

CHEMICAL SAFETY REPORT

Substance Name: Hexabromocyclododecane and all major diastereoisomers identified

EC Number: Previously covered by 221-695-9 and 247-148-4

CAS Number: 3194-55-6 - 1,2,5,6,9,10-hexabromocyclododecane

24637-99-4 - hexabromocyclododecane

134237-52-8 for gamma-hexabromocyclodocecane

134237-50-6 for alpha-hexabromocyclodocecane

134237-51-7 for beta-hexabromocyclodocecane

Applicant's Identity:

INEOS Styrenics Netherlands BV

INEOS Styrenics Ribecourt SAS

INEOS Styrenics Wingles SAS

Synthos Dwory 7 spółka z ograniczoną odpowiedzialnością spółka komandytowo-akcyjna.

Synthos Kralupy a.s.

StyroChem Finland Oy

Monotez SA

RP Compounds GmbH

Synbra Technology bv

Sunpor Kunststoff GmbH

Dunastyr Polystyrene Manufacturing C. Co. Ltd

Versalis SpA

Unipol Holland bv

9 EXPOSURE ASSESSMENT

Information in this section is based on information provided by the applicants.

9.1 GENERAL INFORMATION

Note on exposure estimation: The exposure assessment presented here is done in the way that is conventional for a CSA/CSR. However, in the context of an authorisation of a PBT substance, an exposure assessment that takes into account the amount of substance residing in the environment and the contribution that continued use for the requested period (four years) makes is relevant and useful. A report that sets out an approach that takes into account the amount and concentration in the environment from other uses and the additional contribution of continued EPS use and how that changes over time is presented in Appendix 2 to this CSR, and in the SEA report at Appendix F.

Note on worker exposure: The exposure assessment presented in this CSR focuses on environmental exposure. This is because the concern for the substance is as a PBT and thus its effects and impacts on the environment are of relevance. The criterion for toxicity in the context of PBT is fulfilled by the substance's toxicity to aquatic organisms; however this criterion could also be fulfilled by the classification of the substance as Repr. 2 - H361 (Suspected of damaging fertility or the unborn child) – see section 3. This being the case reproductive toxicity is considered in this present CSA/R in the context of possible consumer exposure (so called man via the environment).

The exposure of workers is not reassessed here since it is considered to be beyond the scope of this assessment. However, worker exposure has been assessed as part of the registration of HBCDD in phase 1 of REACH (although the applicants do not have the right of access to the all of the registration CSR, but have been provided with relevant exposure parts of that CSR via extended safety data sheets - eSDS). The assessment of exposure and the relevant risk management measures for safe use for workers have been communicated by the registrants of HBCDD to their downstream users via eSDS. Since all of the applicants for this authorisation application are supplied by at least one of the registrants of the phase 1 registration of HBCDD, it can be assumed that safe use of the substance for workers in formulation of EPS and manufacture of EPS articles (referred to as Use 1 (ES1) and Use 2 (ES1) in this application) has been assessed and communicated in the supply chain. The applicants therefore implement the conditions and risk management measures detailed in the eSDS in order that safe use for workers is achieved in line with the eSDS they have been provided with.

Note on the use of information on extruded polystyrene (XPS) in the EPS assessment:

The use of data and information that refers to XPS is used to 'read across' to EPS, this is because it is a very similar polymer and also uses HBCDD as a flame retardant. Where data on XPS were considered useful to understand releases and emissions of HBCDD from EPS it is used, however there are difference between the two plastics in application due to structural differences between the two materials, so some uncertainty in the accuracy of data from XPS and its direct application to EPS.

9.1.1 Overview

9.1.1.1 Overview of exposure scenarios and uses

The exposure scenarios are based on information in the public domain and information available to the applicants.

Table 9.0.1 gives the overview of uses and exposure scenarios. Tonnages, as reported in Table 9.0.1, for the exposure scenarios assessed are generic tonnages for the largest site/user. These take into account a reasonable fraction of the region (F_{region}) as reported in the relevant exposure scenario section.

Table 9.1.1 Overview of uses broken down by life cycle stages and the exposure scenarios (ES)

ES Number	Stage No. ¹	CSR Section	Exposure scenario name ²	Main user groups (limited to SU3, 21 and 22)	Sectors of end-use (SU)	Product Category (PC)	Process category (PROC)	Article category (AC)	Environmental Release Category (ERC)	Local tonnage assumed (t/a)
ES1	F-1	9.1	Formulation (compounding)	SU3	SU12 SU10	PC32	PROC 3 PROC 4		ERC 2 ERC 3	938
ES2	IW-1	9.2	Manufacture of articles (conversion), cutting of articles and subsequent use	SU3 SU22	SU12 SU19	PC32	PROC 5 PROC 8b PROC 9 PROC 14 PROC21	AC13	ERC 5 ERC11a ERC 12a	90 (conversion) 0.8 (professional use, service life and end of life demolition) 27 (end of life disposal)

¹ Consecutive numbers of each stage; no unique ID numbers.

² An abbreviated names for the exposure scenarios are use the full wording for Use 1 and Use 2 is given in the text.

Manufacture: M-#, Formulation: F-#, Industrial end use: IW-#, Professional end use: PW-#,

9.1.2 Key property data used in the assessment

HBCDD consists of three constituents - the γ -, α - and β -diastereoisomers of hexabromocyclododecane. The substance is a solid at standard temperature with a molecular weight of 641.70 g/mol. The melting points of the three isomers are in the range 170-209°C. The key physicochemical properties that are used in the environmental exposure assessment are:

- Water solubility = 66 $\mu\text{g/l}$
- Log K_{OW} = 5.63. A log K_{oc} of 4.66 is predicted based on this log K_{ow} .
- Vapour pressure = 6.3×10^{-5} Pa (21 °C)

These properties are considered to be reasonable to represent the properties of the whole substance. Further details of physicochemical properties can be found in Section 1.3 of the CSR.

HBCDD is not readily biodegradable in standard studies and does not undergo significant abiotic degradation in water or air. Simulation studies in sediment indicate that HBCDD is degraded in sediment and a half-life of 191 days for the whole substance is used in the assessment. The key simulation study in soil indicated no significant degradation of any of the constituents and therefore no degradation in soil is assumed in the assessment as a reasonable worst-case. Further details of degradation properties can be found in Section 4.1 of the CSR.

The PNECs used in the assessment are as follows:

- Freshwater: 0.31 $\mu\text{g/l}$
- Marine water: 0.031 $\mu\text{g/l}$
- Freshwater sediment: 0.86 mg/kg dwt
- Marine sediment: 0.086 mg/kg dwt
- Soil: 5.9 mg/kg dwt
- Sewage treatment plant: 0.15 mg/l
- Secondary poisoning: 5 mg/kg

The DNEL used for the assessment of man via the environment is:

- General population, oral route: 0.1 mg/kg bw/d

The PNECs and DNEL are taken from the EU Risk Assessment Report (European Commission 2008).

9.1.3 Considerations on the multi-constituent nature of the substance

HBCDD consists of three constituents - the γ -, α - and β -diastereoisomers of hexabromocyclododecane. All Predicted Environmental Concentrations (PECs) refer to HBCDD (whole substance rather than individual isomers) and are based on its physicochemical properties as discussed above.

There are however differences in the properties of the three constituents of the substance:

- γ -HBCDD (the main constituent) is the least soluble and has the highest Log K_{OW}, although these differences are small.
- The key simulation test for biodegradation in sediment showed differences in the rates of degradation of the three constituents. The uncertainties were too great to allow half-lives for each constituent to be defined but it seems that α -HBCDD degrades slowest.

However, the differences are relatively small compared to uncertainties in the measurements and values for individual isomers could not be determined for all relevant properties. Detection of the different isomers of HBCDD has been complicated by the fact that the high temperatures used in GC systems may cause thermal conversion of HBCDD isomers. The key properties listed above are considered representative of the whole substance as registered and are used in the assessment.

9.1.4 Scope and type of exposure assessment

9.1.5 Environment

Table 9.1.2 Scope and type of exposure assessment based on hazard assessment

Protection target	Type of assessment	Explanation / Justification
Water: Fresh Water (Pelagic)	Quantitative	Quantitative exposure estimation (EUSES 2.1.2)
Water: Fresh Water (Sediment)	Quantitative	Quantitative exposure estimation (EUSES 2.1.2)
Water: Marine Water (Pelagic)	Quantitative	Quantitative exposure estimation (EUSES 2.1.2)
Water: Marine Water (Sediment)	Quantitative	Quantitative exposure estimation (EUSES 2.1.2)
Water: Fresh Water Food Chain (Predators)	Quantitative	Quantitative exposure estimation (EUSES 2.1.2)
Water: Marine Water Food Chain (Predators)	Quantitative	Quantitative exposure estimation (EUSES 2.1.2)
Water: Marine Water Food Chain (Top Predators)	Quantitative	Quantitative exposure estimation (EUSES 2.1.2)
Water: Sewage Treatment Plant (Effluent)	Quantitative	Quantitative exposure estimation (EUSES 2.1.2)
Air	Quantitative exposure assessment	Quantitative exposure assessment (EUSES 2.1.2)
Soil: Agricultural Soil	Quantitative	Quantitative exposure estimation (EUSES 2.1.2)
Soil: Terrestrial Food Chain (Predators)	Quantitative	Quantitative exposure estimation (EUSES 2.1.2)

9.1.6 Worker

This assessment focuses only on the properties of the substance that lead to it being PBT and therefore specific worker measures are not part of this assessment.

9.1.7 Regional environmental exposure from the releases of all exposure scenarios covered

9.1.7.1 Total releases

Total regional releases based on the exposure scenarios (ES) described in Sections 9.1 - 9.2 are as follows:

Waste water: 93 kg/year

Surface water: 10 kg/year

Air: 142 kg/year

Soil: 0.1 kg/year

9.1.8 Regional exposure: environment

Table 9.1.3 Summary of predicted regional exposure concentrations (Regional PEC)

Protection target	Regional PEC	Units
Fresh Water	5.2E-07	mg/l
Marine Water	5.0E-08	mg/l
Air	8.4E-09	mg/m ³
Agricultural soil	2.2E-03	mg/kgwwt
Fresh Water (sediment)	3.9E-04	mg/kgwwt
Marine Water (sediment)	1.8E-05	mg/kgwwt

9.1.8.1 Regional exposure: man via the environment

9.1.9 Regional total estimated daily intake for humans:

Table 9.1.4 Summary of estimated daily human doses through intake and concentrations in food from regional exposure

Type of food	Estimated daily dose from regional exposure (mg/kg/day)	Concentration in food from regional exposure
Drinking water	7.8E-08	2.7E-06 mg/l
Fish	1.4E-05	8.6E-03 mg/kg
Leaf crops	8.6E-07	5.0E-05 mg/kg
Root crops	4.8E-05	8.7E-03 mg/kg
Meat	2.1E-07	4.9E-05 mg/kg
Milk	1.2E-07	1.6E-05 mg/kg
Total	6.3E-05	

9.3 EXPOSURE SCENARIO 2 (ES2) MANUFACTURE OF FLAME RETARDED EXPANDED POLYSTYRENE (EPS) ARTICLES FOR USE IN BUILDING APPLICATIONS.

This exposure scenario covers:

- Conversion of solid EPS pellets containing HBCDD as a flame retardant additive into expanded beads and then into EPS articles (ES2a).
- Cutting of flame retardant EPS articles at conversion sites (ES2a).
- Professional use of flame retardant EPS articles at construction sites (ES2b).
- Service-life of flame retardant EPS in construction applications (ES2c).
- Demolition of buildings containing flame retardant EPS at end of life (ES2d).
- End of life disposal of flame retardant EPS (ES2e).

Manufacture of expanded polystyrene articles – conversion and subsequent use	
Market sector:	
Polymer preparations and compounds	PC32
Sector of use:	
Industrial uses	
Manufacture of plastics products, including compounding and conversion	SU12
Professional uses	
Building and construction work	SU19
Environment:	
Industrial use resulting in inclusion into or onto a matrix	ERC5
Wide dispersive indoor use of long-life articles and materials with low release	ERC11a
Industrial processing of articles with abrasive techniques (low release)	ERC12a
Worker	
No relevant	N/A

9.3.1 Exposure estimation

9.3.1.1 ES 2a. Exposure estimation for manufacture of expanded polystyrene articles (conversion), including cutting at conversion sites

This section of the exposure scenario covers the conversion of EPS pellets into EPS articles. It includes cutting of the articles into shape at the conversion sites.

The EPS pellets are converted to expanded beads using steam. The expanded beads can then be moulded into boards and shapes (e.g. insulation boards).

The main stages are:

6. Pre-expansion: The flame retardant EPS pellets are expanded with the help of steam in an atmospheric or pressurised stirred vessel to form larger beads, each consisting of a series of non-interconnecting cells.

7. Conditioning (Curing, maturing): The beads still contain small quantities of both condensed steam and pentane gas. The beads are stored in aerated silos to cool and as they cool, air gradually diffuses into the pores, lowering the pentane (blowing agent) to the optimised ratio prior to moulding.
8. Moulding: The beads are moulded to form boards, blocks or customised products, where steam and perforated aluminium moulds are used to shape/fuse each bead to its neighbours, thus forming a homogeneous product.
9. Shaping (Block cutting): The moulded flame retardant EPS is then stored to cool down, decreasing water content and reaching dimension stability equilibrium. The moulded block is removed from the machine, and blocks are cut in boards or in specific shapes.
10. Post-production processing: The finished product can be laminated with foils, plastics, roofing felt, fibreboard or other facings such as roof or wall cladding material.

During manufacture of EPS articles, the EPS pellets/beads are expanded to form moulded articles that can be further shaped by cutting, sawing or grinding.

In the first processing stage the pellets/beads of EPS are expanded at a temperature of about 100-110°C in a sealed vessel called a 'pre-expander' into which steam is fed. The temperature softens the beads and the expansion of blowing agent they contain (i.e. pentane) causes the pellets/beads to expand up to 50 times their original size. The final bulk density of the beads depends on temperature and steaming time. The bulk density at this stage determines the density of the resulting article. Pre-expansion can be done batch-wise or continuously.

In a batch pre-expander, the vessel is charged with an appropriate mass of EPS raw material pellets/beads and purged with steam to remove most of the air. While the beads are agitated by a stirrer, further steam is admitted until the pressure reaches the desired value. Since the level of the material in the vessel rises as the beads expand, the beads can be discharged shortly after the required degree of expansion has been attained. The density of the pre-expanded beads can be adjusted automatically in different ways. The pressure in a batch pre-expander can exceed atmospheric pressure, so that steam temperatures can be appreciably greater than 100 °C.

In a continuous pre-expander, the EPS raw material is introduced continuously at the bottom of the vessel and expanded beads leave at the top. As in a batch pre-expander, the beads are agitated by a stirrer. Steam is supplied steadily at a fixed rate; the inlet excess pressure is kept as low as possible. As a rule, the expanded beads leave the vessel through an opening at a constant height. The density can be adjusted automatically by varying the feed rate.

The beads cool down when leaving the pre-expander. A partial vacuum develops within the individual expanded beads caused by condensation of residual blowing agent. The pressure is equalized by storing the beads to allow air to diffuse into the cells, which is a relatively slow process. The intermediate storage in silos lasts for about 12 hours and stabilizes the beads, making them ready for further processing.

Expansion of the EPS beads takes place within a closed system; aqueous solutions which may potentially contain the registered substance are recycled back into the system to avoid waste of the registered substance and environmental release.

For the moulding of blown EPS beads into blocks and boards, the beads are placed into a metal mould. The mould is closed and steam is passed through it. A vacuum is introduced before and after the steaming. The residual blowing agent within the beads causes them to expand again and fuse together into a homogenous block of foam. After a short cooling phase, the EPS article

CHEMICAL SAFETY REPORT – HEXABROMOCYCLODODECANE CAS 3194-55-6, 24637-99-4, 134237-52-8, 134237-50-6, 134237-51-7

(e.g. board or block) is removed from the mould and allowed to stabilize before being processed further.

After some hours of ageing, the moulded blocks may be cut into final dimensions. Cutting is needed to split the block and to achieve better tolerances and flatness. One standard dimension is 600 mm x 1200 mm x length. Normally, dimensions that make use of the total volume of the block are preferred. This cutting is usually done with hotwire cutting equipment, however sawing or grinding of boards can take place. Grinding can be used to improve the adhesion properties of the surface prior to laminating.

Operational conditions and risk management measures	
Control of environmental exposure: Manufacture of expanded polystyrene articles - conversion	
Product characteristics	
Physical Form	Within polymer matrix
Substance in preparation	No
Amounts used	
Daily use at a site	≤391 kg
Annual use at a site	≤90 tonnes (of HBCDD, equivalent to approximately 13 000 tonnes EPS)
Percentage of total EU tonnage used at regional scale	10
Fraction of regional tonnage used at local scale	0.11
Frequency and duration of use	
Number of Emission days per year:	≥230
Environment factors not influenced by risk management	
Receiving surface water flow rate	18000 m ³ /day (corresponding to a dilution factor of 10).
Basis for the above: Default for a standard town - (corresponding to a dilution factor of 10).	
Other given operational conditions affecting environmental exposure	
Technical conditions and measures at process level (source) to prevent release	
Exhaust/ventilation systems. Local Exhaust Ventilation used when cutting, sawing or grinding EPS boards. No dust emission to air. Contaminated dust ('wipe dirt') to landfill or incineration.	
Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil	
Use of dust filters (95% efficiency). Use of industrial vacuum cleaners (90% efficiency). Process water recirculated. Residual direct to drain. EPS scrap is recycled back into the process at the same site. EPS scrap cannot be sold for recycling.	
Organisational measures to prevent/limit release from site	
Conditions and measures related to municipal sewage treatment plant	
Onsite/Municipal STP	Yes
Discharge rate of STP	2000 m ³ /day
Basis for the above: Default assumption	
Application of the STP sludge on agricultural soil	Yes (worst case)
Basis for the above: Default assumption	

Conditions and measures related to external treatment of waste for disposal
Appropriate waste code (EC, 2000): 07 02 13* waste plastic
Conditions and measures related to external recovery of waste
N/A
Additional good practice advice beyond the REACH CSA

9.3.1.1.1 Exposure estimation for the environment

Conversion

This scenario covers conversion of solid EPS pellets containing HBCDD as a flame retardant additive into expanded beads and then into EPS articles. HBCDD is bound into the polymer matrix of the polystyrene pellets; therefore potential for release is minimal.

Conversion of EPS containing flame retardants is discussed in the OECD Emissions Scenario Document for Plastics Additives (OECD 2009). EPS conversion is stated to take place in a closed process. Therefore, the default release factors from the Emission Scenario document for conversion in a closed process are used here.

Some of the losses are of particulates. Some of the loss is likely to be initially to the atmosphere (as dust), but ultimately all particulates will be removed or settle and losses will be to solid waste or to waste water as a result of wash down. Therefore, as a worst case it is assumed that all this loss will eventually be released to waste water. Volatile losses are initially losses to the atmosphere. However, the processes involve elevated temperatures and subsequent condensation could result in losses to liquid waste. As a reasonable worst case it was assumed that 50% of this is lost to waste water and 50% is lost to the atmosphere (OECD 2009). This approach is followed in the current assessment.

The release factors apply to sites producing >750 tonnes plastic per year and processes at $\leq 200^{\circ}\text{C}$ (OECD 2009); these conditions apply to the current assessment.

Releases to air

The release factor to air of 0.001% ($1\text{E-}05$) is used.

This is a loss of HBCDD of $391 \text{ kg/day} * 1\text{E-}05 = 3.9\text{E-}03 \text{ kg/day}$.

Releases to water

The release factor to water of 0.001% ($1\text{E-}05$) is used.

This is a loss of HBCDD of $391 \text{ kg/day} * 1\text{E-}05 = 3.9\text{E-}03 \text{ kg/day}$.

Cutting

The EU RAR for HBCDD (European Commission 2008) estimates a worst-case loss of 100 g/tonnes HBCDD from cutting of boards. This is based on a measurement of 445 g particles per tonne EPS being released during sawing of EPS boards. This estimate assumed that every tenth board was sawed, and always along the short side. The boards were 6 cm thick, the short side 60 cm, and the long side either 125 or 104 cm. The overall estimate is reduced to 100 g / tonnes because it is more common to make a cut in the board with a sharp knife and then to break the board, or -at large sites, to cut the boards with a “hot wire”. In both methods of

cutting EPS-boards result in much less particles being formed, as compared to sawing. The distribution of this release was assumed to be 50 % to surface water and 50 % to air.

This is covered under the professional use scenario in the RAR. However, information from the EPS industry (gathered from the applicants – EPS HBCDD consortium members) indicates that the majority of cutting takes place at conversion sites. The majority of this cutting is done using hot-wire techniques, however, other techniques may be used, including grinding of surfaces to improve adhesion properties. Therefore, the estimate of 100 g particles/tonne EPS being released during cutting of boards is used as a reasonable worst-case. However, control measures including use of Local Exhaust Ventilation (LEV), collection of dust, and use of industrial vacuum cleaners are in place at conversion sites. Therefore, at least 95% of this release is removed by the ventilation system and by clean-up operations. This waste may be recycled into the process on site or landfilled or incinerated. This leaves a release of 5 g/tonne, which is assumed, as a reasonable worst case, to go 50% to air and 50% to water. The release fractions are therefore 2.5E-6 to both air and waste-water. The release to water is treated in WWTP before discharge.

Releases to air

The release factor to air of 2.5E-06 is used.

This is a loss of HBCDD of $391 \text{ kg/day} * 2.5\text{E-}06 = 9.8\text{E-}04 \text{ kg/day}$.

Releases to water

The release factor to water of 2.5E-06 is used.

This is a loss of HBCDD of $391 \text{ kg/day} * 2.5\text{E-}06 = 9.8\text{E-}04 \text{ kg/day}$.

Considerations on waste

The foreseeable non-aqueous and solid wastes containing the substance arising from this use are waste packaging contaminated with EPS, filters and filter dust, and dust from vacuuming. Non-contaminated dust is recycled back into the process; contaminated dust may be landfilled or incinerated.

The release factors for conversion above are assumed to include consideration of losses from waste (European Commission 2008).

For cutting of boards, 95% of the particles generated during cutting operations are assumed to end up in waste. This is a total of 95 g/tonne (a fraction of 9.5E-5). This waste may be recycled into the process on site or landfilled or incinerated. The greatest environmental releases would result if all this waste were landfilled. Therefore, releases from landfill of this waste are quantified based on default values from the ECHA guidance on exposure scenario building and environmental release estimation for the waste life stage (Chapter R.18) (ECHA, 2010b).

Release fraction to water: 0.032

Release fraction to air: 0

Release fraction to soil: 0.0016

Therefore, the release of HBCDD to water resulting from landfilling of EPS waste is:

$391 \text{ kg/day} * 9.5\text{E-}5 * 3.2\text{E-}2 = 391 * 3.0\text{E-}6 = 1.2\text{E-}3 \text{ kg/d}$

Therefore, the release of HBCDD to soil resulting from landfilling of EPS waste is:

$$391 \text{ kg/day} * 9.5\text{E-}5 * 1.6\text{E-}3 = 391 * 1.5\text{E-}7 = 5.9\text{E-}5 \text{ kg/d}$$

Table 9.3.1 Summary of the local releases to the environment

Compartment	Release factor estimation method	Explanation / Justification
Water	OECD ESD Plastics Additives (OECD 2009)	<p>Use in EPS conversion: Release factor: 1.0E-05 Use in EPS conversion: Local release rate (kg/day): 3.9E-03 kg/d</p> <p>Use in EPS cutting: Release factor: 5.5E-06 (2.5E-06 for cutting, 3.0E-06 for landfill) Use in EPS cutting: Local release rate (kg/day): 2.2E-03 kg/d</p> <p>Use in EPS conversion and cutting: Release factor: 1.55E-05 Use in EPS conversion and cutting: Local release rate (kg/day): 6.1E-03 kg/d</p>
Air	OECD ESD Plastics Additives (OECD 2009)	<p>Use in EPS conversion: Release factor: 1.0E-05 Use in EPS conversion: Local release rate (kg/day): 3.9E-03 kg/d</p> <p>Use in EPS cutting: Release factor: 2.5E-06 (cutting) Use in EPS cutting: Local release rate (kg/day): 9.8E-04 kg/d</p> <p>Use in EPS conversion and cutting: Release factor: 1.25E-05 Use in EPS conversion and cutting: Local release rate (kg/day): 4.9E-03 kg/d</p>
Soil	OECD ESD Plastics Additives (OECD 2009)	<p>Use in EPS conversion: Release factor: 0 Use in EPS conversion: Local release rate (kg/day): 0</p> <p>Use in EPS cutting: Release factor: 1.5E-07 (landfill) Use in EPS cutting: Local release rate (kg/day): 5.9E-05 kg/d</p> <p>Use in EPS conversion and cutting: Release factor: 1.5E-07 Use in EPS conversion and cutting: Local release rate (kg/day): 5.9E-05 kg/d</p>

Summed releases from all life cycle stages: see section 9.0.3.

9.3.1.2 ES2b. Exposure estimation for professional use of flame retardant EPS articles at construction sites

This section of the exposure scenario covers professional use of EPS insulation boards at construction sites.

Uses of EPS can be broadly categorised into two main groups: building applications and packaging, with most (>85%) flame retarded (FR) EPS (i.e. containing HBCDD) being used for building applications. A list of building applications are shown below (from EUMEP¹⁴):

- 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
- Civil engineering applications
- 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)
- Seismic applications
- EPS drainage boards

The relative market share of FR EPS, compared to alternative FR products, is largely attributed to its price-competitiveness and the desirable function of being very light and easy to use as a final product (i.e. it can be easily mounted and fitted together).. In construction applications, use of FR EPS reduces costs in transport, handling and overall construction time to insulate buildings.

The use of flame retardant EPS boards is not uniform across Europe as both fire safety regulations and general building practice vary between countries. Germany has a more extensive use of EPS for building insulation than most other countries, (IAL 2009). This is estimated as 20% of that used in the EU-28 and therefore, a fraction for the region of 20% is used in the chemical safety assessment. This applies to professional use and the subsequent service life, demolition and disposal stages. This gives a regional tonnage of $8000 * 0.2 = 1600$ tpa.

The fraction of the regional tonnage at the local site is taken as 0.0005, as this is a wide-dispersive used. This gives a local tonnage of $1600 * 0.0005 = 0.8$ tpa HBCDD. This is equivalent to approximately 110 tpa EPS. Assuming a density of 0.045 g/cm^3 (Brandsch 2012) or 45 kg/m^3 , this is 2400 m^3 . If an average board is 6 cm thick, this is $40\,000 \text{ m}^2$ of EPS boards. This represents a large construction site; therefore, the number of days per year is taken as 250.

The assessment below is based on a modelling approach applied using the parameters set out in the table below.

Operational conditions and risk management measures for professional use, service life

¹⁴EUMEPS website: EPS material structure

http://www.eumeps.org/applications_4536.html?psid=48b0867885827f241ef221fd4693fc2d

and demolition

Operational conditions and risk management measures	
Control of environmental exposure: use of flame-retarded expanded polystyrene articles.	
Product characteristics	
Physical Form	Solid (within polymer matrix)
Substance in preparation	N/A
Amounts used (quoted as amount of HBCDD)	
Daily use at a site	0.0032 t/d (3.2 kg/d)
Annual use at a site	0.8 t/a
Percentage of total EU tonnage used at regional scale	20
Fraction of regional tonnage used at a local site	0.0005
Frequency and duration of use	
Number of emission days per year:	250
Basis for the above: Defaults for a wide-dispersive use	
Environment factors not influenced by risk management	
Receiving surface water flow rate	18000 m ³ /day (corresponding to a dilution factor of 10).
Basis for the above: Default for a standard town	
Other given operational conditions affecting environmental exposure	
Technical conditions and measures at process level (source) to prevent release	
Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil	
Waste EPS boards are disposed of via incineration	
Organisational measures to prevent/limit release from site	
Conditions and measures related to municipal sewage treatment plant	
Onsite/Municipal STP	No
Discharge rate of STP	n/a
Basis for the above: Default for a standard town	
Application of the STP sludge on agricultural soil	n/a
Basis for the above: Default assumption.	
Conditions and measures related to external treatment of waste for disposal	
Appropriate waste code (EC, 2000): 07 02 13* waste plastic	
Conditions and measures related to external recovery of waste	
N/A	
Additional good practice advice beyond the REACH CSA	
None	

9.3.1.2.1 Exposure estimation for the environment

Volatilisation of HBCDD from boards during construction is considered to be very minimal compared to the release during service life due to the shorter timescale. Any release is considered to be covered by the estimates of releases during service life in Section 9.3.3 below.

This part of the exposure scenario therefore covers release of HBCDD resulting from cutting or shaping of boards during the construction process. As far as possible, boards are shaped and processed (for example laminated with foils, plastics, roofing felt, fibreboard or other facings) at conversion sites. They can then quickly be put in place at the construction site. However, a small proportion will need some further processing, for example, cutting to fit around windows or doors. This is commonly done by making a cut in the board with a sharp knife and then breaking the board or, at large sites by hot-wire cutting (European Commission 2008). However, it may occasionally be done by sawing or grinding.

The EU RAR for HBCDD uses a worst-case estimate of the releases from cutting of EPS boards containing HBCDD as 100 g/tonne. This was based on 10% of the boards being cut. Information from the EPS industry (information gathered from the applicants) indicates that this is correct and 10% of boards are cut at conversion sites with measures to capture dust in place (see Section 9.3.1). During professional use (i.e. at construction sites) it is estimated that only 10% of boards are cut due to the need to cut boards to the correct size for installation (so called on-site sizing), involving hot-wire, knife and saw. Industry recommends the use of hot wire cutting which is used on larger building works. The estimate for cutting by saw is ca. 1-2% of sizing operations. Therefore a release of 10 g/tonnes during professional use is used in this assessment. The distribution of this release is assumed to be 50 % to surface water and 50 % to air, following the approach in the EU RAR.

Releases to air

The release factor to air of 5E-06 is used.

This is a loss of HBCDD of $3.2 \text{ kg/day} * 5\text{E-}06 = 1.6\text{E-}05 \text{ kg/day}$.

Releases to water

The release factor to water of 5E-06 is used.

This is a loss of HBCDD of $3.2 \text{ kg/day} * 5\text{E-}06 = 1.6\text{E-}05 \text{ kg/day}$.

Considerations on waste

Any waste flame retardant EPS should be disposed of via incineration. Releases from incineration are covered under the releases from end of life disposal.

Table 9.3.2 Summary of the local releases to the environment for professional use

Compartment	Release factor estimation method	Explanation / Justification
Water	EU RAR (European Commission 2008)	Cutting of boards: Release factor: 5E-06 Cutting of boards: Local release rate (kg/day): 1.6E-05 kg/d
Air	EU RAR (European Commission 2008)	Cutting of boards: Release factor: 5E-06 Cutting of boards: Local release rate (kg/day): 1.6E-05 kg/d

Soil	EU RAR (European Commission 2008)	Cutting of boards: Release factor: 0 Cutting of boards: Local release rate (kg/day): 0
------	--------------------------------------	---

Summed releases from all life cycle stages: see section 9.0.3.

9.3.1.3 ES2c. Exposure estimation for service-life of flame retardant EPS in construction applications

This section of the Exposure Scenario covers releases from flame retardant EPS during service life. HBCDD is used in EPS foams for insulating applications in buildings and in uses related to civil engineering where fire safety has to be considered. The following main applications have been identified:

- Internal and external walls.
- Roofs¹⁵.
- Floors.
- Perimeters.

The service life of the boards is estimated as 30 to 100 years (European Commission 2008).

As discussed in Section 9.3.1.2 above, use of flame retardant EPS insulation boards is not uniform over Europe and the percentage of the EU tonnage at regional scale is taken to be 20%. The fraction of the regional tonnage used at a local scale is taken as 0.0005; the default for a wide-dispersive use.

The assessment below is based on a modelling approach applied using the parameters set out in the table below.

Operational conditions and risk management measures for service life

Operational conditions and risk management measures	
Control of environmental exposure: use of flame-retarded expanded polystyrene articles.	
Product characteristics	
Physical Form	Solid (within polymer matrix)
Substance in preparation	N/A
Amounts used (quoted as amount of HBCDD)	
Daily use at a site	0.002 t/d (2 kg/d)
Annual use at a site	0.8 t/a
Percentage of total EU tonnage used at regional scale	20
Fraction of regional tonnage used at a local site	0.0005
Frequency and duration of use	
Number of emission days per year:	365

¹⁵ Includes inverted roof applications (where the insulation is above the waterproof layer, rather than below it as in other forms of roofing). Note that inverted roof is a very limited use of EPS.

Basis for the above: Defaults for a wide-dispersive use	
Environment factors not influenced by risk management	
Receiving surface water flow rate	18000 m ³ /day (corresponding to a dilution factor of 10).
Basis for the above: Default for a standard town	
Other given operational conditions affecting environmental exposure	
Technical conditions and measures at process level (source) to prevent release	
Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil	
N/A	
Organisational measures to prevent/limit release from site	
Conditions and measures related to municipal sewage treatment plant	
Onsite/Municipal STP	No
Discharge rate of STP	n/a
Basis for the above: Default for a standard town	
Application of the STP sludge on agricultural soil	n/a
Basis for the above: Default assumption.	
Conditions and measures related to external treatment of waste for disposal	
Appropriate waste code (EC, 2000): 07 02 13* waste plastic	
Conditions and measures related to external recovery of waste	
N/A	
Additional good practice advice beyond the REACH CSA	
None	

9.3.1.3.1 Exposure estimation for the environment

Losses of HBCDD to the environment during service life of EPS may result from volatilisation or leaching to water (OECD 2009). The experimental and modelling data relating to both of these losses are reviewed below. The possibility that exposure to light might cause degradation of the EPS and therefore increase losses of HBCDD is also considered. Measurements made on both EPS and XPS foam are considered; read-across between XPS and EPS is discussed in Section 9.0.

For EPS used in walls, exposure to air and light may be relevant. Under typical applications the foam is not exposed to light since the foam is covered with a facing or layer so that light is not able to reach the EPS. Generally, in Europe the foam is used quickly meaning that it is normally not stored for long periods of time outside before construction, which limits exposure to light. Only in the case of agricultural building is the foam exposed on the walls; however, even in this case there is limited exposure to light.

For inverted roof, cellar and perimeter applications, exposure to (rain) water is relevant. Although this use is limited, the inverted roof (upside-down roof) is considered to be the worst-case application scenario for potential emissions of HBCD to water. This is because there is direct contact with water in the form of rain, and the water run-off may lead to exposure to the environment via drains and directly to the soil compartment.

a) Durability of EPS under exposure to light

Experience from long-term results (up to 32 years' service-life) indicates that the foam is durable during service life when the foam is covered according to the technical rules. It has been found that no decomposition of foam is expected after prolonged service life when it is covered in the application, which indicates that it can reasonably be expected that HBCD remains retained within the stable polymer matrix (Exiba 2013).

For uncovered XPS specimens, measurements of bromine content have been made in XPS foam specimens for a period of approximately 19 years. The specimens were cubes of approximately 8 cm³ volume with HBCD content in the range of 0.3% to 5.8%. The cubes were stored in natural light and under standard laboratory conditions with respect to temperature and humidity. Total bromine content was measured in 1987/8 using the neutron activation method and in 2007 using X-ray fluorescence. According to these measurements it was concluded that levels of HBCD remained stable in all the cubes for a period of approximately 19 years (Exiba 2013).

The conclusion (Exiba 2013) is that no loss of HBCD is expected to occur in the foam during service life, even when exposed to natural light. Hence, it is demonstrated that HBCD is retained in a stable polymer matrix during service life. It can be assumed that the same assessment can be applied to EPS (see Section 9.0).

b) Exposure to water – Inverted roof

An examination of an XPS foam board from an inverted roof (25 years' service life) has been made by measurements of the bromine level in samples taken at different points across the board. Total bromine content was measured and compared to the original levels detected immediately after the production of the foam. The original concentration of HBCD in 1982 was 0.61%. In 2007, concentrations across the foam were between 0.59% and 0.62%, with an average of 0.61%. The standard deviation for the total 12 analyses was 0.01%. This study showed that the HBCDD was equally distributed in the foam and the levels remain at a similar level (within the experimental error of 0.01%) compared to the initial levels (Exiba 2013).

The conclusion is that HBCDD is not likely to be released into the rain water during service life of XPS foam boards, even when considering the worst case scenario of inverted roof. It is understood that EPS is used in inverted roofs only in very limited applications and hence not exposed to water in the same way as XPS in this particular application. This could therefore represent a worst case for read across in terms of exposure of the foam to water in service life. However, as with other read-across from XPS to EPS, it is acknowledged that XPS is different foam to EPS and XPS is known to be more resistant to water than EPS. Nevertheless, this information on XPS regarding the stability of HBCDD within the polystyrene matrix should not be disregarded as it is demonstrated that HBCDD is retained in a stable polymer matrix during service life. It can be assumed that this assessment can be applied to EPS (Exiba 2013).

c) Emissions to air: emission test chamber experiment

The emission test chamber experiment can, similarly to the inverted roof case, be considered to be the worst-case scenario for potential emissions of HBCDD to, in this case, the (indoor) air compartment. This is because of the relatively small volume of the test chamber and the high air exchange rate (Exiba 2013).

Polystyrene boards with an emitting surface of 0.931 m² were incubated in an emission test chamber with a volume of 200 L and an air exchange rate of 0.4 m³ / h for 90 days at room

temperature. The air was directed through glass wool adsorber for 42 and 48 days, respectively (total duration 90 days) and the latter extracted with dichloromethane. For both collection periods no HBCDD could be found in the dichloromethane extract (limit of quantification 20 ng/m³).

The conclusion is that HBCDD is not likely to be emitted into the surrounding air during service life of PS foam boards. Hence also this experimental setup demonstrates that HBCD is retained in a stable polymer matrix during service life (Exiba 2013).

d) Emissions to air: Air blowing experiment

Emission experiments have been conducted to measure the loss of HBCDD from foamed polystyrene (EC 2008). Air was blown through a tube with a surface of 0.15 m² (40 mm diameter and length of 1200 mm, 15 l/h flow) of foamed polystyrene (extruded polystyrene -XPS, containing respectively 1.2 and 2.0 % HBCDD with a density of 35 g/l). The emitted HBCDD was adsorbed on PUR-foams thus minimising any surface effects. After the sampling period the PUR-foams were extracted and HBCDD was determined by LC/MS with a detection limit of about 4 ng HBCDD per sample (EC 2008).

The highest total emission measured was 70 ng/m² HBCDD in five days (= 5 µg/m² per year) (EC 2008).

The following limitations of the experiment were noted:

- The material used in the experiment was new and the release may differ over time because of migration. [The modelling work discussed below indicates that it would decrease over time].
- The environment in which the material is located during use may be different to the experiment.
- The experiment does not consider air saturation.

e) Migration modelling

HBCDD emissions from EPS/XPS have been simulated using standard models for migration of substances out of plastics (Brandsch 2012). A model based on the diffusion law was used. This assumes that the diffusion process is the rate determining step and may result in an overestimation if the evaporation rate becomes rate determining. This may be the case for a low vapour pressure substance such as HBCDD.

A two layer model was used. The skin layer of the polystyrene material was a continuous layer of polystyrene (PS) with a density of 1.05 g/cm³ and estimated thickness of 1 µm. The bulk layer of the material was formed by polystyrene foam, with an apparent density of 0.045 g/cm³. The concentration of HBCD in both layers was 1% (= 10000 ppm or mg/kg).

An activation energy of 140 kJ/mol was derived by fitting to data from measurements of HBCDD emissions to air from polystyrene boards. The emission rate was found to decrease over time with a rate of 881 ng/m²/day on day 1, 68.7 ng/m²/day on day 30 and 49.8 ng/m²/day on day 85. Over a 100 year service life a cumulated total emission of 175 µg/m² HBCDD after 100 years at 23°C was calculated.

Approach to emission fractions

The EU RAR for HBCDD (EC 2008) considered that there were no releases to water from polystyrene boards during service life. This approach is supported by the exposure to water study above (b), which demonstrated that HBCDD levels in XPS in an inverted roof remained stable over a 25 year service life. It is also consistent with the low solubility in water of HBCDD. This approach is therefore followed in the current assessment.

The air blowing experiment discussed in point (d) above was used in the EU RAR as the basis of the estimate of emissions to air (EC 2008). A total annual use of 350 million m² flame retarded foamed polystyrene in Western Europe and an emission of 70 ng/m² (0.07 µg/m²) HBCDD in five days was used to calculate an emission of HBCDD per year to air of about 1.8 kg HBCDD. The consumed annual amount of HBCDD in these applications of 7364 tonnes was used to give a loss factor to air of about 2.4E-05 % per year. The steady state emissions from the polystyrene boards are the emissions from the annual consumed amount multiplied with the service life of the boards (30-100 years). To reflect current emissions, a service life of 30 years was assumed because the boards were not believed to have been used much more than 30 years back. This gives a steady state emission of 7.2E-04% (EC 2008).

The same method may be applied to the calculated total emission of 175 µg/m² HBCDD after 100 years from the migration modelling ((d) above):

- 350 million m² flame retardant foamed polystyrene corresponds to 7364 tonnes, therefore the service area to mass ratio is 48 000 m² EPS/tonne HBCDD.
- The total emission over the maximum 100 year service life is 175 µg/m². 175 µg/m² * 48 000 m²/tonne = 8 400 000 µg/tonne = 8.4 g/tonne = 8.4E-04 %.
- This is an average emission per year of 8.4E-06 %.

The steady state emission of over the service life of 100 years is therefore 8.4E-04%. This is consistent with the figure calculated in the EU RAR.

In the current assessment, the slightly higher figure of 8.4E-04% is used.

Emission to Air

As discussed above, the release factor to air of 8.4E-06 over a 100 year service life is used in the modelling.

This gives a local release of HBCDD of 0.8 tpa * 8.4E-06 = 6.7E-03 kg over a 100 year service life. A local release of 6.7E-03/365 days = 1.8E-05 kg/day is used in the modelling.

Emission to water

There are no emissions to water from this part of the scenario.

Table 9.3.3 Summary of the local releases to the environment for service life

Compartment	Release factor estimation method	Explanation / Justification
Water	EU RAR (European Commission 2008)	Service life of EPS articles: Release factor: 0 Service life of EPS articles: Local release rate (kg/day): 0

Air	EU RAR (European Commission 2008)	Service life of EPS articles: Release factor: 8.4E-06 Service life of EPS articles: Local release rate (kg/day): 1.8E-05 kg/d
Soil	EU RAR (European Commission 2008)	Service life of EPS articles: Release factor: 0 Service life of EPS articles: Local release rate (kg/day): 0

Summed releases from all life cycle stages: see section 9.0.3.

9.3.1.4 ES2d. Exposure estimation for demolition of buildings containing flame retardant EPS at end of life

This section of the exposure scenario covers demolition of buildings containing flame retardant EPS at end of life. In general, methods for demolition of buildings include (US EPA; www.epa.gov/epaoswer/non-hw/debris/):

- implode a structure with explosives,
- use a crane and wrecking ball technique, or
- deconstruct the structure.

These methods may all result in release of small particles and fragments of EPS to the environment. HBCDD may then be released to the environment.

Current practice at the time of writing for demolition of buildings insulated with EPS was discussed in the EU RAR (European Commission 2008). Future releases of HBCDD from demolition of buildings insulated with flame retarded polystyrene were identified as an uncertainty in that assessment. The uncertainties depended, among other things, on how and by whom the demolition would be performed. It was estimated at this time that approximately 30% of boards were recycled, requiring manual deconstruction of the structures. The remaining 70% of material was disposed of, and these buildings were assumed not to be manually deconstructed.

However, the EPS articles produced during the Authorisation period will not reach end of life for several decades. Practice for demolition of buildings may change significantly during this period, with a greater trend towards manual deconstruction such that those components that are recyclable can be recycled and other components can be disposed of in a way that is not damaging to the environment.

In recent years, awareness of the potential environmental impact of the HBCDD flame retardant has grown. The current Application for Authorisation does not include recycling of flame retardant EPS. A labelling scheme is proposed to allow boards not containing flame retardant to be identified as appropriate for recycling (a proposal for this scheme is described in section 5.2 of the Analysis of Alternatives that is part of this application). The following Risk Management Measures are applied in this CSR to prevent release of HBCDD to the environment:

- All flame retardant EPS will be incinerated at end of life (see Section 9.3.1.5).
- Buildings will be manually deconstructed (see Section 9.3.1.4.1).

As discussed in Section 9.3.1.2 above, use of flame retardant EPS insulation boards is not uniform over Europe and the percentage of the EU tonnage at regional scale is taken to be 20%. The fraction of the regional tonnage used at a local scale is taken as 0.0005; the default for a wide-dispersive use.

The assessment below is based on a modelling approach applied using the parameters set out in the table below.

Operational conditions and risk management measures for demolition

Operational conditions and risk management measures	
Control of environmental exposure: use of flame-retarded expanded polystyrene articles.	
Product characteristics	
Physical Form	Solid (within polymer matrix)
Substance in preparation	N/A
Amounts used (quoted as amount of HBCDD)	
Daily use at a site	0.002 t/d (2 kg/d)
Annual use at a site	0.8 t/a
Percentage of total EU tonnage used at regional scale	20
Fraction of regional tonnage used at a local site	0.0005
Frequency and duration of use	
Number of emission days per year:	365
Basis for the above: Defaults for a wide-dispersive use	
Environment factors not influenced by risk management	
Receiving surface water flow rate	18000 m ³ /day (corresponding to a dilution factor of 10).
Basis for the above: Default for a standard town	
Other given operational conditions affecting environmental exposure	
Technical conditions and measures at process level (source) to prevent release	
Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil	
Buildings containing flame retardant EPS are manually deconstructed.	
Organisational measures to prevent/limit release from site	
Conditions and measures related to municipal sewage treatment plant	
Onsite/Municipal STP	No
Discharge rate of STP	n/a
Basis for the above: Default for a standard town	
Application of the STP sludge on agricultural soil	n/a
Basis for the above: Default assumption.	
Conditions and measures related to external treatment of waste for disposal	
Appropriate waste code (EC, 2000): 07 02 13* waste plastic	
Conditions and measures related to external recovery of waste	
N/A	
Additional good practice advice beyond the REACH CSA	
None	

9.3.1.4.1 Exposure estimation for the environment

Releases from manual deconstruction of buildings containing EPS were estimated as 90 g/tonne in the EU Risk Assessment Report for HBCDD (European Commission 2008). This was based on an experiment mimicking manual deconstruction by manual breaking of boards. The release was measured by weighing of particles being formed. No particles were formed by two breaks of a 456 g XPS-board, whereas two breaks of a 287 g EPS-board was estimated to generate 0.026 g particles, giving an emission factor of 90 g EPS-particles/tonne EPS.

For the demolition material not being recycled, the lack of information on how much the PS-boards are being broken during demolition made it difficult to calculate the potential emissions (European Commission 2008). Therefore, the release factor of 0.1 % was used in the EU RAR for the 70 % of EPS not being recycled (European Commission 2008).

Manual deconstruction of buildings containing fire retardant EPS is imposed as a Risk Management Measure in the present assessment. This allows largely intact boards to be incinerated and releases to the environment to be minimised. Therefore, a release factor of 9.0E-05 (90 g/tonne) is used in the current modelling, based on the EU RAR estimate for manual deconstruction. 50% is assumed to go to waste water and 50% to air.

Emission to Air

The release factor to air of 4.5E-05 is used in the modelling.

This gives a local release to air of HBCDD of $4.5\text{E-}05 * 2 \text{ kg/day} = 9\text{E-}05 \text{ kg/day}$.

Emission to water

The release factor to water of 4.5E-05 is used in the modelling.

This gives a local release to water of HBCDD of $4.5\text{E-}05 * 2 \text{ kg/day} = 9\text{E-}05 \text{ kg/day}$.

Table 9.3.4 Summary of the local releases to the environment for demolition

Compartment	Release factor estimation method	Explanation / Justification
Water	EU RAR (European Commission 2008)	Demolition of buildings containing EPS articles: Release factor: 4.5E-05 Demolition of buildings containing EPS articles: Local release rate (kg/day): 9E-05 kg/d
Air	EU RAR (European Commission 2008)	Demolition of buildings containing EPS articles: Release factor: 4.5E-05 Demolition of buildings containing EPS articles: Local release rate (kg/day): 9E-05 kg/d
Soil	EU RAR (European Commission 2008)	Demolition of buildings containing EPS articles: Release factor: 0 Demolition of buildings containing EPS articles: Local release rate (kg/day): 0

Summed releases from all life cycle stages: see section 9.0.3.

9.3.1.5 ES2e. Exposure estimation for end of life disposal of flame retardant EPS

This part of the Exposure Scenario covers the end of life disposal of flame retardant EPS from construction applications.

Current practice at the time of writing for demolition of buildings insulated with EPS was discussed in the EU RAR (European Commission 2008). It was estimated at this time that approximately 30% of boards were recycled. The remaining 70% of material was disposed of by landfill or incineration or remained in the environment at end of life. Waste remaining in the environment applies to use of construction material on or in the ground, such as insulation under parking decks, or exterior insulation of cellars. No figures were available for the amounts going to each of these destinations.

The current Application for Authorisation does not include recycling of flame retardant EPS. A labelling scheme is proposed to allow boards not containing flame retardant to be identified as appropriate for recycling (a proposal for this scheme is described in section 5.2 of the Analysis of Alternatives that is part of this application and below). The following Risk Management Measure is applied in this CSR to prevent release of HBCDD to the environment:

- All flame retardant EPS will be incinerated at end of life.

A declaration of performance requirements of the Construction Products Regulation, which came into force on July 1st 2013, mandates the identification of HBCDD. This means that there is a relevant documentation – a ‘paper trail’- for identification; however, a practical visual identification is also needed. A more positive proposed approach would be to label EPS foams not containing HBCDD with the international recyclable symbol for PS (as below). In that way it indicates that the EPS not containing HBCDD is recyclable and all other EPS not so marked recovered from building uses in the EU could be considered to contain HBCDD and therefore not to be recyclable, unless it can be demonstrated that it does not contain HBCDD. This is currently under discussion with the EPS industry.

As discussed in Section 9.3.1.2 above, use of flame retardant EPS insulation boards is not uniform over Europe and the percentage of the EU tonnage at regional scale is taken to be 20%. The fraction of the regional tonnage used at a local scale is taken as 0.0005; based on the default scenario for municipal waste incineration in ECHA Guidance R18 (ECHA 2010).

The assessment below is based on a modelling approach applied using the parameters set out in the table below.

Operational conditions and risk management measures for end of life disposal

Operational conditions and risk management measures	
Control of environmental exposure: use of flame-retarded expanded polystyrene articles.	
Product characteristics	
Physical Form	Solid (within polymer matrix)
Substance in preparation	N/A
Amounts used (quoted as amount of HBCDD)	
Daily use at a site	0.082 t/d (82 kg/d)
Annual use at a site	27 t/a
Percentage of total EU tonnage used at regional scale	20
Fraction of regional tonnage used at a local site	0.017

Frequency and duration of use	
Number of emission days per year:	330
Basis for the above: default from REACH Guidance R18 municipal waste incineration scenario	
Environment factors not influenced by risk management	
Receiving surface water flow rate	18000 m ³ /day (corresponding to a dilution factor of 10).
Basis for the above: Default for a standard town	
Other given operational conditions affecting environmental exposure	
Technical conditions and measures at process level (source) to prevent release	
Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil	
Organisational measures to prevent/limit release from site	
Conditions and measures related to municipal sewage treatment plant	
Onsite/Municipal STP	yes
Discharge rate of STP	2000 m ³ /day
Basis for the above: Default for a standard town	
Application of the STP sludge on agricultural soil	yes
Basis for the above: Default assumption.	
Conditions and measures related to external treatment of waste for disposal	
Appropriate waste code (EC, 2000): 07 02 13* waste plastic	
Conditions and measures related to external recovery of waste	
N/A	
Additional good practice advice beyond the REACH CSA	
None	

9.3.1.5.1 Exposure estimation for the environment

In future, it will not be permitted to recycle or landfill EPS containing HBCDD; all waste will need to be incinerated. This is a Risk Management Measure imposed in the current assessment.

The decomposition of brominated flame retardants, including HBCDD, in incinerators has been investigated at plants in Denmark, Sweden and Norway (Norden 2005). The amount of brominated flame retardants in output flows was less than 0.001 % by weight of the total amount of BFRs in the waste mix. These are initially losses to the atmosphere. However, the processes involve elevated temperatures and subsequent condensation could result in losses to liquid waste. As a reasonable worst case it is assumed that 50% of this is lost to waste water and 50% is lost to the atmosphere.

Emission to Air

The release factor to air of 5E-06 is used in the modelling.

This gives a local release to air of HBCDD of 5E-06 * 82 kg/day = 4.1E-04 kg/day.

Emission to water

The release factor to water of 5E-06 is used in the modelling.

This gives a local release to water of HBCDD of 5E-06 * 82 kg/day = 4.1E-04 kg/day.

Table 9.3.5 Summary of the local releases to the environment for end of life disposal

Compartment	Release factor estimation method	Explanation / Justification
Water	EU RAR (European Commission 2008)	End of life of EPS articles: Release factor: 5.0E-06 End of life of EPS articles: Local release rate (kg/day): 4.1E-04 kg/d
Air	EU RAR (European Commission 2008)	End of life of EPS articles: Release factor: 5.0E-06 End of life of EPS articles: Local release rate (kg/day): 4.1E-04 kg/d
Soil	EU RAR (European Commission 2008)	End of life of EPS articles: Release factor: 0 End of life of EPS articles: Local release rate (kg/day): 0

Summed releases from all life cycle stages: see section 9.0.3.

9.3.2 Environmental exposure

9.3.2.1 ES2a. Environmental exposure for manufacture of expanded polystyrene articles (conversion), including cutting

Predicted Environmental Concentrations (PECs) are shown in the table below.

Table 9.3.6. Summary of exposure concentrations for ES2a

Protection target	Local PEC	Unit	Explanation / Justification
Air	6.8E-07	mg/m ³	Annual average local PEC in air (total)
Fresh Water	3.8E-05	mg/l	Local PEC in surface water during emission episode (dissolved)
Fresh Water (sediment)	3.7E-02	mg/kgwwt	Local PEC in fresh-water sediment during emission episode
Marine Water	3.8E-06	mg/l	Local PEC in seawater during emission episode (dissolved)
Marine Water (sediment)	3.7E-03	mg/kgwwt	Local PEC in marine sediment during emission episode
Agricultural soil	5.6E-02	mg/kgwwt	Local PEC in agric. soil (total) averaged over 30 days
Sewage Treatment Plant	4.0E-04	mg/l	PEC for micro-organisms in the STP
Fresh Water Food Chain (predators)	1.3E+00	mg/kgwwt	Concentration in fish for secondary poisoning (freshwater)
Marine Water Food Chain (predators)	1.3E-01	mg/kgwwt	Concentration in fish for secondary poisoning (marine)
Marine Water Food Chain (top predators)	1.8E-01	mg/kgwwt	Concentration in fish-eating marine top-predators
Terrestrial Food Chain (predators)	1.7E-01	mg/kg	Concentration in earthworms from agricultural soil

For regional PECs see section 9.0.3.2.

9.3.2.2 ES2b. Environmental exposure for professional use of flame retardant EPS articles at construction sites

Predicted Environmental Concentrations (PECs) are shown in the table below.

Table 9.3.7. Summary of exposure concentrations for ES2b

Protection target	Local PEC	Unit	Explanation / Justification
Air	1.1E-08	mg/m ³	Annual average local PEC in air (total)
Fresh Water	6.3E-07	mg/l	Local PEC in surface water during emission episode (dissolved)
Fresh Water (sediment)	6.3E-04	mg/kgwwt	Local PEC in fresh-water sediment during emission episode
Marine Water	1.2E-07	mg/l	Local PEC in seawater during emission episode (dissolved)
Marine Water (sediment)	1.2E-04	mg/kgwwt	Local PEC in marine sediment during emission episode
Agricultural soil	3.3E-04	mg/kgwwt	Local PEC in agric. soil (total) averaged over 30 days
Sewage Treatment Plant	1.6E-06	mg/l	PEC for micro-organisms in the STP
Fresh Water Food Chain (predators)	5.7E-02	mg/kgwwt	Concentration in fish for secondary poisoning (freshwater)
Marine Water Food Chain (predators)	7.9E-03	mg/kgwwt	Concentration in fish for secondary poisoning (marine)
Marine Water Food Chain (top predators)	3.4E-02	mg/kgwwt	Concentration in fish-eating marine top-predators
Terrestrial Food Chain (predators)	7.4E-03	mg/kg	Concentration in earthworms from agricultural soil

For regional PECs see section 9.0.3.2.

9.3.2.3 ES2c. Environmental exposure for service-life of flame retardant EPS in construction applications

Predicted Environmental Concentrations (PECs) are shown in the table below.

Table 9.3.8. Summary of exposure concentrations for ES2c

Protection target	Local PEC	Unit	Explanation / Justification
Air	1.4E-08	mg/m ³	Annual average local PEC in air (total)
Fresh Water	4.8E-07	mg/l	Local PEC in surface water during emission episode (dissolved)
Fresh Water (sediment)	4.8E-04	mg/kgwwt	Local PEC in fresh-water sediment during emission episode

Marine Water	4.8E-08	mg/l	Local PEC in seawater during emission episode (dissolved)
Marine Water (sediment)	4.8E-05	mg/kgwwt	Local PEC in marine sediment during emission episode
Agricultural soil	9.3E-05	mg/kgwwt	Local PEC in agric. soil (total) averaged over 30 days
Sewage Treatment Plant	0.0E+00	mg/l	PEC for micro-organisms in the STP
Fresh Water Food Chain (predators)	5.2E-02	mg/kgwwt	Concentration in fish for secondary poisoning (freshwater)
Marine Water Food Chain (predators)	5.2E-03	mg/kgwwt	Concentration in fish for secondary poisoning (marine)
Marine Water Food Chain (top predators)	3.1E-02	mg/kgwwt	Concentration in fish-eating marine top-predators
Terrestrial Food Chain (predators)	6.7E-03	mg/kg	Concentration in earthworms from agricultural soil

For regional PECs see section 9.0.3.2.

9.3.2.4 ES2d. Environmental exposure for demolition of buildings containing flame retardant EPS at end of life

Predicted Environmental Concentrations (PECs) are shown in the table below.

Table 9.3.9. Summary of exposure concentrations for ES2d

Protection target	Local PEC	Unit	Explanation / Justification
Air	3.6E-08	mg/m ³	Annual average local PEC in air (total)
Fresh Water	5.1E-06	mg/l	Local PEC in surface water during emission episode (dissolved)
Fresh Water (sediment)	5.1E-03	mg/kgwwt	Local PEC in fresh-water sediment during emission episode
Marine Water	5.1E-07	mg/l	Local PEC in seawater during emission episode (dissolved)
Marine Water (sediment)	5.1E-04	mg/kgwwt	Local PEC in marine sediment during emission episode
Agricultural soil	9.4E-05	mg/kgwwt	Local PEC in agric. soil (total) averaged over 30 days
Sewage Treatment Plant	4.9E-05	mg/l	PEC for micro-organisms in the STP
Fresh Water Food Chain (predators)	3.0E-01	mg/kgwwt	Concentration in fish for secondary poisoning (freshwater)
Marine Water Food Chain (predators)	3.0E-02	mg/kgwwt	Concentration in fish for secondary poisoning (marine)
Marine Water Food Chain (top predators)	6.1E-02	mg/kgwwt	Concentration in fish-eating marine top-predators

Terrestrial Food Chain (predators)	6.7E-03	mg/kg	Concentration in earthworms from agricultural soil
------------------------------------	---------	-------	--

For regional PECs see section 9.0.3.2.

9.3.2.5 ES2e. Environmental exposure for end of life disposal of flame retardant EPS

Predicted Environmental Concentrations (PECs) are shown in the table below.

Table 9.3.10. Summary of exposure concentrations for ES2e

Protection target	Local PEC	Unit	Explanation / Justification
Air	1.1E-07	mg/m ³	Annual average local PEC in air (total)
Fresh Water	4.4E-06	mg/l	Local PEC in surface water during emission episode (dissolved)
Fresh Water (sediment)	4.4E-03	mg/kgwwt	Local PEC in fresh-water sediment during emission episode
Marine Water	2.0E-06	mg/l	Local PEC in seawater during emission episode (dissolved)
Marine Water (sediment)	2.0E-03	mg/kgwwt	Local PEC in marine sediment during emission episode
Agricultural soil	6.1E-03	mg/kgwwt	Local PEC in agric. soil (total) averaged over 30 days
Sewage Treatment Plant	4.2E-05	mg/l	PEC for micro-organisms in the STP
Fresh Water Food Chain (predators)	2.4E-01	mg/kgwwt	Concentration in fish for secondary poisoning (freshwater)
Marine Water Food Chain (predators)	9.9E-02	mg/kgwwt	Concentration in fish for secondary poisoning (marine)
Marine Water Food Chain (top predators)	1.4E-01	mg/kgwwt	Concentration in fish-eating marine top-predators
Terrestrial Food Chain (predators)	2.4E-02	mg/kg	Concentration in earthworms from agricultural soil

For regional PECs see section 9.0.3.2.

9.3.3 Indirect exposure of humans via the environment

9.3.3.1 ES2a. Indirect exposure of humans via the environment for manufacture of expanded polystyrene articles (conversion), including cutting

Table 9.3.11 Summary of estimated daily human doses through intake and concentrations in food for ES2a

Type of food	Estimated daily dose from regional exposure (mg/kg/day)	Concentration in food from regional exposure
--------------	---	--

Drinking water	3.1E-06	1.1E-04 mg/l
Fish	1.1E-03	6.7E-01 mg/l
Leaf crops	8.7E-05	5.1E-03 mg/l
Root crops	1.9E-03	3.4E-01 mg/l
Meat	1.7E-05	3.9E-03 mg/l
Milk	9.9E-06	1.2E-03 mg/l
Total	3.1E-03	

Dose from regional exposure: see section 9.0.3.3.

9.3.3.2 ES2b. Indirect exposure of humans via the environment for professional use of flame retardant EPS articles at construction sites

Table 9.3.12 Summary of estimated daily human doses through intake and concentrations in food for ES2b

Type of food	Estimated daily dose from regional exposure (mg/kg/day)	Concentration in food from regional exposure
Drinking water	1.2E-08	4.0E-07 mg/l
Fish	1.7E-05	1.1E-02 mg/kg
Leaf crops	1.1E-06	6.7E-05 mg/kg
Root crops	7.0E-06	1.3E-03 mg/kg
Meat	2.1E-07	4.9E-05 mg/kg
Milk	1.3E-07	1.6E-05 mg/kg
Total	2.6E-05	

Dose from regional exposure: see section 9.0.3.3.

9.3.3.3 ES2c. Indirect exposure of humans via the environment for service-life of flame retardant EPS in construction applications

Table 9.3.13 Summary of estimated daily human doses through intake and concentrations in food for ES2c

Type of food	Estimated daily dose from regional exposure (mg/kg/day)	Concentration in food from regional exposure
Drinking water	3.4E-09	1.2E-07 mg/l
Fish	1.4E-05	8.6E-03 mg/kg
Leaf crops	1.4E-06	7.9E-05 mg/kg
Root crops	2.0E-06	3.7E-04 mg/kg
Meat	2.5E-07	5.7E-05 mg/kg
Milk	1.5E-07	1.8E-05 mg/kg
Total	1.8E-05	

Dose from regional exposure: see section 9.0.3.3.

9.3.3.4 ES2d. Indirect exposure of humans via the environment for demolition of buildings containing flame retardant EPS at end of life

Table 9.3.14 Summary of estimated daily human doses through intake and concentrations in food for ES2d

Type of food	Estimated daily dose from regional exposure (mg/kg/day)	Concentration in food from regional exposure
Drinking water	3.6E-08	1.3E-06 mg/l
Fish	1.5E-04	9.1E-02 mg/kg
Leaf crops	3.6E-06	2.1E-04 mg/kg
Root crops	2.0E-06	3.7E-04 mg/kg
Meat	6.5E-07	1.5E-04 mg/kg
Milk	3.9E-07	4.8E-05 mg/kg
Total	1.6E-04	

Dose from regional exposure: see section 9.0.3.3.

9.3.3.5 ES2e. Indirect exposure of humans via the environment for end of life disposal of flame retardant EPS

Table 9.3.15 Summary of estimated daily human doses through intake and concentrations in food for ES2e

Type of food	Estimated daily dose from regional exposure (mg/kg/day)	Concentration in food from regional exposure
Drinking water	2.1E-07	7.5E-06 mg/l
Fish	1.2E-04	7.3E-02 mg/kg
Leaf crops	1.1E-05	6.5E-04 mg/kg
Root crops	1.3E-04	2.4E-02 mg/kg
Meat	2.1E-06	4.9E-04 mg/kg
Milk	1.2E-06	1.5E-04 mg/kg
Total	2.7E-04	

Dose from regional exposure: see section 9.0.3.3.

9.3.4 Exposure estimation for workers

This assessment focuses only on the properties of the substance that lead to it being PBT and therefore specific worker measures are not part of this assessment.