory report and in the national contaminate site database.

The PSI stage 1 report would identify potential contamination:

- Potential source of contamination;
- Potential other–contaminants of concern (e.g. chlorinated and brominated dibenzo-p-dioxins and dibenzofurans if a fire was involved in the contamination);
- Areas of potential environmental concern (potential lateral extent, vertical extent and media).

If for (selected) sites a PSI stage 2 **assessment** would identify contamination and potential contamination including:

- Source of HBCD contamination;
- Other contaminants of concern (i.e. other POPs or unintentional POPs released);
- Areas of environmental concern (potential lateral extent, vertical extent, media);
- Recommendations for action.

For further information on reporting, refer to the *Contaminated Site Investigation and Management Toolkit*.

The inventory of contaminated sites could include:

- Types and quantities of HBCD-containing materials disposed;
- The names and addresses of those entities responsible for disposal of HBCD-containing materials;
- Details of the treatment of waste before disposal;
- Records of site contamination;
- Details of the clean-up process (if any) once a site has been registered as being contaminated;
- Information on the monitoring of contaminated sites;
- Records of ongoing monitoring and research.

As mentioned in chapter 8.1 above, a contaminated site management policy requires established “maximum

permissible levels" and "levels of concern" (values that trigger action) in corresponding media such as e.g. soil, sediment or water. Such permissible levels are, however, not established for HBCD at the national or international level. Therefore for the time being, levels at HBCD contaminated or impacted sites might be compared to background levels (below 1 ng/kg) (Desborough 2011; Harrad et al. 2010a; Tang et al. 2014) and other contaminated sites reported in literature (e.g. Dames and Moore 2000; Li et al. 2012 Remberger et al. 2004). For further assessment of exposure risk and possible needed securing or remediation activities "maximum permissible levels" and "levels of concern" would need to be defined.

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ANNEX A. SAMPLE QUESTIONNAIRE

ANNEX A.1 SAMPLE QUESTIONNAIRE for compiling information on the presence of hexabromocyclododecane (HBCD) in Expanded Polystyrene (EPS) and Extruded Polystyrene (XPS) in insulation in construction, packaging and other uses and related recycling and waste

1) Background information

In May 2013, hexabromocyclododecane (HBCD) was listed in the Stockholm Convention as a persistent organic pollutant (POP) in Annex A, with specific exemption in insulation in construction[32] available to Parties who wish to register for it. Since November 2014 the listing of HBCD to the Stockholm Convention entered into force for most parties[33]. [Describe when your country ratified and if it registered for the exemption.]

Parties to the Convention for which the amendments have entered into force have to meet the obligations under the Convention to eliminate HBCD for the production and uses not exempted.

Under Article 7 of the Stockholm Convention, Parties are required to develop and endeavour to implement a plan for the implementation of their obligations under the Convention.

To develop effective strategies to eliminate HBCD, Parties need to acquire a sound understanding of their national situation. Such information can be obtained through an inventory of HBCD in different uses.

Expanded Polystyrene (EPS) and Extruded Polystyrene (XPS) were the major uses of HBCD in the world market. Only flame retarded EPS contains HBCD. The use of HBCD in XPS and EPS depends on the application and on the region. E.g. in Western Europe approximately 70 % of the EPS has been flame retarded while in East Europe it has been about 99% (Seppälä 2013)[34]. The major use of HBCD was in EPS and XPS has been in the construction sector (see chapter 2 of this HBCD inventory guidance). However not all EPS and XPS in the construction sector contain HBCD. Recently also alternative flame retardants have become available for EPS/XPS. EPS/XPS packaging is normally not treated with HBCD. However preliminary screening has revealed that at least in some countries packaging including food packaging can contain HBCD (Rani et al. 2014)[35].

2) Purpose of the questionnaire

This questionnaire is aimed at gathering information on the current and former use of HBCD in insulation in buildings and construction as well as in possible use in packaging and other applications. The Questionnaire is an example that should be adapted to suit national circumstances

This information will be very valuable in order to assess the current situation and will constitute the basis for a country to manage HBCD and related treated materials as part of the update of the National Implementation Plan of the country.

[32] United Nations (2013) SC-6/13: Listing of hexabromocyclododecane. Reference: C.N.934.2013.Treaties-XXVII.15 (Depositary Notificatification). (decision SC-6/13)

[33] Amendments shall not enter into force for those Parties that have submitted a **notification** pursuant to the provisions of paragraph 3(b) of Article 22 of the Stockholm Convention. Also, in accordance with paragraph 4 of article 22, the amendment will not enter into force with respect to any Party that has made a **declaration** regarding the amendment to the Annexes in accordance with paragraph 4 of Article 25.

[34] Listing hexabromocyclododecane in Annex A of Stockholm Convention Presentation. 12th HCH and Pesticide Forum, 6-8 November 2013, Kiev Ukraine. http://www.hchforum.com/12th/presentations/pdf/2_Timo%20Seppala%20-%20HBCD%20in%20the%20Stockholm%20Convention.pdf

[35] Rani et al. (2014) HBCD in polystyrene based consumer products: an evidence of unregulated use. Chemosphere 110, 111-119.

1. Name and address of industry:

Name of industry/company or institution	Address

2. Type of company or industry:

☐ Production of EPS and XPS foam for building & construction ☐ Production of EPS and XPS for packaging
☐ Import of EPS and XPS for building & construction ☐ Import of EPS/XPS for packaging production
☐ Retail of EPS and XPS foam for building & construction ☐ Retail of EPS XPS for packaging production
☐ Recycling of EPS and XPS from construction/packaging and other uses[36]
☐ Disposal of EPS and XPS from construction/packaging[37]
☐ Other uses of EPS/XPS (please specify):

3. Use of HBCD in EPS and XPS in different products and use (please see also table Q1 and Q2)

Was or Is HBCD currently used in EPS or XPS production and application? (Please fill details in table Q1/Q2 below)

Are you planning to further use HBCD in EPS or XPS applications? For which uses?

What alternatives are available for HBCD in XPS/EPS or alternatives to XPS/EPS in the country/region?

[36] Recycling of EPS and XPS is not exempted by the Stockholm Convention.

[37] EPS and XPS packaging is normally not treated with HBCD. However initial screening have reviled that at least in some countries packaging including food packaging can contain HBCD (Rani et al. 2014).

Table Q1: HBCD use in different EPS uses in construction and other uses and related volumes (current and past)

EPS Uses	HBCD content (%)	**Years of production and use (from and until)**	**Total volume of HBCD containing XPS (tonnes) (Total historic production/ Current production)**
EPS Flat roof insulation			**……t/……t**
EPS Pitched roof insulation			**……t/……t**
Floor insulation 'slab-on-ground' insulation			**……t/……t**
Insulated concrete floor systems			**……t/……t**
Interior wall insulation with gypsum board			**……t/……t**
Exterior wall insulation or ETICS (External Insulated Composite Systems)			**……t/……t**
Cavity wall insulation boards			**……t/……t**
Cavity wall insulation loose fill			**……t/……t**
Insulated concrete forms (ICF)			**……t/……t**
Foundation systems and other void forming systems			**……t/……t**
Load bearing foundation applications			**……t/……t**
Core material for EPS used in sandwich and stressed skin panels (metal/wood fibreboard)			**……t/……t**
Floor heating systems			**……t/……t**
Sound insulation in floating floors (to avoid transmission of contact sound)			**……t/……t**
EPS drainage boards			**……t/……t**
EPS concrete bricks, EPS concrete			**……t/……t**
EPS Soil stability foam (civil engineering use)			**……t/……t**
EPS Seismic insulation			**……t/……t**
EPS Packaging materials made of PS foams*			**……t/……t**
Other moulded EPS articles, such as ornaments, decorations, logos, etc.			**……t/……t**
Other EPS application (please specify):			**……t/……t** **……t/……t** **……t/……t**

***Only those packaging which has been treated with HBCD

Table Q2: HBCD use in different XPS uses in construction and other uses and related volumes (current and past)

XPS Use	HBCD content (%)	Years of production and use (from and until)	Total volume of HBCD containing XPS (tonnes) (Total historic production/ Current production)
Cold bridge insulation			……t/……t
Floors			……t/……t
Basement walls and foundations			……t/……t
Inverted roofs			……t/……t
Ceilings			……t/……t
Cavity insulation			……t/……t
Composite panels and laminates			……t/……t
Food packaging			……t/……t
Other uses: (please specify)			
			……t/……t
			……t/……t

4. Recycling of EPS and XPS and related HBCD containing products and waste

Although **EPS and XPS can be recycled, the recycling of EPS and XPS that contains HBCD is not allowed in the Convention. If the HBCD concentration is below the low POPs limit of 100 or 1000 mg/kg[38] recycling might be allowed. In the following table information on EPS/XPS recycled, the related HBCD content and the final products will be listed.**

EPS/XPS materials used in recycling (tonnes)	HBCD present or absent and content (mg/kg)*	Products made from recycling (tonnes) Related HBCD content (mg/kg)*	Waste generated during recycling (tonnes) Related HBCD content (mg/kg)*

*** Please provide the levels/range of HBCD in case it is discovered in recycling and provide more detailed information (possibly in an additional explanatory sheet):**

[38] The provisional definition of low POP content for HBCD is 100 mg/kg or 1000 mg/kg (UNEP 2015).

5. HBCD containing EPS/XPS waste (from production and end of life) and related management?[39] (Please use separate sheet if necessary to document all information)

Type of waste/stockpile	Stockpile - total volume (tonnes) - HBCD content (%) - address/location - Condition of stockpile	Waste treatment (please specify), A. destroyed in waste treatment facility, B. Sent to landfill , C. others (also specify) (including addresses)
(a) HBCD as chemical: (i) Pure HBCD; (ii) Obsolete HBCD, which can no longer be used;		
(b) HBCD containing mixtures and articles: (i) EPS beads; (ii) XPS masterbatch; (iii) EPS/XPS foam production waste (cutting waste, etc.);		
c) HBCD-containing waste from demolition: (i) Construction and demolition waste (insulation boards used in foundation, walls and ceilings, ground deck, parking deck, etc.);		
d) HBCD-containing other wastes (i) Packaging materials made of PS foams; (ii) Ornaments and decorations; (iii)EPS loose filling used in furniture (bean bags, sofas etc);		

[39] For the environmental sound management of HBCD containing waste see the *Draft Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with hexabromocyclododecane* (UNEP 2015).

6. Locations contaminated or possibly contaminated with HBCD or EPS/XPS containing HBCD (Please see chapter 8 of the HBCD inventory guidance)

Location/address	**Type of contamination (impacted river or land or landfill) and extent ***	**Type of activity at the location**	**Has the site been investigated?**	**Levels of HBCD in soils and sediments (if available)**

***Details of the contaminated site can be described and submitted on a separate sheet**

7. Further Remarks

8. Information on respondent

Name	
Department	
Position	
Telephone	
Mobile Phone	
Email Address	
Signature of respondent	
Date	

The answers are correct

ANNEX A.2 SAMPLE QUESTIONNAIRE[40] for compiling information on the presence of HBCD in textile application and related recycling and waste

1) Background information

In May 2013, HBCD was listed in the Stockholm Convention as persistent organic pollutants (POPs) in Annex A, with specific exemption in insulation in construction[41] for parties who wish to register for it. Since November 2014 the listing of HBCD to the Stockholm Convention entered into force for most parties[42].

Parties to the Convention for which the amendments have entered into force have to meet the obligations under the Convention to eliminate HBCD for the production and uses not exempted.

Under Article 7 of the Stockholm Convention, Parties are required to develop and endeavour to implement a plan for the implementation of their obligations under the Convention.

To develop effective strategies to eliminate HBCD, Parties need to acquire a sound understanding of their national situation. Such information can be obtained through an inventory of HBCD in different uses.

Extended Polystyrene (EPS) and Extruded Polystyrene (XPS) were the major uses of HBCD in the world market.

The second most important application is in polymer dispersion on cotton or cotton mixed with synthetic blends or synthetic, in the back-coating of textiles (UNEP 2010). The HBCD use in textile is not exempted from Stockholm Convention provisions. Therefore the use of HBCD in this application need to be stopped and the treated textiles are not allowed to be recycled.

2) Aim of this questionnaire

This questionnaire is aimed at gathering information on the current and former use of hexabromocyclododecane (HBCD) in textiles. This include flame retarded textiles in the transport sector, flame retarded textiles in indoor use (e.g. curtains, furniture, mattress ticking) and flame retarded clothing (e.g. fire fighter uniform; military uniform; sleep wear). It needs to be emphasizes that only some of flame retarded textiles in these use sector contain HBCD and also materials can be used which do not need addition of flame retardants. Furthermore the use of flame retardants depend also on the flammability standards in a country.
The information on current and former use of HBCD in the textile sector will be very valuable in order to assess the current situation in these uses sector and will constitute the basis for the country to manage HBCD and related treated materials within the update of the National Implementation Plan of the country.

[40] The questionnaire can be adjusted to suit national circumstances

[41] United Nations (2013) SC-6/13: Listing of hexabromocyclododecane. Reference: C.N.934.2013.Treaties-XXVII.15 (Depositary Notificatification). (decision SC-6/13)

[42] Amendments shall not enter into force for those Parties that have submitted a **notification** pursuant to the provisions of paragraph 3(b) of Article 22 of the Stockholm Convention. Also, in accordance with paragraph 4 of article 22, the amendment will not enter into force with respect to any Party that has made a **declaration** regarding the amendment to the Annexes in accordance with paragraph 4 of Article 25.

1. Name and address of the flame retarded textile producer, user or (major) retailer:

Name	Address

2. Select the type of activity of your textile business or textile use that apply

Manufacturing of textiles in transport seating and other textile/synthetics in transport sector[43]	☐	Manufacturing of textiles applications used indoor[44]	☐
Manufacturing of flame retarded textile clothing[45]	☐	Import of textiles in transport seating and other textile/synthetics in transport sector[43]	☐
Import of flame retarded textile applications used indoor[44]	☐	Import of flame retarded textile clothing[45]	☐
Retail sale of textiles in transport seating and other textile/synthetics for transport sector[43]	☐	Retail sale of flame retarded textiles applications used indoor[44]	☐
Retail sail of flame retarded textile clothing[45]	☐	Recycler of possibly flame textiles from transport sector[43], flame retarded textiles applications used indoor[44], flame retarded textile clothing[45]	☐
Disposal of textiles in transport seating and other textile/synthetics in transport sector[43], textiles applications used indoor[44], textiles clothing[45]	☐	Others (Please specify):	☐

3. Indicate the type of textiles you deal with

Textiles for transport seating and other textile/synthetics in transport sector[43]	☐	Flame retarded textiles applications used indoor[44]	☐
Flame retarded clothing[45]	☐	Textiles for recycling to produce other products	☐
Flame retarded textiles for disposal	☐	Others (Please specify):	☐

[43] Flame retarded textiles in transport might be used in seating, floorcoverings, roof-lining fabrics and other furnishings within the vehicle or vessel interior (see Guidance for the inventory, identification and substitution of Hexabromocyclododecane (HBCD) see chapter 6 (Secretariat of the Stockholm Convention 2017).

[44] This might include curtains, textile upholstery of furniture, bed mattress ticking, wall coverings and draperies (UNEP (2010). Risk profile on hexabromocyclododecane. UNEP/POPS/POPRC.6/13/Add.2; Horrocks 2013).

[45] In particular specific personal protective equipment (PPE) clothing (e.g. for fire fighter and military uniform; other technical textiles, sleep wear) can contain HBCD or other flame retardants.

3. Current and past use of HBCD in flame retarded textile applications (please see table Q3 on next page)

Was or Is HBCD currently used in your textile production, use or sale? (Please fill details in table Q3 below)

Are there particular flammability standards requiring the use of flame retardants (for which textile applications)?

Are you aware that the use of HBCD in textile will be phased out? When have you stopped producing or using HBCD in textiles or when are you planning to stop the use of HBCD?

What alternative chemicals are used for impregnation or coating of textiles? You might fill in the information available from safety data sheets or suppliers/producers.

Name of chemical or mixtures	Product code or number/ CAS number	Use on what type of textile for which product	Weight ratio applied
			[wt%]
			[wt%]
			[wt%]
			[wt%]

Table Q3: (Former) HBCD use in different flame retarded textile application, related content and textile volumes

Flame retarded textile uses	HBCD content (%)	**Years of production and use (from and until)**	**Total volume of HBCD containing textiles (tonnes) (Total historic production/ Current production)**
Textiles used in upholstery in vehicles (cars, busses, trucks) (please specify)			**……t/……t**
Textiles used in user transport (trains, air planes, ships) (please specify)			**……t/……t**
Textiles used in upholstery furniture			**……t/……t**
Mattress ticking			**……t/……t**
Textiles used in roller blinds			**……t/……t**
Other flame retarded textiles used indoor (please specify)			**……t/……t**
			……t/……t
Fire fighter uniform			**……t/……t**
Flame retarded military uniform			**……t/……t**
Flame retarded sleepwear			**……t/……t**
Other flame retarded clothing (please specify)			**……t/……t**
			……t/……t
			……t/……t

Other related information and comments:

4. HBCD containing textile stockpiles and waste (from production and end of life) and related management[46] (Please use separate sheet if necessary to document all information)

Type of waste/stockpile	Stockpile - total volume (tonnes) - HBCD content (%) - address/location - Condition of stockpiles	Waste treatment (please specify including addresses of facilities) A. destroyed in waste treatment facility, B Sent to landfill, C. others (also specify).
(a) Textiles for/from transport Light shredder residues from transport sector (cars, busses, trucks) containing textiles and polymers; Textiles from other transport (trains, air planes, ships)		
(b) Treated Textiles for/from indoor uses (curtains, roller blinds; textiles from furniture upholstery)		
c) Mattress ticking		
d) Flame retarded clothing - Fire fighter uniform - Military uniform - Sleep wear		

Other related information and comments:

[46] For the environmental sound management of HBCD containing waste see the *Draft Technical guidelines onr the environmentally sound management of wastes consisting of, containing or contaminated with hexabromocyclododecane* (UNEP 2015)

5. Locations contaminated or possibly contaminated with HBCD or EPS/XPS containing HBCD (Please see chapter 8 of the HBCD inventory guidance)

Location/address	**Type of contamination**	**Type of activity at the location**	**Have the site been investigated?**	**Levels of HBCD (if available)**

6. If you are a supplier/producer or downstream user of HBCD in textiles please name the company you sell to or buy from (indicate respective):

Name of company	Product	Contact information

7. Please specify the suppliers/producers of the HBCD containing mixtures/materials used

Name of company	Product	Contact information

8. Other remarks from your side

9. Respondent

Name	
Department	
Position	
Telephone	
Mobile Phone	
Email Address	
Signature	
Date	