EU SHIP RECYCLING REGULATION

Study of two hazardous substances (PFOS and HBCDD) included in the annexes of regulation (EU) 1257/2013 on ship recycling

EMSA European Maritime Safety Agency

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Objective:

Reduce knowledge gaps in relation to including the substances PFOS and HBCDD in the implementation of Regulation (EU) 1257/2013.

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1 EXECUTIVE SUMMARY

The EU Ship Recycling Regulation entered into force on 30 December 2013. This Regulation is aimed at facilitating early ratification of the Hong Kong Convention 2009, both within the EU and in other countries outside the EU, by applying controls to ships and ship recycling facilities based on the Hong Kong Convention. It aims to ensure that vessels are recycled in EU-approved facilities worldwide.

EU legislation sets additional requirements compared to the Hong Kong Convention for the Inventory of Hazardous Materials (IHM), by including the substances perfluorooctane sulfonic acid (PFOS) and hexabromocyclododecane (HBCDD) in the list of hazardous substances. To fulfill these requirements, some knowledge gaps need to be closed to implement proper actions and procedures. Increased knowledge is for instance needed regarding properties and use of these materials in ships, current regulation, updated material lists, sampling, handling and analyzes of these substances.

The European Maritime Safety Agency (EMSA) has therefore initiated a project to study the two hazardous substances (PFOS and HBCDD) included in the Annexes of Regulation (EU) 1257/2013 on Ship Recycling, to close knowledge gaps and facilitate a proper implementation of relevant requirements in EU Ship Recycling regulation.

The EU regulation on ship recycling will be implemented at various intervals. Existing EU-flagged vessels are required to have on board a verified Inventory of Hazardous Materials (IHM) with an inventory certificate at the latest by 2020-12-31 (or if the ship is to be recycled, the IHM should be on board from the date when the European list of ship recycling facilities is published). EU-flagged new ships are required to have on board a verified IHM with an inventory certificate at the latest by 2018-12-31. If the cumulative recycling capacity of the EU listed yards exceeds 2.5m LDT, the EU flagged new buildings will be required to have an inventory certificate, however as of today the list has not exceeded the required capacity. Non-EU-flagged vessels (third-party vessels) calling at EU ports are also required to have on board a verified IHM with a Statement of Compliance after 2020-12-31.

In addition to the 13 substances stated in the Hong Kong Convention, two substances have been added in the EU SRR, namely perfluorooctane sulfonic acid (PFOS) and the brominated flame retardant hexabromocyclododecane (HBCDD). This study has shown that the two hazardous substances PFOS and HBCDD can be found onboard ships and rigs. To gather information on these two substances, either sampling check, supplier's material declarations (MDs) or both are required.

Yards are responsible in IHM Part 1 for gathering MDs and Suppliers Declaration of Conformity (SDoC) and collocate this information in IHM Part 1. Suppliers are responsible for evaluation of their products in a detailed way, check of their own products from upstream suppliers and provide information on hazardous material in the form MDs and SDOCs. In practice, there have been cases where random sampling checks proved that MDs were not accurate. In addition to collecting declarations, the EU SRR IHM guidance suggests a random sampling check for new buildings.

1.1 PFOS

Firefighting foam is expected to have the highest concentration of PFOS and the most relevant material to analyse and check for inclusion in the IHM Part I. The amounts on board may be substantial (range 400-19 000 litres).

Protective coatings for fabrics such as carpets, textiles, upholstery and electronics such as semiconductors not integral to ship in operation, is also relevant, however falling out of scope with regards to IHM Part I in general. But, for example carpets glued to the floor is considered integral part and should be included in IHM Part 1. Possible content of HBCDD need to be addressed, whenever replaced or when vessel is due for recycling, to ensure safe and environmentally sound disposal as the recycling yard need to be able to demonstrate downstream waste management broadly equivalent to international and Union standards. Regular consumable goods, as provided in table D of appendix 1 in MEPC.269(68), should be listed in part 3 of the inventory if they are delivered with the ship to the ship recycling facility. A general description including the name of item, manufacturer, quantity and location should be entered in part III of the inventory. This includes electrical and electronic equipment and furniture, interior and similar equipment. Possible content of PFOS need to be addressed, whenever replaced or when vessel is due for recycling, to ensure safe and environmentally sound disposal.

Paint and coatings may be relevant but it is not expected to find PFOS in paint and coatings because other surfactants are probably used and it is not detected in paint in any samples looked at (inventories in 21 ships).

For PFOS in firefighting foam, global, regional and national legislation as well as shelf life need to be taken into consideration.

AFFF firefighting foam has a shelf life of 20-25 years. There's no requirement in SOLAS to conduct testing on board with the firefighting foam concentrate, hence firefighting foam concentrate prior to 2002 may contain PFOS and needs to be analysed/declared.

From 2002 3M stopped using PFOS in its firefighting foam concentrate and other producers followed. In the period between 2002 and 2010, when the Stockholm Convention entered force, PFOS containing firefighting foam concentrate may have been brought on board vessels.

After 2010 PFOS containing firefighting foams is less likely on board vessels at all, unless vessels built in China, where it at that time and still is legal to produce and sell.

Having in mind that the reporting limit is set to 0,001%, incomplete emptying of tanks and hoses, previously holding PFOS containing foam concentrate, may contaminate new non-PFOS containing foam above the threshold level, hence sampling and analysis is recommended.

Sampling should in general follow the EMSAS's Best practice guidance on the inventory of hazardous material (2016) and the IMO resolution MEPC.269(68) Guidelines for inventory of hazardous material. Health, safety and environmental (HSE) aspects during sampling should be focused on proper ventilation, especially if working in confined spaces, use eye protection and gloves and have available safety data sheets and eye wash bottles.

There exist standards that is used for extraction and analysis of PFOS and which have adequate level of detection (LOD) compared to a suggested hazardous waste limit of 50 mg/kg and 0.001 % in new products, which is relevant for inventories of hazardous materials. More advanced techniques such as ultra-performance liquid chromatography achieve much lower detections limits (0.015 ng/l range). Based on a literature review a suggested hazardous waste limit for PFOS is set to 50 mg/kg and 0.001 % in new products.

The Basel Convention technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with PFOS, its salts and PFOSF, list two methods for destruction and irreversible transformation; (a) Cement kiln co-incineration and (b) Hazardous waste incineration. Destruction and irreversible transformation methods applicable for the environmentally sound disposal of wastes with a content of PFOS, its salts or PFOSF at or above 50 mg/kg.

1.2 HBCDD

HBCDD in polystyrene foam (EPS and XPS) is the most relevant area of use. Other but less significant area of use are in textiles and High Impact Polystyrene (HIPS). HBCDD is found in textiles (carpets) in IHM's. HBCDD can be found on board all vessels types and should in particular be considered in the IHM Part I for insulation used in the walls and ceiling of cold provision rooms. Special attention is recommended to insulation on board reefers, insulation in refrigerated containers and tank insulation of LPG, LEG and LNG cargo tanks.

HBCDD should be considered sampled for carpets and vinyl flooring, however falling out of scope with regards to IHM Part I if it is not an integral part of ship in operation, meaning that for example carpets of flooring glued to the floor should be included. High Impact polystyrene is relevant for instrument panels and computer housings and alike but not considered inside scope of IHM Part 1 in general. Possible content of HBCDD need to be addressed, whenever replaced or when vessel is due for recycling, to ensure safe and environmentally sound disposal as the recycling yard need to be able to demonstrate downstream waste management broadly equivalent to international and Union standards.

As for PFOS, sampling should in general follow the EMSAS's Best practice guidance on the inventory of hazardous material (2016) and the IMO resolution MEPC.269(68) Guidelines for inventory of hazardous material. Particular HSE aspects have not been identified for sampling, as the most relevant is polystyrene foam.

No standards exist for analysis of HBCDD. Existing standards used in IHMs is for brominated flame retardants in general and it is uncertain to what extent these standards are quantitative for HBCDD, and they cannot discriminate between the most common "types" of HBCDD. A standard is under development for water phase analysis, but no upcoming standards are known for solids. Based on literature review most labs prefer reverse-phase LC MS/MS to quantify HBCDD. Based on a literature review a suggested hazardous waste limit for HBCDD is set to 1000 mg/kg and 0.01 % in new products.

As described for PFOS the Basel Convention technical guidelines for the environmentally sound management of wastes list two methods for destruction and irreversible transformation; (a) Cement kiln co-incineration and (b) Hazardous waste incineration. Method (a) and (b) are applicable to HBCDD as well. Destruction and irreversible transformation methods applicable for the environmentally sound disposal of wastes with a content of HBCDD at or above 1000 mg/kg.

2 INTRODUCTION

European Maritime Safety Agency (EMSA) is assisting the Commission in its work on a proper and timely implementation of the Regulation (EU) 1257/2013 on the European Parliament and the Council on ship recycling, with focus on the development and maintenance on board ships of an Inventory of Hazardous Materials. One of the issues that has been raised during this work, is the lack of substantial, objective and ship related information on the two hazardous substances perfluoroctane sulfonic acid (PFOS) and the brominated flame retardant hexabromocyclododecane (HBCDD).

The EU Ship Recycling Regulation entered into force on 30 December 2013. This Regulation is aimed at facilitating early ratification of the Hong Kong Convention 2009, both within the EU and in other countries outside the EU, by applying controls to ships and ship recycling facilities based on the Hong Kong Convention. It aims to ensure that vessels are recycled in EU-approved facilities worldwide.

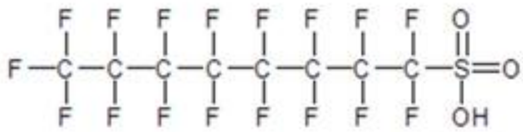
EU legislation sets additional requirements compared to the Hong Kong Convention for the Inventory of Hazardous Materials (IHM), by including the substances Perfluorooctane sulfonic acid (PFOS) and Hexabromocyclododecane (HBCDD) in the list of hazardous substances. To fulfill these requirements, some knowledge gaps need to be closed to implement proper actions and procedures. Increased knowledge is for instance needed regarding properties and use of these materials in ships, current regulation, updated material lists, sampling, handling and analyzes of these substances.

The European Maritime Safety Agency (EMSA) has therefore initiated a project to study the two hazardous substances (PFOS and HBCDD) included in the Annexes of Regulation (EU) 1257/2013 on Ship Recycling, to close knowledge gaps and facilitate a proper implementation of relevant requirements in EU Ship Recycling regulation.

3 PFOS

3.1 Physical and chemical properties

Perfluorooctane sulfonic acid (PFOS and derivates) belong to a group of chemicals called Polyfluorinated compounds (PFCs). PFC-generated fluoropolymers have been used as additives for a vast array of materials to either lower their surface tension (e.g. in hydraulic fluids, photographic emulsifiers and paints), or as a coating to make materials more stain and water repellent (e.g. in carpets, textiles, adhesives). A unique and important application is specialised aqueous film forming foams (AFFFs) to extinguish oil and jet fuel fires, as PFCs, being powerful surfactants, can facilitate mixture of water and oil, thus facilitating flame extinguishment and eliminating the dispersion of burning oils.



Perfluorooctosulfonic acid (PFOS)

$F(CF_2)_8SO_3H$

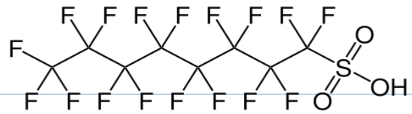
Perfluorooctane sulfonic acid (PFOS) is a strong acid; when dissolved in water it quantitatively deprotonates to become the anionic (negatively-charged) perfluoroctanesulfonate, even in already acidic water with a pH < 1 (Cheng et al 2009.). In its pure form, PFOS can be commercially available as a pure acid, or more commonly as a salt with one of many different cation pairs. The most common commercially available salts of PFOS are listed in Table 3-1. PFOS has been used in many applications for two essential reasons: 1) it is one of the best performing chemical surfactants ever synthesized; 2) it is extremely stable and therefore has a long shelf-life. Why it exhibits both these features can be understood by first considering the "PFO - perfluorooctane" and the "S - sufonate" moieties separately. Perfluorinated carbon chains, like "PFO", are the most hydrophobic (water resistant) chemical moieties known, as they exhibit less van der Waals interactions with surrounding media than even aliphatic carbon chains (like oils), due to the fluorine atom being more electronegative then hydrogen atom. By analogy, this is why materials like Teflon™ are less sticky to water than oil coated surfaces. When such a perfluorinated moiety is immediately attached to strongly hydrophilic moiety, like sulphonate, it makes an excellent surfactant, because there is one hydropobic end and one hydrophilic end (water liking). Further, the strong electronegative interactions of the fluorine molecules in the PFO chain can stabilize the anionic charge on the sulphonate through electron-withdrawal of the anionic charge towards the molecule making the sulphonate in PFOS even more hydrophilic than it would be if placed on any other type of moiety. PFOS was a popular ingredient in aqueous-film forming foams, because, being a good surfactant that is not instantly destroyed by heat, it could readily and instantly blend oil and water, preventing the burning oil or jet fuel from igniting further. When PFOS is applied as a surface coating, the anionic sulphonate will bind to any cation on the surface, and give the cationic charge a "perfluorinated", water-resistent coating.

PFOS can be considered relatively weakly sorbing. The K_D for standard European sediments (with 5% organic carbon) is estimated at 50 L/kg, which is not strong. Therefore, in the marine environment, PFOS is largely dissolved in water, or is accumulating at the water surface microlayer (as surfactants tend to do) (Ju *et al.* 2008). The K_D value of 50 should be considered as approximate, however, the actual sorption is highly variable, being dependant on both water and sediment composition (Higgins and Luthy 2006).

PFOS is extremely environmentally persistent, also due to this combination of PFO- and S moieties. The C-F bonds in the PFO- tail (or any per fluorinated alkyl group) cannot be oxidized in the environment, e.g. to benign CO2 and F- fragments, unless a substantial amount of external energy is applied, as this is thermodynamically unfavourable (i.e. it is an endothermic reaction). Similarly, the sulphonate group cannot be oxidized further, because it is already fully oxidized. Therefore, PFOS represents, along with some other PFCs, some of the most environmentally stable molecules possible.

PFOS can readily accumulate and bio magnify in organisms that are exposed to it, having a bioconcentration factor of 2796 in fish (i.e. the concentration in fish that is low in the food chain is approximately 2796 times higher than the water it is swimming in), and biomagnification factors of 5 in freshwater and 25 in marine water, meaning that the concentration increases by factors of 5 – 25 through food chain exposure. The mechanism for this bioaccumulation and biomagnification are still under discussion, but PFOS can sorbe to the surface of phospholipid membranes, adipose tissue, proteins and hormone receptors.

Table 3-1. Selected structural, physical-chemical, environmental and toxicological properties of PFOS.

Parameter	Definition	Value	Notes and references
CAS Registry #		1763-23-1 (PFOS) 307-35-7 (PFOSF) 2795-39-3 (PFOSK) 29081-56-9 (PFOSNH4) 29457-72-5 (PFOSLi) 70225-39-5 (PFOSDEA) 56773-42-3 (PFOSTEA) 251099-16-8 (PFOSDEA)	(Perfluorooctane sulfonic acid - PFOS) (Perfluorooctane sulfonyl fluoride -PFOSF) (Potassium perfluorooctane sulfonate - PFOSK) (Ammonium perfluorooctane sulfonate - PFOSNH4) (Lithium perfluorooctane sulfonate - PFOSLi) (Ammonium perfluorooctane sulfonate - PFOSDEA) (Tetraethylammonium perfluorooctane sulfonate - PFOSTEA) (Didecyldimethylammonium perfluorooctane sulfonat - PFOSDDA)
EC number		217-179-8 (PFOS) 220-527-1 (PFOSK) 249-415-0 (PFOSNH4) 249-644-6 (PFOSLi)	
Molecular formula		$C_8F_{17}SO_3$ (main anion)	
Molecular weight		500.13 (PFOS)	
Water solubility (mg/L)		marine: 12.4 freshwater: 519	PFOS EQS Dossier (2011), note at elevated concentrations PFOS will form micelles, one estimate of the critical micelle concentration is 4 g/L (Harada et al, 2005)
log K_{OW} (l/l)	logarithm of the octanol-water partition coefficient	Not known for ionic form	3.4 (neutral form), (Arp et al., 2006)
K_{OC}(l/kg TS)	organic carbon-water partition coefficient	1000	Zareitalabad et al. (2013), Note, in the PFOS EQS Dossier (2011) the K_{oc} value of 66 is listed as uncertain.
$K_{D,sed}$(l/kg TS)	sediment-water partition coefficient (assuming 5% organic carbon content)	50	Based on f_{OC} = 5% and K_{OC} = 1000

Henry (-)	air-water partitioning coefficient (dimensionless)	0.000000032	
BCF fish (l/kg w.w.)	bioconcentration factor in fish	2796	PFOS EQS Dossier (2011)
BMF	biomagnification factor in fish	marine:25 freshwater: 5	PFOS EQS Dossier (2011)) derived value from other studies
Hydrolysis half-life		No evidence of hydrolysis	PFOS EQS Dossier (2011)
Photolysis half-life		No evidence of photolysis	PFOS EQS Dossier (2011)
Biodegradation half-life		No evidence of biodegradation	PFOS EQS Dossier (2011)
MTDI (mg/kg/d)	Maximum tolerable daily intake to humans	0.00015	PFOS EQS Dossier (2011)

In addition to the salts of PFOS, there are many PFOS related substances that contain PFOS as a structural element or easily degrade in the environment to PFOS. These are referred to as PFOS-related substances, sometimes referred to as a "PreFOS" (Martin et al. 2010). The UK has listed 98 of such substances (UK 2004). In seeking out restrictions and regulations on PFOS, the Stockholm Convention on Persistent Organic Pollutants includes in Annex B restrictions on perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOSF). PFOSF (CAS 307-35-7) is the most common starting material for different PFOS derivatives. There are other PreFOS or PFOS relatated substances which are not included in the Stockholm Convention. The " Consolidated guidance on alternatives to perfluorooctane sulfonic acid and its related chemicals, 2'nd draft (May, 2016)", lists the following such substances as examples of PFOS-related substances that are not explicitly accounted for in the Stockholm convention:

Table 3-2. Example list of PFOS-related substances not listed in the Stockholm Convention (from the Stockholm Convention - Consolidated guidance on alternatives to perfluorooctane sulfonic acid and its related chemicals, 2'nd draft (May, 2016).

Chemical names	Acronyms	CAS No:
Perfluorooctane sulfonamide	PFOSA	754-91-6
N-Methyl perfluorooctane sulfonamide	MeFOSA	31506-32-8
N-Methyl perfluorooctane sulfonamidoethanol	MeFOSE	2448-09-7
N-Methyl perfluorooctane sulfonamidoethyl acrylate	MeFOSEA	25268-77-3
Ammonium bis[2-*N*-ethyl perfluorooctane sulfonamidoethyl] phosphate[1]		30381-98-7
N-Ethyl perfluorooctane sulfonamide (sulfluramid)	EtFOSA	4151-50-2
N-Ethyl perfluorooctane sulfonamidoethanol	EtFOSE	1691-99-2
N-Ethyl perfluorooctane sulfonamidoethyl acrylate	EtFOSEA	432-82-5
Di[*N*-ethyl perfluorooctane sulfonamidoethyl] phosphate	EtFOSEP	67969-69-1
3-[[(Heptadecafluorooctyl)- sulfonyl]amino]-*N,N,N*-trimethyl-1-propanaminium iodide/perfluorooctyl sulfonyl quaternary ammonium iodide	Fluorotensid e-134	1652-63-7
Potassium *N*-ethyl-*N*-[(heptadecafluorooctyl) sulfonyl] glycinate		2991-51-7
N-Ethyl-*N*-[3-(trimethoxysilyl)propyl] perfluorooctane sulfonamide		61660-12-6

Finally, it should be mentioned that there are a broad family of non-PFOS related perfluorinated substances, many of which are currently considered Substances of Very High Concern (SVHC) by REACH, like perfluorodecanoic acid (CAS 3830-45-3), perfluorononanoic acide (CAS 375-95-1) and perfluorooctanoic acid (CAS 335-67-1); therefore, it should be considered that many products using PFOS may contain these chemicals as well. The general issue of persistency and toxicity of perfluorinated substances has prompted initiatives to phase out the use of perfluorinated substances in general, such as through the Madrid Statement (Blum et al. 2015).

[1] Alternative CAS name: 1-Octanesulfonamide, *N,N'*- [phosphinicobis(oxy-2,1-ethanediyl)]bis[*N*-ethyl]-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-, ammonium salt.

3.2 PFOS production

In 2002, 3M voluntarily stopped production of several products including AFFF agents because they contain and degrade into PFOS. Regulations in the United States, Canada, European Union, Australia, and Japan act as a ban on new production of PFOS-based products including foams. These regulations do not currently restrict the use of existing stocks of PFOS-based foam in the US, Australia, or Japan. In the EU and Canada, existing stocks of PFOS-based foam must be removed from service in 2011 and 2013, respectively. Production and sale of PFOS foams continues in China (www.fffc.org).

China is one of the major ship building countries and has registered for exemption for PFOS in among other firefighting foams. There was an increase in PFOS producers from 2002 to 2006 in China with a peak of 13-15 producers. Subsequently, production volumes of PFOS increased. In 2002, production volume of PFOS was about 30 t in China, increasing to 246.88 t in 2006. Since then, due to the impact of the international policy to restrict or eliminate PFOS production, production volume of PFOS has declined to about 100 t/y in 2008 (Zhang et al., 2012).

According to Zhang et al. (2012) PFOS and related substances are no longer used in applications such as textiles, carpets, leathers due to international restrictions. Further on, the use of PFOS is very limited in semi-conductors and aviation. Currently, PFOS and related substances are mainly used in metal plating, aqueous fire-fighting foams (AFFFs) synthesis and sulfluramid formulation. The distribution of use of in metal plating, fire-fighting foams and sulfluramid applications in 31 provinces of China is shown in the Figure 3-1 below.

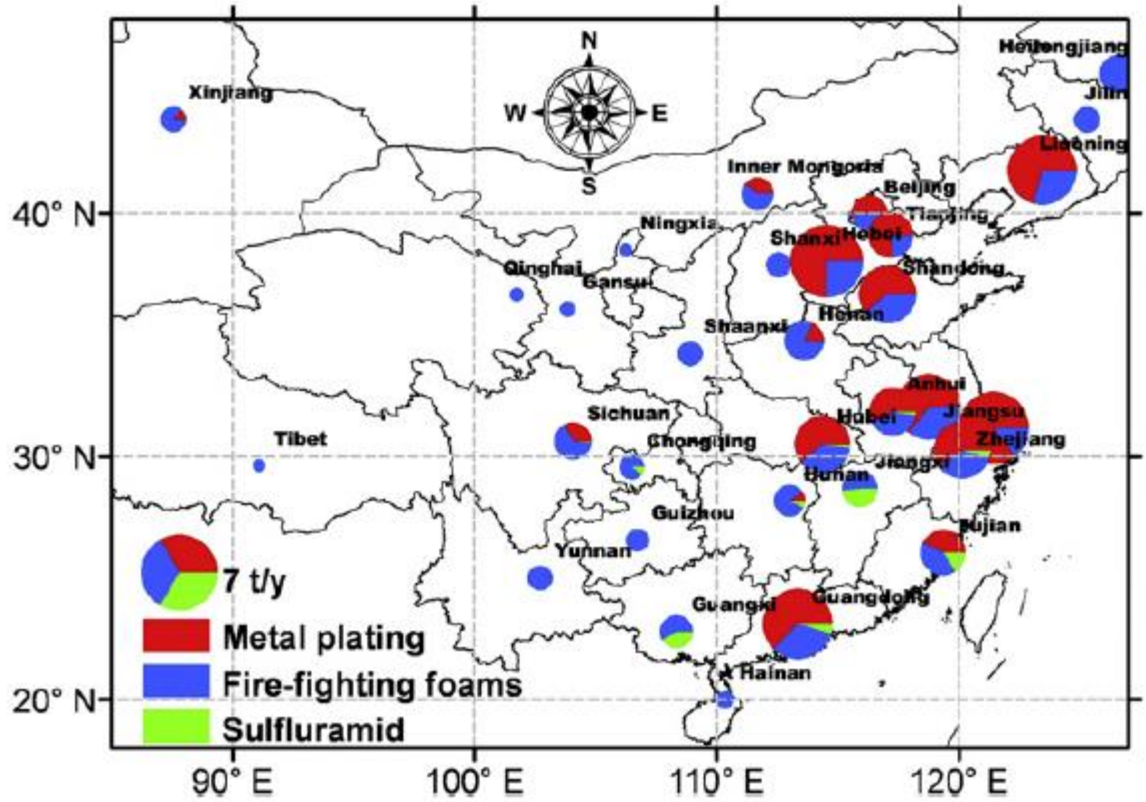


Figure 3-1. The distribution of PFOS use amounts used in metal plating, fire-fighting foams and sulfluramid applications in 31 provinces of China (from Zhang et al. 2012).

A survey conducted by Fire Department of Ministry of Public Security of China indicated that 28% of fire-fighting foams producers were using PFOS as a raw material to synthesize AFFFs. The percentage of AFFFs in all types of foams were increasing from 24.8% to 32.4% (Yu et al., 2010). Assuming that the percentage of PFOS among AFFFs product is 0.5%-1.5% (Moody and Field, 2000), the use of PFOS in this application was 25-35 t per year as fluorinated surfactants. AFFFs containing PFOS are especially applied for fire protection in petrochemical, fire brigade and military facilities and similar areas. By contrast, it is a minimal amount used in residential and commercial buildings fire services.

The World Bank's Board of Executive Directors approved in April 2017 a $24.25 million grant from the Global Environment Facility (GEF) to support China's efforts to reduce perfluorooctane sulfonic acid (PFOS) in selected sectors and enterprises in a sustainable manner. By converting or closing production lines and facilities and promoting cleaner production, the Reduction and Phase-out of PFOS in priority sectors such as metal plating, firefighting foam and pest-management techniques and practices for the control of red imported fire ant. Technical assistance will be provided to strengthen the regulatory and policy framework, standards, and capacity building. The project aims to reduce by 44 tons the amount of PFOS produced and used yearly, and set up a control and monitoring system for tracking PFOS production and sales. In addition to its global impact, the project is expected to help reduce PFOS exposure for at least 7.2 million people living and working in the PFOS production areas or using PFOS-based pesticides (http://www.worldbank.org/en/news/press-release/2017/04/07/gef-grant-to-assist-china-efforts-to-phase-out-pops).

3.3 Expected use and materials

In the sub chapters below a presentation of materials which may contain PFOS is presented. The information is gathered trough literature searches and liaising with relevant industries that could provide information on the topic. A detailed reference list for the findings are listed (Chapter 7).

Materials that are considered relevant for the IHM is highlighted. This is based on an evaluation if it is relevant for ships and rigs, and if it is expected to be found in concentrations or amounts higher than the threshold listed in EMSAS Best Practice Guidance on IHM (2016). The Best Practice Guidance Document lists 3 threshold values for PFOS (for new constructions):

1. above 10 mg/kg (0,001% by weight) when it occurs in substances or in preparation;

2. equal to or above 0,1 % by weight (1000 mg/kg authors note) calculated with reference to the mass of structurally or microstructurally distinct parts that contain PFOS, in semi-finished products or articles or parts thereof;

3. For textiles or other coated materials, if the amount is equal or above 1 µg/m2 of the coated material.

In relation to IHM in ships and rigs in general, it is expedient to distinguish between new buildings and existing ships. New buildings in this regard is related to the timeline of implementation of Regulation (EU) N.1257/2013 where 31.12.2018 is the latest possible date of entry into force. New ship' means a ship for which either:

(a) the building contract is placed on or after the date of application of the Regulation;

(b) in the absence of a building contract, the keel is laid or the ship is at a similar stage of construction six months after the date of application of this Regulation or thereafter; or

(c) the delivery takes place thirty months after the date of application of this Regulation or thereafter;

For new buildings, the material declaration shall provide information of any hazardous material, including amount, and as such this should provide the necessary information for proper handling and disposal of those materials. If in doubt one can take a random check(s) by sampling and analysis to confirm if materials contain PFOS or not. In practice, there have been cases where random sampling checks proved that MDs were not accurate. In addition to collecting declarations, the EU SRR IHM guidance suggests a random sampling check for new buildings.

For older ships and rigs which do not have a complete material declaration for various systems and equipment, more detailed information retrieval about materials which may contain PFOS is necessary, as well as a more detailed sampling and analysis program.

3.4 Literature research - PFOS

A summary of areas of use and relevance for ships & rigs of PFOS and related substances, based on literature research, is summarized in Table 3-3.

Table 3-3. Area of use of PFOS related substances. Colour coding: Light Green: Considered relevant for ships & rigs, Orange: Considered relevant but normally not expected to contain PFOS on board ships (but cannot be excluded), Red: considered not relevant for ships & rigs.

Main area of use		
Area of use	**Short description**	**Considered relevant for ships & rigs**
Metal (chromium) plating	To lower the surface tension of metal plating solutions to prevent formation of mists and bubbles containing potentially harmful components from the baths. In anodising and acid pickling. Considered mostly relevant during the metal plating process. It is understood that PFOS is not integrated in the metal plating product but act only as a surfactant in the tank (bath) to reduce mist and bubbles being transported to air and hence pose a working environment risk. As such it may be an effluent issue. PFOS salt type used.	No, relevant as a surfactant during the metal plating process to reduce exposure of potentially hazardous mist and bubbles in the working area (air). Not a part of the metal product, but may be an effluent issue during production.
Semi-conductors/ Photolithography	Different functions on semi-conductors. This relates to photolithography, the process by which the circuits are produced on semi-conductor wafers. This process use photoresist material. PFOS can form part of the photoresists material or as coatings. Also, used as surfactants in developers or in ancillary products such as edge bead removers. Expected concentrations in photoresists are 0.02-0.1 % and approx. 0.1 % in coatings. In coatings applied to photographic films, papers and printing plates. Main function is as anti-static agents.	Yes, may be found at levels equal or above threshold value of 0,1 %. Relevant materials are electronic products in general. May also contain preFOS substances.
Aviation	Fire resistant hydraulic fluids in air crafts	No

Table 3-3 continues.

Firefighting foams	Foams to fight fires involving flammable liquids. Fluorocarbon surfactants are a component of such foams. It is stated that most fluorocarbons in foams produced currently (2004) will not give rise to PFOS, hence this is probably more related to older productions of foams still in use. A content of 0,5 - 1,5 % (Unido, 2012) is assumed.	Yes, may contain high concentrations of PFOS.
	Other area of use	
Protective coatings for fabrics	PFOS have been used on a range of fabrics (carpets, textiles/upholstery and leather/apparel) to provide soil, water and oil resistance. Typically applied as coatings to protect the fabrics. Assumed to be present at a level 1 % of the polymer.	PFOS has not been detected in the samples checked by DNV GL (see Chapter 3.11) but it cannot be ruled out.
Paper treatment	As for fabrics PFOS have been used to treat a range of papers and paper products to provide resistance to the products. Mainly applied during the paper making process.	No
Coatings	In this regard, PFOS is assumed use in paintings for protective purposes. A PFOS content of 0.01-1 % is indicated.	PFOS has not been detected in the samples checked by DNV GL (see Chapter 3.11). According to UNEP (2017), concentrations used are below 0.01 wt %. Information from suppliers in the paint and varnish industries suggests use of other less expensive surfactants. PFOS used in situations where a very low surface tension is needed. However, it cannot be ruled out that coatings contain PFOS.
Sealants and adhesive products	This area of use is listed in UNEP (2010). It is stated low volumes PFOS used in sealants and adhesive product but no detail regarding production or quantities is given.	Based on findings in IHMs assessed by DNV GL, PFOS has not been detected in any of the samples (rubber seal), see Chapter 3.11. It can, however not be ruled out that sealants and adhesive products contain PFOS.
Toner and printing inks	Used as additive A PFOS content 100 mg/kg or 0,01 %. According to OECD (2006) less than 1 tonne used globally as additive.	Yes, but limited use

Table 3-3 continues.

Pesticides	**Use of PFOS related substances in baits against ants and beetles.**	**No**

1mg/kg=1ppm=0,0001%

3.5 Industry information

A summary of materials that may contain PFOS based on interviews with the industry is presented in the table below. The company names are anonymous but a short general description is provided in Appendix A.

Table 3-4. Materials that may contain PFOS based on industry interviews.

Company	Summary
1	Find PFOS in the waste (fluids) they receive. They assume it mainly comes from fire-fighting foam. PFOS is also found in drilling fluids, where it is added due to better performance, they assume.
2	Find PFOS in fire-fighting foam and powder. It could also be that PFOS could be in other (hard) plastic products, but these are not analyzed.
3	From demolition of buildings, it was registered that PFOS has been used in carpets to improve soil, water and stain resistance.
4	Analysed 5 PFOS samples the last 1.5 years, 4 in fire-fighting foam and 1 in concrete. PFOS was detected in one sample in a concentration of 2200 mg/kg. PFOS was also detected in concrete (32 mg/kg).
5	Never used PFOS in the coatings produced. Phosphates and borates are used in flame-retardant coatings.
6	Find PFOS in firefighting foam.
7	PFOS is found in firefighting foam above the threshold level for hazardous waste
8	PFOS in generally only found in firefighting foams above the threshold level for hazardous waste.
9	PFOS is found in firefighting foam above the threshold level for hazardous waste.
Summary	Based on the information from the industry interviews, materials that potentially contains PFOS is: ✓ Firefighting foam ✓ Drilling fluids ✓ Carpets ✓ Concrete

3.6 Overall summary of materials containing PFOS

Based on the findings from the literature study and interviews with the industry, relevant materials which may contain PFOS are listed Table 3-5.

Table 3-5 Identified materials that may contain PFOS.

Most relevant	Other
✓ **Firefighting foam**	✓ Carpets, textiles, upholstery ✓ Paint/coatings ✓ Electronics ✓ Drilling fluid ✓ Sealants and adhesive products ✓ Toner and printing inks

3.7 Occurrence onboard ships of the relevant materials containing PFOS

3.7.1 Firefighting foam

Firefighting systems on board vessels can be of various types, including fixed gas systems, fixed water-fire extinguishing systems, or foam fire extinguisher systems. PFOS can be found in foam systems, mainly in aqueous film-forming foam (AFFF).

Foam concentrates used for fixed deck foam fire-extinguishing systems are required for:

- tankers by SOLAS regulations II-2/10.8 and chapter 14 of the International Code for Fire Safety Systems (FSS Code), and

- chemical tankers as specified by SOLAS regulation II-2/1.6.2.1.2 and the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code).

Fixed foam fire-extinguishing systems are also required in machinery spaces according to chapter 6 of the FSS Code and for portable foam applicators according to chapter 4 of the FSS Code

Based on this and some other typical applications, it is recommended that firefighting foams onboard are given special attention when developing the IHM Part 1 for:

- Tanker for oil
- Tanker for chemicals
- Vessels with helideck
- Low Flashpoint Liquid fuelled vessels
- Vessels with firefighting foam in machinery spaces

For fixed fire-fighting foam systems, typical volumes range from 400 – 19 000 litres of foam concentrate, with a possible PFOS content of 0,5 -1,5 % (Unido, 2012). This concentrate is mixed with typically 94% or 97% water to produce the foam.

Portable foam fire extinguishers can be found in various locations throughout the vessel, generally ranging from 9-50 litres. In the portable fire extinguisher, the foam concentrate is mixed with water, typically 3% foam concentrate and 97% water.

3.7.2 Fabrics and textiles

Fabrics and textiles are relevant for all ship- and rig types in areas such as accommodation areas, offices and passageways especially. Carpets, furniture's and curtains are relevant items, however falling out of scope with regards to IHM Part I. Material Declarations, Suppliers Declarations of Conformity and listing in the IHM Part I, is not required for equipment listed in Table D in Res. MEPC.269(68). Exception is related to if material, for example carpet, is glued to the construction (floor). Regular consumable goods, as provided in table D of appendix 1 in MEPC.269(68), should be listed in part 3 of the inventory if they are delivered with the ship to the ship recycling facility. A general description including the name of item, manufacturer, quantity and location should be entered in part III of the inventory. This includes electrical and electronic equipment and furniture, interior and similar equipment. Possible content of PFOS need to be addressed, whenever replaced or when vessel is due for recycling, to ensure safe and environmentally sound disposal.

3.7.3 Paints/coatings

Paints and coatings are in general relevant for all ship- and rig types. Paints can be found almost anywhere in the construction such as floors, walls and roofs as well as on the hull. Information from suppliers in the paint and varnish industries suggests use of other less expensive surfactants than PFOS, but paints may contain a range of hazardous substances that need to be considered. In general, one would expect that it is more likely to find quantities of lead and cadmium above threshold level than PFOS in paints on board vessels.

3.7.4 Electronics – semiconductors and photolitography

In electrical products with semiconductors (transistors, diodes) and photographic equipment such as printing plates, photo paper and photographic films. Obvious areas are technical rooms such as bridge and control rooms. Electronic products not integral to ship operations, fall out of scope with regards to IHM Part I. Material Declarations, Suppliers Declarations of Conformity and listing in the IHM Part I, is not required for equipment listed in Table D in Res. MEPC.269(68). Regular consumable goods, as provided in table D of appendix 1 in MEPC.269(68), should be listed in part 3 of the inventory if they are delivered with the ship to the ship recycling facility. A general description including the name of item, manufacturer, quantity and location should be entered in part III of the inventory. This includes electrical and electronic equipment and furniture, interior and similar equipment. Waste from end-of-life electrical and electronic equipment, known as e-waste, may contain a range of hazardous substances, including PFOS. E-waste need to be disposed of in a safe and environmentally sound manner whenever replaced or when vessel is due for recycling.

3.7.5 Sealants and adhesive products

Wide area of use and can be found on a variety of locations where sealants and adhesive products are applied, such as tube- and pipe ends, glues, around gaskets and more.

3.7.6 Toner and printing inks

Mainly related to printers and copying machines, however not integral part of ship in operation and fall out of scope for IHM Part 1, but should be listed in Part 3. Please refer to 3.7.4 above.

3.7.7 Drilling fluids

Drilling fluids are only relevant for drilling units/rigs. There are designated areas on a rig where drilling fluids and mud is handled.

3.8 Sampling on board ships

For existing ships, the ship owner is responsible for the preparation of the IHM Part I. To develop IHM Part I for existing vessels, documents of the individual ship as well as the knowledge and experience of specialist personnel is required. Ship owners may draw upon assistance by an IHM expert for preparation of the IHM for vessels in service. Further information regarding the development of IHM for existing vessels can be found in the 2016 EMSA's Best Practice Guidance on the Inventory of Hazardous Materials and in IMO Resolution MEPC.269(68). for more specific information regarding PFOS in materials and equipment see section 3.6 and 3.11.

The main objectives for performing a IHM for a ship or rig can be summarized as:

- ✓ To be compliant with regulations, i.e. have sufficient knowledge about types and amount of hazardous substances for a responsible management of such
- ✓ As input information for assessing impacts and considering waste management as part of a ship recycling plan
- ✓ As basis for tendering processes for disposal and recycling
- ✓ As input to the personnel involved with the decommissioning work (potential exposure to hazardous substances)

Sampling and analytical methods should follow the principles stated in the EMSA's Best Practice Guidance on the inventory of hazardous Materials (2016). The EMSA guideline states:

"The overall objective of any sampling and analytical activity is to obtain a sample which can be used to identify the presence or absence of HM contained in the equipment, systems, and/or areas on board a ship by suitable and generally accepted methods such as laboratory analysis."

To prepare for sampling and analysis the following general items should be covered:

- ✓ Sampling and sampling check program
- ✓ Preservation and labelling of samples
- ✓ Analysis - strategy
- ✓ Identification of IHM expert survey and sampling personnel
- ✓ Risk assessment of the process – safety & health aspects

3.9 Analysis

3.9.1 Todays practice

A review of analytical methods applied in IHMs for PFOS based on findings in 24 IHM reports (DNV GL data) indicates different practices with regards to analytical procedures. A summary of applied analytical procedures is presented in

Table 3-6.

Table 3-6. Analytical procedures applied in IHMs.

Stated analytical procedure PFOS	Ship built (year)
German Method DIN 38414-14(S14)	1977, 1978, 1985, 1994
German Method DIN 38414-14 (S20)/1990, 1998, 2015	1990, 1998, 2015
ISO 25101-2009, LC-MS-MS	2008
US EPA 3550 C:2007/1977, 2012	1977, 2012
Material declaration/2016	2016
Unknown/2003	2003
Soxhlet method, LC-MS/1987	1987
Ultrasonic extraction, Q/CTI LD-SHPCHL-0006 PFOS & PFOA Test Procedure, Refer to ISO 25101-2009, LC-MS-MS	1986, 2008, 2009

With reference to the table above, standarized methods are available for analyzing PFOS in solids and liquids. For solid samples, the standard DIN 38414-14(S14) "Bestimmung ausgewählter polyfluorierter Verbindungen in Schlamm, Kompost und Boden – Verfahren mittels Hochleistungs Flüssigkeitschromatographie und massenspektrometrischer Detektion (HPLC-MS/MS)" (translation: Quantification of selected polyflourinated substances in sludge, compost and soil – methods using high performance liquid chromatography and mass spectrometery detection" is used, which applies to sludges, compost and solids. The limit of detection (LOD) for this method for most soils is given as 10 µg/kg (Validierungsdokument zu DIN 38414-14, October 2011). This method can be applied to other solid materials, such as those found on ships, though the limit of detection may vary depending on the sample type and its processing. Another standard method commonly used for the extraction of PFOS from samples (prior to quantification) include US EPA 3550 C:2007 "Ultrasonic extraction (for solids)", which can be combined with various methods for PFOS quantification.

For water samples, the standardized method is ISO 25101-2009 "Water quality — Determination of perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) — Method for unfiltered samples using solid phase extraction and liquid chromatography/mass spectrometry", which is also based on HPLC-MS/MS. The method is applicable to a range of concentrations between 2.0 ng/l to 10 000 ng/l, with the lowest reported LOD with this method being 0.1 ng/l (Loos, 2012).

3.9.2 Literature review

Literature about methods to sample and analyze PFOS have been reviewed several times (e.g. Xu et al. 2013, Jahnke & Berger. 2009). Methods are continually being optimized to handle emerging perfluorinated substances, many of which are substitutes to PFOS (Ullah, 2013). In summary, glassware is generally avoided in the extraction of PFOS, as the sulphonate part PFOS can sorb to glass. Generally plastic vials and equipment are preferred. Further, fluoropolymers like Teflon™ are also avoided, as they can preferentially sorb the perfluornated group. PFOS can be extracted from various media using polar solvents (typically methanol or acetonitrile), and further purified using weak-anion exchange solid-phase extraction (SPE). After extraction, PFOS is generally quantified using liquid chromatography-mass spectrometry. Advanced methodologies, such as ultra performance liquid chromatography coupled to two-dimentional MS systems (UPLC-MS/MS) have aquatic detection limits as low as 0.015 ng/L, which is lower than the typical range of ISO 25101-2009 (2 ng/L). It should be noted that these high-performance methods are needed to go below the current AA-EQS threshold for PFOS according to the Water Framework Directive (0.65 ng/L, see Chapter 3.133.16), as standardized methods are not sufficient (Loos, 2012).

A recent PhD thesis reviewed optimized strategies to extract PFOS and other perfluorinated substances from diverse media (Ullah, 2013). An overview of the optimized protocols and detection limits is reproduced in the table below.

Table 3-7. Overview of state-of-the art methods for quantifying PFOS (referred to as PFSA – C8) and other perfluorinated substances in diverse matrices (reproduced from Ullah et al, 2013).

		Method I (**Paper I**)	Method II (**Paper II**)	Method III (**Paper III**)	Method IV (**Paper IV**)
Extraction and cleanup	Analytes	PFCAs (C5-C12), PFSAs (C4, C6, C8, C10) and PFPAs (C6, C8, C10)	PFCAs (C4-C12), PFSAs (C4, C6, C8, C10) and PFPAs (C6, C8, C10)	Mono-, di- and triPAPs, PFCAs (C4-C15)	PFSAs (C4, C6, C8, C10) and selected precursors
	Matrix	Tap water (500 mL)	Diverse food matrices (5 g) Baby food was used as test matrix	Diverse food matrices (5g), packaging materials	Fish muscle and liver
	Extraction		ACN:water (90:10) and ACN	ACN or MeOH	ACN
	SPE column	CUQAX (C8 + quaternary amine)	CUQAX (C8 + quaternary amine)	Oasis WAX (mixed mode weak anion exchange)	CUNAX2 (C8+aminopropyl)
	Washing solvent	MeOH	MeOH:MTBE (95:5) containing 2% HCOOH	2% aqueous HCOOH and water	2% aqueous HCOOH and water
	Eluent	Warm MeOH:ACN (80:20) with 2% 1-MP	MeOH:ACN (60:40) with 2% 1-MP	MeOH, and 1% NH4OH in MeOH	MeOH, and 2% NH4OH in MeOH
	Recoveries	40-56%, 56-97% and 55-77% for PFPAs, PFCAs and PFSAs extracted from HPLC grade water	59-98% for all analytes extracted from baby food	72 – 110% for all detected analytes	50 -115% and 150% only for FASEs
Chromatography	Analytical column	Zorbax Extend C18	UPLC BEH C18	UPLC BEH C18	UPLC HSS T3
	Dimensions	150 × 1.0 mm	50 × 2.1 mm	50 × 2.1 mm	100 × 2.1 mm
	Particle size	3.5 µm	1.7 µm	1.7 µm	1.8 µm
	Injection volume	5 µL	5 µL	5 µL	5 µL
	Mobile phase	MeOH, ACN, water, 2 mM ammonium acetate, 5 mM 1-MP	MeOH, ACN, water, 2 mM ammonium acetate, 5 mM 1-MP	MeOH, ACN, water, 2 mM ammonium acetate, 5 mM 1-MP	MeOH, ACN, water, 2 mM ammonium acetate
	Flow rate	50 µL/min	120 µL/min	300 µL/min	250 µL/min
MS detection	Instrument	QToF-HRMS	QToF-HRMS	Xevo TQ-S-MS/MS	Xevo TQ-S-MS/MS
	Quantitative detection	ESI⁻, full scan	ESI⁻, full scan	ESI⁻, MRM	ESI⁻, MRM
	Method detection limits	0.095-0.17 ng/L, 0.027-0.17 ng/L and 0.014-0.052 ng/L for PFPAs, PFCAs and PFSAs	5.5-17 pg/g, 1.8-20 pg/g and 2.2-4.5 pg/g for PFPAs, PFCAs and PFSAs	As low as pg/g range	0.05 – 7 pg/g for all except for alkyl-FOSAs and FASEs (18 to 80 pg/g)
	Whole method linearity $(r^2)^a$	≥0.99	≥0.99	≥0.99	≥0.99

3.10 Safety and health aspects for sampling and handling

There have been developed technical guidelines for environmentally sound management for PFOS by the Parties of the Basel Convention that were published by UNEP in 2015 (UNEP, 2015a and 2015b).

For general information about sampling and handling of PFOS the Parties of the Basel Convention have published general technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants (UNEP 2015c).

3.10.1 General

Sampling

The general guideline published by UNEP state that standard sampling procedures should be established and agreed upon before the start of the sampling campaign. Sampling should comply with specific national legislation, where it exists, or with international regulations and standards.

Elements of the standard sampling procedures include the following:

(a) The number of samples to be taken, the sampling frequency, the duration of the sampling project and a description of the sampling method (including quality assurance procedures put in place, e.g., field blanks and chain-of-custody);

(b) Selection of location or sites and time of sample-taking (including description and geographic localization);

(c) Identity of the person who took the sample and conditions during sampling;

(d) Full description of sample characteristics – labelling;

(e) Preservation of the integrity of samples during transport and storage (before analysis);

(f) Close cooperation between the sampler and the analytical laboratory; and

(g) Appropriately trained sampling personnel.

Handling

The general guideline published by UNEP states that the main concerns when handling POP wastes are human exposure, accidental releases to the environment and contamination of other waste streams with POPs. POP wastes should be handled separately from other types of waste to prevent contamination of other waste streams. The management of liquid waste streams, in particular, and other wastes streams as appropriate should include the following recommended practices:

(a) Inspecting containers for leaks, holes, rust or high temperature, and appropriate repackaging and relabeling as necessary;

(b) Handling wastes at temperatures below 25°C, if possible, because of increased volatility at higher temperatures;

(c) Ensuring that spill containment measures are adequate and would contain liquid wastes if spilled;

(d) Placing plastic sheeting or absorbent mats under containers before opening them if the surface of the containment area is not coated with a smooth surface material (paint, urethane or epoxy);

(e) Removing liquid wastes either by removing the drain plug or by pumping with a peristaltic pump and suitable chemical-resistant tubing;

(f) Using dedicated pumps, tubing and drums, not used for any other purpose, to transfer liquid wastes;

(g) Cleaning up any spills with cloths, paper towels or absorbent;

(h) Triple rinsing of contaminated surfaces with a solvent;

(i) Treating all absorbents and solvent from triple rinsing, disposable protective clothing and plastic sheeting as wastes containing or contaminated with POPs when appropriate; and

(j) Training staff in the correct methods of handling POP wastes.

3.10.2 PFOS specific

Matrices that are typically sampled for PFOS substances includes:

Liquids: (i) Leachate from dumpsites and landfills; (ii) Water (surface water, groundwater, drinking water and industrial and municipal effluents); (iii) Biological fluids (blood, in the case of worker health monitoring; breast milk) and in this regard firefighting foam;

Solids: (i) Soil, sediment and municipal and industrial sludge; (ii) Indoor dust, and in this regard material in general.

Gases: (i) Air (indoor and outdoor); (ii) Exhaust gases.

In general matrices that are sampled will only have low amounts of PFOS (<<0,1 %) or none. They will therefore not need special precautions with respect to safety and health aspects for sampling and handling. The focus should be related to the type of matrix that is sampled and the general guideline about sampling and handling should be followed as described in Chapter 3.8.

An important exception is the firefighting foams where there is still some equipment that is containing PFOS (normally older equipment). The amount of PFOS in such equipment can be substantial (Unido 2012, 0,5 -1,5 % in general). In such concentrations PFOS may be harmful if swallowed, inhaled, or absorbed through the skin. Further it may cause eye and skin irritation and it may also cause respiratory problems. The following safety and health aspects must be taken when working with matrices with high amounts of PFOS (firefighting foams) (UNEP, 2015d):

- An up to date product Safety Data Sheet should be consulted.
- Mechanical ventilation: the use of mechanical ventilation is recommended whenever the PFOS-containing product is used in a confined space. Otherwise, assure use in an area where there is natural air movement.
- Use respiratory protection: in operations where the vapour can be released, wear a respirator with organic vapour canister or cartridge.
- Use protective gloves: rubber or neoprene.
- Use eye protection: goggles.
- Additional protective equipment: eyewash bottles or other rinsing equipment should be accessible.

3.11 Current situation in the maritime industry regarding inventories of PFOS

DNV GL has considered results of material analysis from inventories of hazardous materials for 21 vessels (DNV GL data) where PFOS has been considered. They have mainly been prepared on board existing ships, but also a few during new building. The ships for which PFOS were sampled, were built between 1977 and 2015, whereof almost half of the ships being built between 2008 and 2012. For the new buildings included in the data set (built in 2016), no material was sampled for PFOS. Referring to MEPC.269(68) IHM guideline sampling of e.g. plastic parts and lacquers of electrical or electronical components (where PFOS may be present) is out of scope with regards to sampling for vessels in operation, hence the IHM will in most cases not provide sufficient information to the yard with regards to hazardous materials such as PFOS. These items should be evaluated and disposed of in a safe and environmentally sound manner whenever replaced, or when vessel is due for recycling.

PFOS is not reported, meaning no positive findings, in any out of the 265 samples analysed. An overview of type of materials sampled is presented in Figure 3-2. Paint and rubber seal are the materials most often sampled. Interestingly firefighting foam is analysed only in 2 samples. The reason for the low number of samples from firefighting foam is assumed to be that declarations on PFOS-content is sought for rather than undertaking samples, such as material data safety sheets PFOS was neither recorded in MDs.

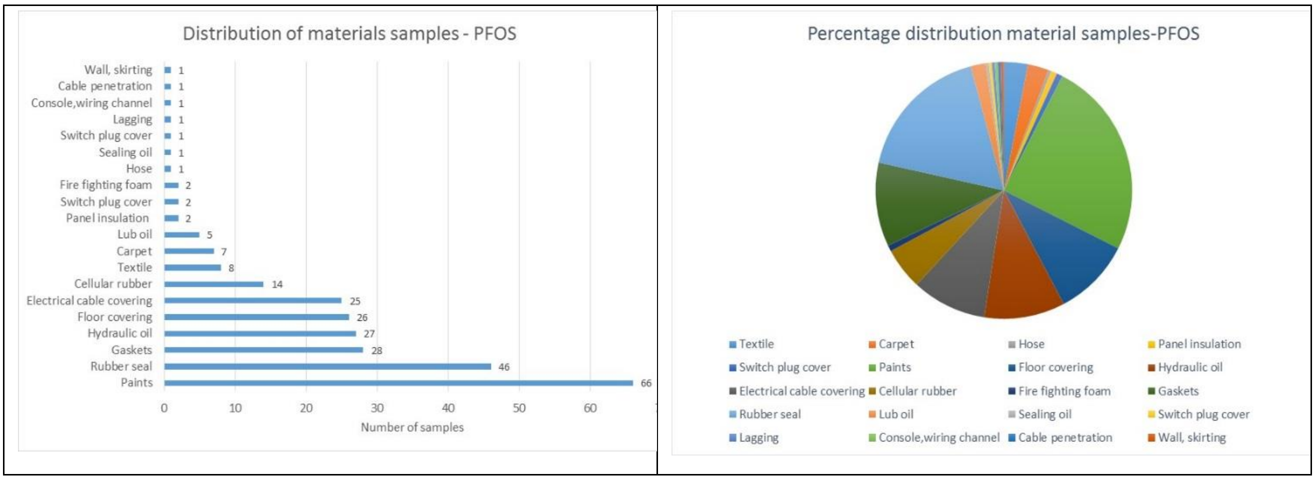


Figure 3-2. Number of different materials analysed for PFOS.

3.12 Regulatory requirements – threshold levels for detection and reporting

In Table 3-8 below, threshold values for PFOS in new products and threshold values for hazardous waste in international, regional and national legislation is presented.

Table 3-8. Examples on PFOS threshold levels in new products and threshold level for hazardous waste.

Regulation	PFOS	
	In new products	*Threshold level hazardous waste*
Basel Convention		50[1] mg/kg
Australia	0,001%[3]	50[1] mg/kg
EU	0,001%[3]	50[4] mg/kg
Norway	0,001%[2]	50[4] mg/kg
China	Not specified	Unknown
USA	No concentration provision for products, subject to reporting under the Significant New Use Rule	Unknown
Canada	0.005[5] %	50[1] mg/kg
Switzerland	0,001%[6]	50[1] mg/kg

[1]Draft technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOSF)
[2]Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with hexabromocyclododecane (HBCDD) (adopted by COP.12, May 2015)
* Determined according to national or international methods and standards. It is noted that further work to agree on one value will be undertaken according to decision BC-12/3
[3] Firefighting foam
[4]COMMISSION REGULATION (EU) No 1342/2014 of 17 December 2014 amending Regulation (EC) No 850/2004 of the European Parliament and of the Council on persistent organic pollutants as regards Annexes IV and V (PFOS)
[5] Perfluorooctane sulfonate, its salts and its precursors (PFOS) and the Prohibition of Certain Toxic Substances Regulations, 2012
[6] Ordinance on the Reduction of Risks relating to the Use of Certain Particularly Dangerous Substances, Preparations and Articles (Chemical Risk Reduction Ordinance, ORRChem)

Regulation (EC) 850/2004 on persistent organic pollutants (POP Regulation) aims among others at protecting the environment and human health from certain specified substances that are transported across international boundaries far from their sources, persist in the environment, and cause bioaccumulation, by implementing relevant international agreements. The Regulation's scope is restricted to those substances with POP properties specified in the Annexes of the Regulation. Following Article 7 of the POP Regulation, wastes consisting of POPs, containing or contaminated with them above specific limit values (concentration limit referred to in Article 7(4)(a) – the so called 'low POP-content limit value'), must be disposed of or recovered, without undue delay and in accordance with the provisions laid down in the POP Regulation in such a way as to ensure that the persistent organic pollutant content is destroyed or irreversibly transformed so that the remaining waste and releases do not exhibit the characteristics of persistent organic pollutants. Disposal or recovery operations that may lead to recovery, recycling, reclamation or re-use of the POPs are prohibited (EC guidance document, 2015). PFOS is amongst the POPs regulated by Regulation (EC) 850/2004.

Based on literature search on threshold values it is suggested that threshold value for PFOS in new products remain at 0,001%. If PFOS is added to a product to achieve specific characteristics the concentration is above 0,001%. PFOS below 0,001% is most likely related to unintentional trace contaminant in substances. With regards to waste treatment when a vessel is due for recycling it is suggested that hazardous waste threshold level is set to 50 mg/kg, in accordance with Basel Convention and Regulation (EC) 850/2004.

3.13 Detection and reporting thresholds – environmental media

In environmental media, such as freshwater, marine water, sediments and soils, reporting thresholds should generally be below the derived Environmental Quality Standard (QS) value. A QS value is generally indicative of threshold concentration for which chronic effects may be observed to humans or within an ecosystem. In the European Union's Water Framework Directive (2013/39/EU), they use two major types of QS values for water, the Annual Average EQS (AA-EQS) value which is the acceptable average QS over a one year period of unfiltered water, and the maximum acceptable concentration EQS, which is the maximum for a short period time, as this concentration could lead to short-term (acute) effects to humans or an ecosystem.

Table 3-9. Threshold values for PFOS in different environmental compartments according to European Union's Water Framework Directive (2013/39/EU).

EU QS Parameter	Definition	PFOS	Notes and references
$QS_{biota,sp}$ (mg/kg_{biota})	Quality standard to prevent chronic secondary poisoning to predators	33	EU dossier (PFOS)
$QS_{biota,hh}$ (mg/kg_{biota})	Quality standard to prevent chronic human health effects	9.1	WATER FRAMEWORK DIRECTIVE 2013/39/EU
$AA\text{-}EQS_{freshwater}$ (µg/L)	Average annual environmental quality standard to prevent chronic toxicity to freshwater organisms	0.00065	WATER FRAMEWORK DIRECTIVE 2013/39/EU
$MAC\text{-}EQS_{freshwater}$ (µg/L)	Maximum acceptable concentration environmental quality standard to prevent acute toxicity to freshwater organisms	36	WATER FRAMEWORK DIRECTIVE 2013/39/EU
$AA\text{-}EQS_{marine\ water}$ (µg/L)	Average annual environmental quality standard to prevent chronic toxicity to marine organisms	0.00013	WATER FRAMEWORK DIRECTIVE 2013/39/EU
$MAC\text{-}EQS_{marine\ water}$ (µg/L)	Maximum acceptable concentration environmental quality standard to prevent acute toxicity to marine organisms	7.2	WATER FRAMEWORK DIRECTIVE 2013/39/EU

Table 3-9 continues.

QS_{sed} (mg/kg_{sed} d.w.) **(f_{OC} = 5%)**	Quality standard to prevent chronic effects to benthic species	marine: 0.0115 freshwater: 0.00115	Norwegian recommendation (M-608), adjusted for 5% fOC in European sediments following the EU TGD (2011). The EU dossier (PFOS) concludes there is insuffient data to confirm the need or derive a value.
QS_{soil} (mg/kg_{soil} d.w.) (f_{OC} = 2%)	Quality standard to prevent chronic effects to soil dwelling organisms	0.046	UK Environment Agency (2004), for plants (max value), AF = 100

3.14 Stockholm convention

The Stockholm Convention on Persistent Organic Pollutants was adopted on 22 May 2001 and entered into force on 17 May 2004. The information in this chapter is mainly derived from webpages of the Stockholm convention (http://chm.pops.int/). The Stockholm convention is applicable to ships. Specific obligations are associated with the POPS listed in Annexes A, B and C, and some exceptions apply in certain circumstances. PFOS was listed under Annex B at the fourth meeting in May 2009. Parties must take measures to restrict the production and use of the chemicals listed under Annex B considering any applicable acceptable purposes and/or specific exemptions listed in the Annex.

Acceptable purposes may be decided by the Conference of the Parties when it adopts a decision amending the Annexes to the Convention to list a new chemical. Firefighting foam is listed as an acceptable purpose for the use and production of PFOS, its salts and PFOSF in part I of Annex B.

In accordance with paragraph 1 of Part III of Annex B to the Convention, if a Party not listed in the Register determines that it requires the use of PFOS, its salts or PFOSF for the acceptable purposes listed in part I of Annex B, it shall notify the Secretariat as soon as possible to have its name added to the Register. Furthermore, in accordance with paragraph 5 of part III of Annex B, the Conference of the Parties evaluates the continued need for these chemicals for the various acceptable purposes and specific exemptions based on available scientific, technical, environmental and economic information. The process for the evaluation was adopted by the Conference of the Parties in decision SC-6/4 and amended by decision SC-7/5.

In accordance with paragraph 6 of part III of Annex B, the first such evaluation took place in 2015 at COP-7. By its decision SC-7/5, the Conference of the Parties concluded that Parties may need to continue to produce and use PFOS, its salts and PFOSF for acceptable purposes as provided in part I of Annex B and consequently need to notify the Secretariat of their intention to produce and/or use those chemicals for those purposes. It is therefore currently possible for a Party to notify the Secretariat of its intention to produce and/or use PFOS, its salts and PFOSF in fire-fighting foam.

The next evaluation shall take place at the ninth meeting of the Conference of the Parties in 2019.

The specific exemptions available for other applications of PFOS, its salts and PFOSF, such as photo masks in the semiconductor and liquid crystal display industries are time limited. Pursuant to Article 4 (4) of the Convention, registrations of specific exemptions expire five years after the date of entry into force of the Convention with respect to that chemical unless an earlier date is indicated in the Register by a Party or an extension is granted by the Conference of the Parties pursuant to paragraph 7 of Article 4.

Pursuant to decision SC-7/1, no new registrations may be made regarding the specific exemptions for the production and use of PFOS, its salts and PFOSF for carpets, leather and apparel, textiles and upholstery, paper and packaging, coatings and coating additives and rubber and plastics. The other specific exemptions remain available to Parties in relation to the use of PFOS, its salts and PFOSF. Further information on the procedure to register acceptable purposes and specific exemptions is available at http://chm.pops.int/Procedures/Exemptionsandacceptablepurposes/tabid/4646/Default.aspx

Currently there is no agreed time period for acceptable purposes to be phased out. As indicated above, at its seventh meeting, the Conference of the Parties concluded that Parties may need to continue to produce and use PFOS, its salts and PFOSF for acceptable purposes including fire-fighting foam.

In paragraph 4 of decision SC-7/5, the Conference of the Parties encouraged parties to consider, on the basis of information and the availability of alternatives, withdrawing their names from the register of acceptable purposes for production and use of PFOS, its salts and PFOSF, noting, however, that substitution under "acceptable purposes" with regard to fire-fighting foam may be considered after carrying out techno-economical viability assessment and ensuring functionality in various geo-climatic conditions.

In paragraph 9 of the same decision, the Conference of the Parties further reminded parties that paragraph 4 (c) of part III of Annex B to the Convention encourages parties, within their capabilities, to promote research on and the development of safe alternatives to PFOS, its salts and PFOSF, and invited parties to submit information on such research and development in the process of information collection for the evaluation to take place at COP-9. The exchange of information relevant to alternatives to persistent organic pollutants contributes to the reduction or elimination of the production, use or release of such POPs.

The Register of acceptable purposes should reflect all acceptable purposes registered by Parties and is regularly updated by the Secretariat. Per this registry, Cambodia, Canada, China, Switzerland, Vietnam and Zambia have registered for exemption for PFOS in fire-fighting foam (http://chm.pops.int/Implementation/Exemptions/AcceptablePurposes/AcceptablePurposesPFOSandPFOSF/tabid/794/Default.aspx).

Even though Canada has registered for exemption, PFOS Regulations prohibit the manufacture, import, sale, offer for sale and use of PFOS or products containing PFOS, unless incidentally present, with certain exemptions. After May 29, 2013, the only remaining exemption is for use of AFFF PFOS if the PFOS concentration is less than or equal to 0.5 ppm.

China has registered for exemption and still produce PFOS. This is described in Chapter 3.2.

The Swiss Chemical Risk Reduction Ordinance (ORRChem) entered into force 2005. This Chemical Risk Reduction Ordinance prohibits or restricts the marketing and use of certain hazardous substances on its own or in preparations and articles. Switzerland operates with equal restrictions as found in EU regulations.

Most flag states have ratified the Stockholm Convention except USA, Malaysia and Italy. Italy is obliged to follow EU legislation as a Member State and USA has regulations that restrict the production and importation of PFOS-based products, including firefighting foams.

Aqueous Film Forming Foams (AFFF) currently manufactured or imported into the United States consist of telomer-based short-chain fluorochemicals (that do not contain or break down to PFOS or PFOA) or alternative chemical substances that do not contain long-chain fluorochemicals. However, the Environmental protection Agency's Significant New Use regulations do not affect the continued use of existing stocks of the PFOS-based chemicals that had been manufactured or imported into the U.S. before SNURs took effect in 2002. More information of PFOS regulation can be found under the Toxic Substances Control Act (TSCA): https://www.gpo.gov/fdsys/pkg/FR-2002-03-11/html/02-5746.htm. AFFF discharges are subject to various local and state restrictions because some of the AFFF are formulated with PFOS and PFOA which are of concern to the US EPA since they're persistent, bioaccumulative, and toxic. The US EPA has got many companies to agree to enter a voluntary stewardship program, which had the goal of reducing environmental releases of PFASs to zero by 2015. https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/20102015-pfoa-stewardship-program-2014-annual-progress (Perfluoroalkylated substances (PFAS) is the collective name for a vast group of fluorinated compounds that also includes PFOS).

3.15 EU regulation

PFOS is regulated by Commission regulation (EU) No 757/2010 of 24 August 2010 amending Regulation (EC) No 850/2004 of the European Parliament and of the Council on persistent organic pollutants as regards Annexes I and III. Since June 27th 2011 foam concentrates containing PFOS shall not be used or stored in the EU and PFOS containing materials is considered hazardous in concentrations above 50mg/kg. The European Parliament has placed a restriction on marketing and use of PFOS and its salts (included in EU REACH Annex XVII - Restriction List in 2009).

3.16 Waste disposal regulation

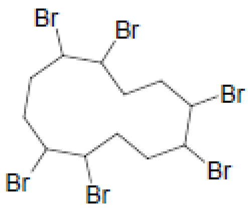
The Basel Convention technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with PFOS, its salts and PFOSF, list two methods for destruction and irreversible transformation; (a) Cement kiln co-incineration and (b) Hazardous waste incineration. Destruction and irreversible transformation methods applicable for the environmentally sound disposal of wastes with a content of PFOS, its salts or PFOSF at or above 50 mg/kg.

4 HBCDD

4.1 Physical and chemical properties

Hexabromocyclododecane (HBCDD) belong to a group of chemicals called brominated flame retardants (BFRs). Brominated flame retardants are a group of approximately 75 different synthetic organic substances containing bromine (Br). Brominated compounds are in general used for several purposes, but the major use is as flame retardants. Bromine interacts with the fire cycle in the gas phase to stop the chemical chain reaction that leads to flame formation and a self-sustaining fire. Brominated flame retardants either prevent a fire from starting in the first place, or significantly slow a fire down and can be added to materials like plastic without altering their properties.

HBCDD is a flame retardant most commonly used in expanded polystyrene foam (EPS) and extruded polystyrene foam (XPS). EPS and XPS are used as insulation in the building and construction industry. HBCDD is also used in materials such as textile back coatings on institutional carpet tiles or upholstery and some military fabrics (U.S. EPA 2012). A minor use of HBCDD is in high-impact polystyrene (HIPS) for electrical and electronic applications such as audio-visual equipment, refrigerator linings, and in wire and cable (U.S. EPA 2010).



Hexabromocyclododecane (HBCDD)

The substance 1,2,5,6,9,10-hexabromocyclododecane (HBCDD, $C_{12}H_{18}Br_6$) is a type of brominated flame retardant (BFR). BFRs are effective flame retardants because when they are heated to combustion temperatures they release bromine radicals, which catalytically bind hydrogen and hydroxyl radicals in the combustion gas, forming water that dilutes the combustion gas and prevents hydroxyl radicals from participating in further combustive reactions. This is the same principle also of other halogenated flame retardants; however, fluorine and chlorine radicals are generally not as economically effective (in terms of cost and amount of chemical needed) in this reaction as bromine radicals.

HBCDD can exist in up to 16 different types of stereoisomers (Heeb *et al.* 2005). In its technical preparation, HBCDD consist primarily of three of these diastereomers, α-, β-, and γ-HBCDD, each of which contain two enantiomeric pairs. The γ-diastereomer generally dominates in industrial mixtures, constituting more than 70% of the total mixture, with the α- and β-isomer typically contributing 10% and 6%, respectively (Morris et al. 2006, Marvin et al. 2011). Environmental studies have found that α -HBCDD dominates in monitored biological materials even though the γ -HBCDD dominates in technical mixtures (Mariussen et al. 2010). The 3D geometry of HBCDD diastereomers has a substantial impact on their physical-chemical properties. Some studies compare the physical-chemical properties of the three dominant diastereomers separately, whereas others are performed for the technical mixture. The different properties of the diasteromers also implies that they behave somewhat differently in the environment, as well as in analytical systems.

In addition to the 16 different stereoisomers, a new isomeric version of HBCDD, with the bromines distributed slightly differently on the dodecane ring, 1,3,5,7,9,11-Hexabromocyclododecane. Less explicit studies are available on this isomeric version, but according to current registration data in REACH, it has a European volume of 10 000 – 100 000 tonnes/year, and like 1,2,5,6,9,10-hexabromocyclododecane HBCDD, is classified as a substance of very high concern for exhibiting persistency, bioaccumulation and toxicity (PBT). It is likely that the physical chemical properties for the stereoisomers of 1,3,5,7,9,11-Hexabromocyclododecane vary somewhat, but are in the same range as ,2,5,6,9,10-hexabromocyclododecane HBCDD. HBCDD (including the technical mixtures of 1,2,5,6,9,10-hexabromocyclododecane and 1,3,5,7,9,11-Hexabromocyclododecane) are currently considered SVHC of REACH (Regulation EC No 1907/2006) according to Article 57, as they fulfil the PBT requirements set out in Annex XIII of REACH. Further, because of these properties, it was formally classified as a POP by the Stockholm Convention in May 2013 (decision SC-6/13; United Nations 2013).

The physical-chemical properties for HBCDD presented below were chosen because of their usage in deriving European QS values. However, other peer-reviewed databases of properties can be found (Marvin et al. 2011). In summary, HBCDD is a strong sorbing (log Kow>5), bioaccumulating (BCF 18100), biomagnifying (BMF 11.6 in marine water) and toxic molecule, that is persistent (no significant transformation products identified). Due to its very low Henry's Law constant (0.0001), it tends to remain in the water phase, where it can be transported as a freely-dissolved molecule or particle sorbed. An additional exposure route is through micro plastics or plastic debris where HBCDD was used as an additive (Jang et al. 2016).

Table 4-1. Selected structural, physical-chemical, environmental and toxicological properties of HBCDD.

Parameter	Definition	HBCDD	Notes and references
CAS Registry #		25637-99-4 (1,3,5,7,9,11-Hexabromocyclododecane) 3194-55-6 (1,2,5,6,9,10- Hexabromocyclododecane) 134237-50-6 (α-Hexabromocyclododecane) 134237-51-7 (β-Hexabromocyclododecane) 134237-52-8 (γ- Hexabromocyclododecane)	There are several other stereoisomers in addition to this list.
EC number		247-148-4 221-69-59	
Molecular formula		$C_{12}H_{18}B_{r6}$	
Molecular weight		642	
Water solubility (mg/L)		0.0488 (α-HBCDD) 0.0147 (β-HBCDD) 0.0021 (γ-HBCDD)	HBCDD EQS Dossier (2011)
log K_{OW} (l/l)	logarithm of the octanol-water partition coefficient	5.62 (technical product)5.07±0.06 α-HBCDD 5.12±0.09 β-HBCDD 5.47±0.10 γ-HBCDD	HBCDD EQS Dossier (2011)
K_{OC}(l/kg TS)	organic carbon-water partition coefficient	45709	EQS Dossier (2011). Technical product. Different congeners likely have different values
$K_{D,sed}$(l/kg TS)	sediment-water partition coefficient (assuming 5% organic carbon content)	2285	Based on f_{OC} = 5% and K_{OC}
Henry (-)	air-water partitioning coefficient (dimensionless)	0.000117	
BCF fish (l/kg w.w.)	bioconcentration factor in fish	18100	HBCDD EQS Dossier (2011). Technical product.
BMF	biomagnification factor in fish	marine: 11.6 freshwater: 5.8	HBCDD EQS Dossier (2011). Technical product.

Parameter	Definition	HBCDD	Notes and references
Hydrolysis half-life		hydrolysis considered of low significance	HBCDD EQS Dossier (2011).
Photolysis half-life		photolysis considered of low significance	only changes in diastereomer composition observed with photolysis. HBCDD EQS Dossier (2011). Technical product.
Biodegradation half-life		some evidence, but variable rates reported (1.5 to 191 days)	HBCDD EQS Dossier (2011). Technical product.
MTDI (mg/kg/d)	Maximum tolerable daily intake to humans	0.1	HBCDD EQS Dossier (2011). Technical product.

4.2 HBCDD production

According to the Bromine Science and Environment Forum, HBCDD is produced in the US, Europe, and Asia (BSEF 2010). Total global demand for HBCDD increased by 2002 to 21,447 tonnes, and rose again slightly in 2003 to 21,951 tonnes (BSEF 2006) with production of 28,000 tonnes in 2010 and an estimated total production of HBCDD at around 31,000 tonnes in 2011. From this about 13,000 tonnes were produced in the EU and the United States, and 18,000 tonnes in China (UNEP/POPS/POPRC.7/19/Add.1, UNEP/POPS/POPRC.8/16/Add.3). Since HBCDD will be phased out in textile due to Convention obligations and alternatives for HBCDD are available for EPS and XPS (ECHA 2009; USEPA 2014; Subsport 2013;), the future production and use volumes might be expected to decrease (ECHA 2009).

HBCDD is for example already regulated in China. Reference is made to the announcement by the Ministry of Environmental Protection of China on 2016-12-26. The Congress approved the new amendment of Stockholm Convention of adding HBCDD as POP, this amendment is applicable in China from 2016-12-26. From this date the production, usage, import and export of HBCDD is banned. According to Stockholm Convention, the following is exempted:

a. For the production of foamed polystyrene and extruded polystyrene (mainly as a flame retardant), in the specific exemption registration of the validity period, can be produced, used, imported and exported. The validity of the registration of a specific exemption is terminated in principle five years after the entry into force of the amendment (December 25, 2021).

b. For laboratory-scale research or as a reference standard, can be produced, used and imported and exported

Japan has added the brominated flame retardant HBCDD and "technical endosulfan" and its related isomers" to its list of class I specified substances, the Ministry of Economy, Trade and Industry announced on 5 July 2013. Class I specified substances are those which are persistent, highly bioaccumulative, have a risk of long-term toxicity to humans or predators high up the food chain; and are specified by Cabinet Order. Manufacturers and importers of the substances must obtain a permit, before their manufacture or import. Usage of the listed substances is prohibited, with exemptions, and the import of products containing such substances is also prohibited (https://chemicalwatch.com/15568/japan-bans-hbcd-and-endosulfan).

4.3 Expected use and materials

In the sub chapters below a presentation of materials which may contain HBCDD is presented. Information is gathered trough literature searches and liaising with relevant industries that could provide information on the topic. A detailed reference list for the findings is listed (Chapter 7).

Materials that are considered relevant for the IHM are highlighted. This is based on an evaluation if it is relevant for ships and rigs, and if it is expected to be found in concentrations or amounts higher than the threshold listed in EMSA's Best Practice Guidance on IHM (2016). The Best Practice Guidance Document lists a threshold value of 100 mg/kg (0,01 %) for HBCDD (for new constructions)

In relation to IHM in ships and rigs in general, it is expedient to distinguish between new ships and existing ships. New ships in this regard are related to the timeline of implementation of Regulation (EU) N.1257/2013 where 31.12.2018 is the latest possible date of general application. New ship means a ship for which either:

(a) the building contract is placed on or after the date of application of the Regulation;

(b) in the absence of a building contract, the keel is laid or the ship is at a similar stage of construction six months after the date of application of this Regulation or thereafter; or

(c) the delivery takes place thirty months after the date of application of this Regulation or thereafter;

For new ships, the material declaration shall provide information of any hazardous material, including amount, and as such this should provide the necessary information for proper handling and disposal of those materials. If in doubt one can take a random check(s) by sampling and analysis to confirm if materials contain HBCDD or not.

For older ships and rigs which do not have a complete material declaration various systems and equipment, more detailed information retrieval about materials which may contain HBCDD is necessary, as well as a more detailed sampling and analysis program.

4.4 Literature research

According to the U.S Environmental Protection Agency (EPA 2014), the main use of HBCCD is in expanded polystyrene foam (EPS) and extruded polystyrene foam (XPS). The substance may also be found in high impact polystyrene (HIPS) and as a flame retardant in textile. Profiles of HBCDD in European markets (year 2006/2007) indicates that 96 % of HBCDD is related to EPS and XPS, meaning only a small fraction in HIPS and textiles.

In Table 4-2 areas of use of HBCDD are listed. In Table 4-3 a more detailed table for XPS and EPS is presented.

Table 4-2. Area of use of HBCDD. Colour coding: Light Green: Considered relevant for ships & rigs, Orange: Considered relevant but normally not expected to contain HBCDD on board ships (but cannot be excluded), Red: considered not relevant for ships & rigs.

Area of use	Short description	Considered relevant for ships and rigs
Textile back coatings	Used as coating in t.ex. carpets, rugs furniture's and fabrics. Flame retardant. 2.2 – 4.3% *in the textiles*	Detected in IHM samples checked by DNV GL and considered relevant (See chapter 10). Expected low volumes of HBCDD are used in textile and back coatings in general as HBCDD is mainly used in XPS- and EPS foam.
HIPS	High impact polystyrene can be described as a versatile, economical and impact resistant plastic used for example as appliance products, toys, TV and audio visual equipment (electrical), instrument panels and fittings and computer housings. Commonly used in electric and electronic appliances as well as building materials.	Considered relevant for electronic housing in general. Expected low volumes of HBCDD are used in HIPS in general as HBCDD is mainly used in XPS- and EPS foam.

Table 4-2 continues.

XPS- and EPS foam	Used in building and construction industry to meet fire safety standards, for insulation, moisture barrier, protect against damage from freezing, provide stable fill material and create high strength composite materials. Typically content of 0.7 % by weight in XPS and 0.5 to 2 % in general.	Main area of use of HBCDD in XPS- and EPS foam. A more detailed area of use is presented in Table 4-3.

Table 4-3. Typical application of EPS and/or XPS. Light Green: Considered relevant for ships & rigs, Orange: Considered relevant but normally not expected to contain HBCDD on board ships (but cannot be excluded), Red: considered not relevant for ships & rigs.

Area of use	Short description	Considered relevant for ships and rigs
Attics and ceilings	Used in interior ceiling panels, etc, see also walls below.	Several type approval certificates have been checked and all off those suggest that steel plates and glass/rock wool are used as material. A supplier has also been contacted, saying that they themselves and all their competitors use steel plates and glass/rock wool. Based on DNV GL experience it cannot be ruled out that EPS or XPS has been used in attics and ceilings.
Roofs	Membrane roofs, Recovery/reroofing Vegetative roofs	No, mostly related to roofing paper not relevant for ships and rigs.
Walls	Continuous insulation, exterior insulating and finishing system (EIFS), garage door panels, insulating concrete foam, masonry cavity walls, one cut stucco panels, precast concrete, steel stud insulation, structural insulation panels (SIPs)	Type approval certificates of 10 suppliers of wall panelling has been assessed. Everyone deliver steel plates with glass/rock wool. Based on DNV GL experience it cannot be ruled out that EPS or XPS has been used in walls.
Flooring	Insulation in flooring	Yes - for example vinyl flooring in accommodation area
Below grade applications	Frost protected shallow foundations (FPSF), geofoam, geotechnical fill & stabilization, highway insulation	No

Table 4-3 continues.

Cold storage	Low temperature buildings	Yes – foam insulation of cold provision rooms, etc.
Transportations	Recreational vehicle panels, shipping containers, electrical parts	Yes
Tank insulation (LPG, LEG and LNG tank) other foam insulation	Used as foam insulation of tanks to achieve thermal efficiency, improved insulation life time and low need for maintenance.	Yes – foam insulation.

Table 4-4 list some other areas of use for BFR in general. These materials are listed since presence of HBCDD cannot be ruled out.

Table 4-4. Area of use of brominated flame retardants in general. Colour coding: Light Green: Considered relevant for ships & rigs, Orange: Considered relevant but normally not expected to contain HBCDD on board ships (but cannot be excluded), Red: considered not relevant for ships & rigs.

Area of use	Short description	Considered relevant for ships
Cellular rubber	Used as seals and gasket for example around pipes, connections and other.	Cannot be ruled out. Cellular rubber is relevant for BFR, but according to NGU (2012) it is rather decaBDE that represent the most commonly found BFR in cellular rubber.
Electronical waste	Printed circuit board (mostly TBBPA), PC cabinet, office machines (mostly TBBPA)	Cannot be ruled out, but not expected as TBBPA is more probable.
Paint	Used as flame retardant in paint, but probably small volumes	Cannot be ruled out, but not found in paint samples looked at by DNV GL, see Chapter 4.11.
Plastic	Various products. See also HIPS in Table 4-2 above.	Yes, in various applications

4.5 Industry information

A summary of materials that may contain HBCDD based on industry interviews is presented in the table below. The company names are anonymous but a short general description is provided in Appendix A.

Table 4-5. Materials that may contain HBCDD based on industry interviews.

Company	Summary
1	Brominated flame retardants (including HBCDD) are found in incoming waste fluids. They assume that brominated flame retardants are mainly originating from paints/coatings on the vessels and rigs, coming in the water they receive for treatment (from flushing and cleaning surfaces).
2	Brominated flame retardants (including HBCDD) is found in flooring and carpets. They also find it in cellular rubber that is used as insulation for pipes, however this is normally in smaller amounts. The chemical analyses are quite expensive, thus sometimes it is easier to just deliver such insulation as hazardous waste instead of doing the analyses. It is known that the insulation for electrical cables often contains brominated flame retardants. Such cables are however never analyzed, they are simply removed and delivered as EE waste.
3	From demolition of buildings, it was registered that carpets and vinyl coating could contain HBCDD.
4	HBCDD had been detected in 12 out of 250 samples since 2016 in insulation material (XPS, EPS) in a range from 67 to 84 000 mg/kg.
5	They have never used HBCDD in their coatings. Phosphates and borates are used in flame-retardant coatings.
6	HBCDD can be found in various products such as insulation material (XPS, EPS, including cellular rubber), cables and upholstery. Cables are however not analyzed; they are delivered as EE waste. In general, all types of waste that may contain HBCDD above the threshold level for hazardous waste, are assumed hazardous waste until material sampling and analysis prove otherwise.
7	and HBCDD has been found above the threshold level for hazardous waste in insulation material (XPS, EPS, including cellular rubber) and various panelling used in hotels and hospitals. It may also be present in carpets and flooring. Vinyl flooring prior to year 2000 is generally always treated as hazardous waste due to content of phthalates, hence samples are seldom analysed for HBCDD.
8	Normally they use a XRF gun to measure the level of brome in cellular rubber, XPS, EPS, carpets, curtains and upholstery. Hence they do not sample and analyse for specific brominated flame-retardant, but for brome content.
9	HBCDD in most frequently found in XPS, EPS and cellular rubber above the threshold level for hazardous waste.
Summary	Based on the information from the industry interviews, materials that potentially contains HBCDD is: ✓ Paint ✓ Carpets ✓ Floor covering ✓ Cellular rubber

	✓ Vinyl coating ✓ Cable insulation ✓ Upholstery ✓ XPS and EPS

4.6 Overall summary of materials containing HBCDD

Based on the findings from the literature study and communication with the industry, materials which may contain HBCDD are listed in Table 4-6.

Table 4-6 Identified materials that may contain HBCDD.

Most relevant	Other
✓ **Polystyrene foam (EPS and XPS)**	✓ HIPS ✓ Textiles and flooring ✓ Paint ✓ Cellular rubber ✓ Electronical waste ✓ Attic and ceilings, walls

4.7 Occurrence onboard ships of the relevant materials containing HBCDD

4.7.1 Polystyrene (EPS and XPS)

Can be found onboard all vessels- and rig types and should be considered for insulation used in the walls and ceiling of cold provision rooms. In addition to above, it is recommended that special attention is paid to insulation on board reefers, insulation in refrigerated containers and insulation of LPG, LEG and LNG tanks.

4.7.2 High Impact Polystyrene (HIPS)

Can be found onboard all vessels- and rig types and relevant for resistant plastic used computer housings and instrument panels especially. Relevant areas are bridge, offices and control rooms. Electronic products not integral to ship operations, fall out of scope with regards to IHM Part I. Material Declarations, Suppliers Declarations of Conformity and listing in the IHM Part I, is not required for equipment listed in Table D in Res. MEPC.269(68). Regular consumable goods, as provided in table D of appendix 1 in MEPC.269(68), should be listed in part 3 of the inventory if they are delivered with the ship to the ship recycling facility. A general description including the name of item, manufacturer, quantity and location should be entered in part III of the inventory. This includes electrical and electronic equipment and furniture, interior and similar equipment. Waste from end-of-life electrical and electronic equipment, known as e-waste, may contain a range of hazardous substances, including HBCDD. E-waste need to be disposed of in a safe and environmentally sound manner whenever replaced or when vessel is due for recycling.

4.7.3 Textiles and flooring

Can be found onboard all vessels- and rig types and relevant items are carpets, furniture's and vinyl flooring in accommodation areas, offices and passageways especially. These products fall out of scope with regards to IHM Part I in general. Material Declarations, Suppliers Declaration of Conformity and listing in the IHM Part I, is not required for equipment listed in Table D in Res. MEPC.269(68). However, if for example glued to the construction it is regarded as an integral part of ship in operation and shall be included. Regular consumable goods, as provided in table D of appendix 1 in MEPC.269(68), should be listed in part 3 of the inventory if they are delivered with the ship to the ship recycling facility. A general description including the name of item, manufacturer, quantity and location should be entered in part III of the inventory. This includes electrical and electronic equipment and furniture, interior and similar equipment. Possible content of HBCDD need to be addressed, whenever replaced or when vessel is due for recycling, to ensure safe and environmentally sound disposal.

4.7.4 Paint

Paints and coatings are in general relevant for all ship- and rig types. Paints can be found almost anywhere in the construction such as floors, walls and roofs as well as on the hull (also relevant for PFOS so samples can be combined).

4.7.5 Cellular rubber

Cellular rubber is frequently used as insulation for cold systems as it can prevent condensation, moisture intrusion and long term degradation. Very often, cellular rubber is found on pipes in connection with the air conditioning plant.

4.8 Sampling onboard ships

See Chapter 3.8 for general description and reference to EMSA's Best Practice Guidance on the Inventory of Hazardous Materials and IMO Resolution MEPC.269(68).

4.9 Analysis

4.9.1 Todays practice

A review of analytical methods applied in IHMs for HBCDD based on findings in 24 IHM reports (DNV GL data base) indicates different practices with regards to analytical procedures. A summary of applied analytical procedures is presented in Table 4-7.

Table 4-7. Analytical procedures applied in IHMs.

Stated analytical procedure HBCDD	Ship built (year)
DIN EN ISO 22032	1994
German method DIN ISO 10382	1977, 1978, 1990, 1998, 2015
Refer to US EPA 3550C:2007&US EPA 8270D:2014, equipment GC-MS	1986, 2008, 2009
GM-MS	2012
Material declaration	2016
Unknown	2003

With reference to the table above, no standard methods exist for HBCDD. An ISO method for water is currently under development, entitled ISO/NP 21677 "Water quality -- Determination of Hexabromocyclododecane (HBCDD) in water -- Method using liquid chromatography-tandem mass spectrometry (LC-MS/MS)".

For solid samples, commercial labs have been observed to apply standardized methods for semi volatile organic compounds. These include US EPA METHOD 8270D "Semi volatile organic compounds by gas chromatography/mass spectrometry (GC/MS)" and DIN ISO10382 "Soil quality -- Determination of organochlorine pesticides and polychlorinated biphenyls -- Gas-chromatographic method with electron capture detection". Several commercial labs have also used combinations of US EPA 3550 C:2007 for extraction (as with PFOS) followed by GC-MS. For water, it has been observed that labs have applied a standard method for polybrominaded diphenyl ethers, namely ISO 22032:2006 "Water quality - Determination of selected polybrominated diphenyl ethers in sediment and sewage sludge - Method using extraction and gas chromatography/mass spectrometry".

It is unknown to what extent these standardized methods are quantitative for HBCDD, as they are developed for other contaminants. It should be emphasized that these methods all use gas chromatography, whereas the forthcoming standard method for HBCDD, and most literature methods for HBCDD, use liquid chromatography. This is because better separation of the HBCDD isomers can be achieved with liquid chromatography, whereas gas chromatography methods would give total HBCDD concentrations (Loos, 2012).

4.9.2 Literature review

Literature about methods to analyze HBCDD have been reviewed in Dirtu et al. (2013). In summary, of the 16 possible diastereomer configurations of HBCDD, only the three predominant diastereomers are commonly analysed (α-, β-, and γ-HBCDD). For extraction from liquid phases, like water, SPE is commonly used (C18) using polar solvents, including methanol, acetonitrile or dichloromethane. For extraction from the solid samples, many options are possible, but Soxhlet extractions are the most common, using typical solvents being s n-hexane, DCM, acetone (or mixtures thereof), though ultrasound and microwave extractions are reported to perform better for HBCDD (Dirtu, 2013). After this, the extracts are cleaned up using destructive or non-destructive methods (referring to if they destroy part of the HBCDD in the sample or not). Destructive methods typically use concentrated acid. Non-destructive methods involve purification on a column containing materials like silica, florisil, etc, and eluting with a solvent. Care must be taken here as the elution time of the various diastereomers can vary depending on the solvent and forelution liquid (Mariussen et al. 2010). Separation of these diastereomers has been found to be near impossible using traditional gas chromatography (GC) techniques, and most labs tend to prefer reverse-phase LC MS/MS to quantify HBCDD. Detection limits under optimal conditions are ca 1 – 4 ng/g in biotic matrices, 0.2 – 20 ng/g in soils and sediments, and 0.1 – 1 µg/L in aquatic matrices (Dirtu, 2013).

4.10 Safety and health aspects for sampling and handling

4.10.1 General

For general information related to sampling and handling see Chapter 3.10.1

4.10.2 Safety and health aspects for sampling and handling of HBCDD

Matrices that are typically sampled for HBCDD include:

Liquids: (i) Leachate from dumpsites and landfills; (ii) Water (surface water and groundwater, drinking water, and industrial and municipal effluents); (iii) Biological fluids (blood, in the case of worker health monitoring);

Solids: (i) Sewage sludge; (ii) Biological samples (adipose tissue); (iii) Stockpiles of HBCDD, mixtures and articles consisting of, containing or contaminated with HBCDD; (iv) Indoor dust;

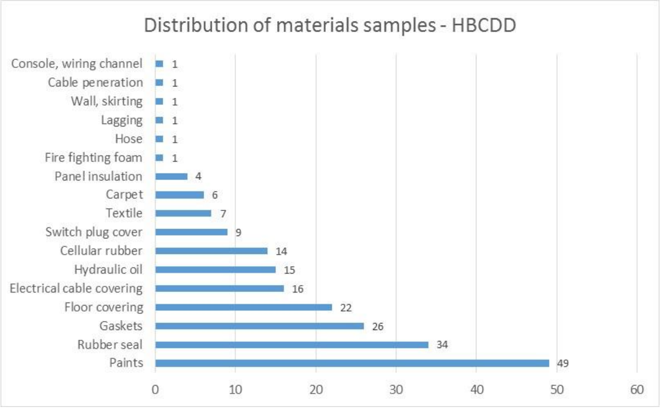
Gases: (i) Air (indoor and outdoor); (ii) Exhaust gas.

In general matrices that are sampled will contain relatively low amounts of HBCDD. The main application of HBCDD is in polystyrene foam (EPS and XPS) that is used in insulation boards in buildings and constructions. In such polystyrene foams HBCDD concentrations ranges from 0.5 % to 2.5 % (UNEP, 2017). Sampling of such polystyrene foams do not need special precautions with respect to safety and health aspects for sampling and handling. The focus should be related to the type of matrix that is sampled and the general guideline about sampling and handling should be followed.

4.11 Current situation in the maritime industry regarding inventories of HBCDD

DNV GL has considered results of material analysis from inventories of hazardous materials for 17 vessels (DNV GL data) where HBCDD has been considered. They have mainly been prepared on board existing ships, but also a few during new building. The ships for which HBCDD were sampled, were built between 1977 and 2015, whereof almost half of the ships being built between 2008 and 2015. For the new buildings included in the data set (built in 2016), no material was sampled for HBCDD. Referring to MEPC.269(68) IHM guideline sampling of e.g. plastic parts and lacquers of electrical or electronical components (where HBCDD may be present) is out of scope with regards to sampling for vessels in operation, hence the IHM will in most cases not provide sufficient information to the yard with regards to hazardous materials such as HBCDD. These items should be evaluated and disposed of in a safe and environmentally sound manner whenever replaced, or when vessel is due for recycling.

HBCDD is detected in only 1 out of 208 samples in total. The substance was found in carpet from a ship built in 1990 in a concentration 280 mg/kg which is above the threshold value in the Guidance document (100 mg/kg), and need to be recorded in the IHM Part 1. An overview of type of materials sampled is presented in Figure 4-1. Paint and rubber seal are the materials most often sampled. Carpets are analyzed on 6 occasions and with one finding, as mentioned. HBCDD was not recorded in any MDs.



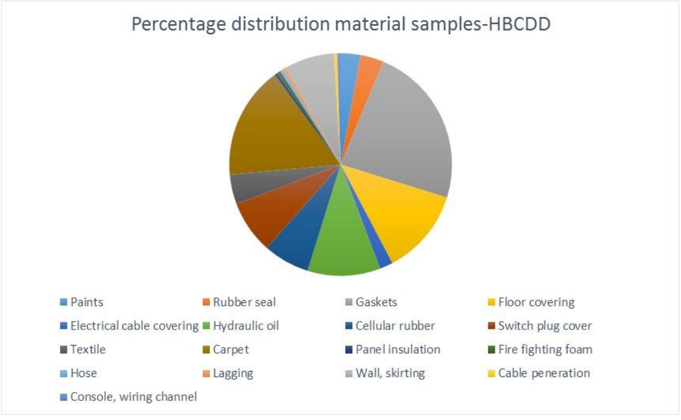


Figure 4-1. Number of different materials analysed for HBCDD.

4.12 Regulatory requirements – threshold levels for detection and reporting

In Table 4-8 below, threshold values for PFOS and HBCDD in new products and threshold values for hazardous waste in international, regional and national legislation is presented.

Table 4-8 . Examples on HBCDD threshold levels in new products and threshold level for hazardous waste.

Regulation	**HBCDD**	
	In new products	*Threshold level hazardous waste*
Basel Convention		100 mg/kg or 1000 mg/kg[1*]
EU	<100 mg/kg as an unintentional trace contaminant in substances	1000[2] mg/kg
Norway	<100 mg/kg as an unintentional trace contaminant in substances	1000[2] mg/kg
China	Not specified but prohibited in accordance with Stockholm convention	Unknown
USA	No concentration provision for products, subject to reporting under the Significant New Use Rule	Unknown
Canada	No[3] threshold level, exemption for incidental presence which means a residual, a trace contaminant or impurity that was not intentionally added to the formulation	Unknown
Switzerland		

[1]Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with hexabromocyclododecane (HBCDD) (adopted by COP.12, May 2015)

* Determined according to national or international methods and standards. It is noted that further work to agree on one value will be undertaken according to decision BC-12/3

[2]COMMISSION REGULATION (EU) 2016/460 of 30 March 2016 amending Annexes IV and V to Regulation (EC) No 850/2004. Subject to review by the Commission by 20.4.2019

[3] Hexabromocyclododecane (HBCDD) and the Prohibition of Certain Toxic Substances Regulations, 2012

Regulation (EC) 850/2004 on persistent organic pollutants (POP Regulation) aims among others at protecting the environment and human health from certain specified substances that are transported across international boundaries far from their sources, persist in the environment, and cause bioaccumulation, by implementing relevant international agreements. The Regulation’s scope is restricted to those substances with POP properties specified in the Annexes of the Regulation. Following Article 7 of the POP Regulation, wastes consisting of POPs, containing or contaminated with them above specific limit values (concentration limit referred to in Article 7(4)(a) – the so called ‘low POP-content limit value’), must be disposed of or recovered, without undue delay and in accordance with the provisions laid down in the POP Regulation in such a way as to ensure that the persistent organic pollutant content is destroyed or irreversibly transformed so that the remaining waste and releases do not exhibit the characteristics of persistent organic pollutants. Disposal or recovery operations that may lead to recovery, recycling, reclamation or re-use of the POPs are prohibited (EC guidance document, 2015). PFOS and HBCDD is amongst the POPs regulated by Regulation (EC) 850/2004.

Based on literature search on threshold values it is suggested that threshold value for HBCDD in new products remain at 0,01%. If HBCDD is added to a product to achieve specific characteristics the concentration is above 0,01%. HBCDD below 0,01% is most likely related to unintentional trace contaminant in substances. With regards to waste treatment when a vessel is due for recycling it is suggested that hazardous waste threshold level is set to 1000 mg/kg, in accordance with Basel Convention and Regulation (EC) 850/2004.

4.13 Detection and reporting thresholds – environmental media

In environmental media, such as freshwater, marine water, sediments and soils, reporting thresholds should generally be below the derived Environmental Quality Standard (QS) value. A QS value is generally indicative of threshold concentration for which chronic effects may be observed to humans or within an ecosystem. In the European Union's Water Framework Directive (2013/39/EU), they use two major types of QS values for water, the Annual Average EQS (AA-EQS) value which is the acceptable average QS over a one year period of unfiltered water, and the maximum acceptable concentration EQS, which is the maximum for a short period time, as this concentration could lead to short-term (acute) effects to humans or an ecosystem.

Table 4-9. Threshold values for HBCDD in different environmental compartments according to European Union's Water Framework Directive (2013/39/EU).

EU QS Parameter	Definition	HBCDD	**Notes and references**
$QS_{biota,sp}$ (mg/kg_{biota})	Quality standard to prevent chronic secondary poisoning to predators	0.167	WATER FRAMEWORK DIRECTIVE 2013/39/EU
$QS_{biota,hh}$ (mg/kg_{biota})	Quality standard to prevent chronic human health effects	6.1	EU dossier (HBCDD)
$AA\text{-}EQS_{freshwater}$ (µg/L)	Average annual environmental quality standard to prevent chronic toxicity to freshwater organisms	0.0016	WATER FRAMEWORK DIRECTIVE 2013/39/EU
$MAC\text{-}EQS_{freshwater}$ (µg/L)	Maximum acceptable concentration environmental quality standard to prevent acute toxicity to freshwater organisms	0.5	WATER FRAMEWORK DIRECTIVE 2013/39/EU
$AA\text{-}EQS_{marine\ water}$ (µg/L)	Average annual environmental quality standard to prevent chronic toxicity to marine organisms	0.0008	WATER FRAMEWORK DIRECTIVE 2013/39/EU
$MAC\text{-}EQS_{marine\ water}$ (µg/L)	Maximum acceptable concentration environmental quality standard to prevent acute toxicity to marine organisms	0.05	WATER FRAMEWORK DIRECTIVE 2013/39/EU
QS_{sed} ($mg/kg_{sed\ d.w.}$) **(f_{OC} = 5%)**	Quality standard to prevent chronic effects to benthic species	marine: 0.17 freshwater: 0.86	M-608
QS_{soil} ($mg/kg_{soil\ d.w.}$) (f_{OC} = 2%)	Quality standard to prevent chronic effects to soil dwelling organisms	12.8	REACH-AF AF:10

4.14 Stockholm convention

The Stockholm Convention on Persistent Organic Pollutants was adopted on 22 May 2001 and entered force on 17 May 2004. The information in this chapter is mainly derived from webpages of the Stockholm convention (http://chm.pops.int/). The Stockholm convention is applicable to ships. Specific obligations are associated with the POPS listed in Annexes A, B and C, and some exceptions apply in certain circumstances. At its sixth meeting held (May 2013), HBCDD was added to Annex A, which means that parties must take measures to eliminate the production and use of the chemicals listed under Annex A. Specific exemptions for use or production are listed in the Annex and apply only to Parties that register for them.

4.15 EU regulation

The European Union became a Party to the Stockholm Convention in 2005. The EU legal instrument for implementing the Stockholm Convention is Regulation (EC) No. 850/2004 on POPs. The Regulation complements earlier EU legislation on persistent organics pollutants and aligns it with the provisions of international agreements on persistent organics pollutants. This regulation has been amended on many occasions. On March 2, 2016, the EU published Regulation (EU) 2016/293 amending Regulation (EC) No 850/2004 of the European Parliament and of the Council on persistent organic pollutants prohibiting the manufacture, placing on the market and use of HBCDD. Some important exemptions to this new law include the following:

- Presence of no more than 100 mg/kg as an unintentional trace contaminant in substances, mixtures, articles or flame-retardant parts of articles. This is subject to review by the Commission by March 22, 2019
- Production of HBCDD for the manufacture of expanded polystyrene articles subject to authorization under REACH. This is allowed until November 26, 2019
- Use of expanded polystyrene and extruded polystyrene in buildings with certain conditions (http://chm.pops.int/Implementation/Exemptionsandacceptablepurposes/RegisterofSpecificExemptions/ChemicalslistedinAnnexA/tabid/4643/Default.aspx).

In addition to the above, HBCDD is listed as a substance subject to authorization under the European Union (EU) REACH Regulation with a phase-out date of 21 August 2015 (Sunset date).

4.16 Waste disposal regulation

As described for PFOS in Chapter 3.16 the Basel Convention technical guidelines for the environmentally sound management of wastes list two methods for destruction and irreversible transformation; (a) Cement kiln co-incineration and (b) Hazardous waste incineration. Method (a) and (b) are applicable to HBCDD as well. Destruction and irreversible transformation methods applicable for the environmentally sound disposal of wastes with a content of HBCDD at or above 1000 mg/kg.

5 CURRENT PRACTICE IN RELATION TO SUPPLIERS AND MATERIAL DECLARATIONS

DNV GL has experience with assessment of Green Passports (Resolution A.962(23)) and IHM per Hong Kong Convention and EU regulation for more than 3500 vessels as a Classification Society. The IHMs have been compiled both for new building and existing vessels, however the majority of IHMs has been prepared for new buildings.

Over the years since 2006 when DNV GL started to offer this service, more than 150 yards in 29 countries have been involved in compiling material declarations (MDs) and Supplier Declarations of Conformity (SDoCs) in preparations of IHM. The table below gives an overview over number of yards in the main countries that have experience with preparation of IHMs subject to review by DNV GL

Table 5-1. Overview over number of yards in the main countries that have experience with preparation of IHMs subject to review by DNV GL.

Country	Number of yards
China	47
Republic of Korea	25
Norway	24
Japan	10
Singapore	8
India	6
Germany	5
Turkey	4
Vietnam	3

Under the Article 5 of the EU SRR, it is stated that each new ship shall have on board a verified IHM. Part I of the IHM shall be developed at the design and construction stage by the shipyard. Main focuses for the shipyard are the hazardous materials on board ships, which must be identified and documented in the IHM. Therefore, a cooperative approach is required from the suppliers and shipyards to effectively follow and implement relevant processes as required for new ships above 500GT.

Hazardous materials concerning Part I of IHM are listed in Annex I and II of the EU SRR. The shipyards must collect and utilize the information regarding the presence of hazardous materials of concern at the very beginning of the design and construction phase. Details on hazardous materials contained in equipment, components and coating systems are unlikely to be known by the shipyard completely and therefore information on the presence of Annex I and II materials must be requested directly from Tier 1 Suppliers. This information must be provided by the suppliers via a "Suppliers Declaration of Conformity" (SDoC) and "Material Declaration" (MD) (see Figure 5-1).

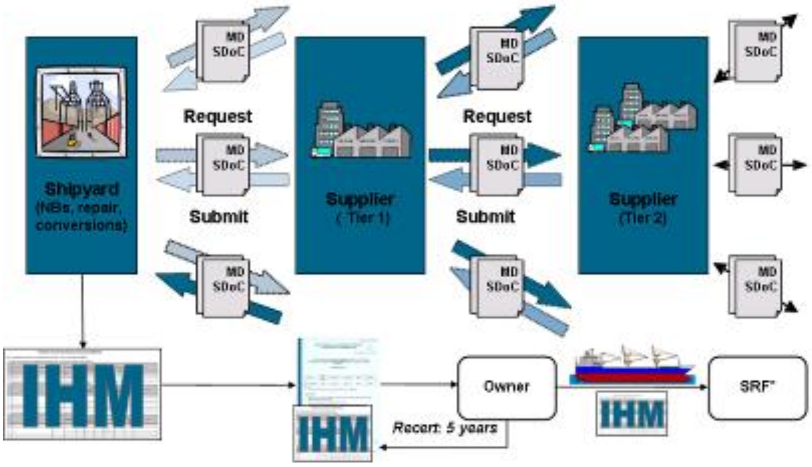


Figure 5-1. Procedure for gathering information within the supply chain, from new building to end of life at the ship recycling facility (SRF).

5.1.1 Tasks for Shipyards

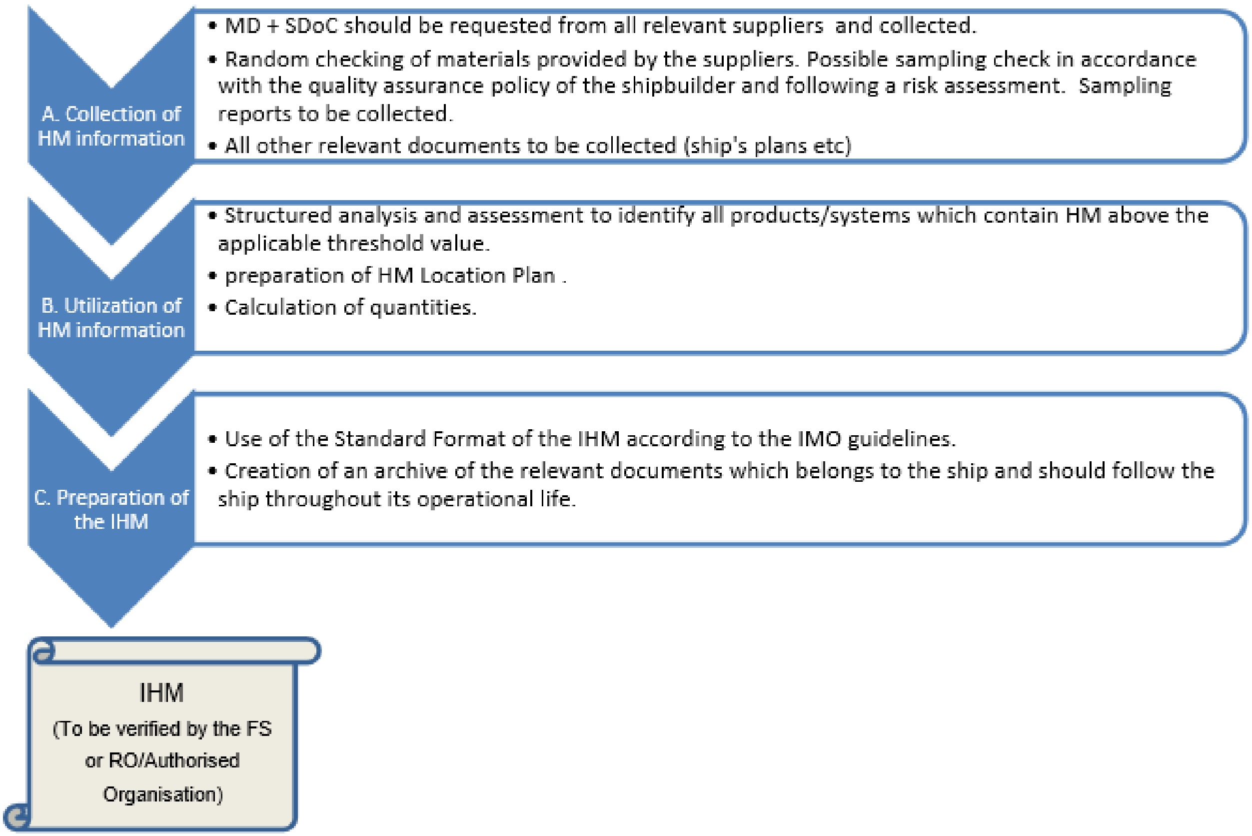
Shipyards are responsible for the following points:

- Identification of their suppliers and request statements on the presence of HazMats (MDs, SDoCs)
- Collection of information from their suppliers in the form of MDs and SDoCs
- Check and confirmation on presence of materials listed in Annex I*and II**
- Listing the quantity and location of Annex I and II materials in Part I of the IHM
- Development of IHM part I by using the information from MDs and SDoCs

* PFOS reporting is mandatory for EU-flagged ships, but is not required for third-party vessels
**HBCDD reporting is mandatory for EU-flagged new buildings, and should be reported as far as practicable for both EU-flagged vessels in operation and third-party vessels

The information gathering process is, especially in the initial stage, a complex and time consuming procedure, which makes early action inevitable. Therefore, it is strongly recommended, that the shipyard that need to collect and utilize the necessary information, should initiate this process at an early stage, e.g. at the design stage. The related procedures for gathering information and required forms for the preparation of the IHM for new ships are shown in

Figure 5-2 for assuring a unified and effective implementation in the supply chain and shipbuilding industry.



SDoC = Suppliers Declaration of Conformity; **MD** = Material Declaration

Figure 5-2. Development process of the IHM for New Ships from the EMSA IHM guideline

Information on Hazardous Materials must be provided by the Tier 1 suppliers in form of "Material Declaration" (MD). Additionally, "Suppliers Declaration of Conformity" (SDoC) statement must be issued by the Tier 1 suppliers to ensure that correct information is provided. The Shipyard collects all information on hazardous materials and quantities (weight/volume) of the products (e.g. coating systems, components and equipment) in the form of MDs and SDoCs. The Shipyard shall only accept properly filled in MDs and related SDoCs. The information of the SDoC and MD received from Tier 1 Suppliers shall be directly utilized and the location and/or the system of the related HazMats onboard including amounts when applicable shall be calculated and added to the IHM Part I by shipyard. In case of a new installation, repair and conversion the shipyard should update the IHM Part I by providing the relevant MDs and SDoCs for the newly installed parts.

In practice, there have been cases where random sampling checks proved that MDs were not accurate. In addition to collecting declarations, the EU SRR IHM guidance suggests a random sampling check for new buildings. The ship builder should establish a quality assurance policy for performing random checking of materials provided by the suppliers. This policy should take into account the type of the material, the location and the intended use on board the ship, the required life-time maintenance and the origin of the material. E.g. firefighting foam concentrate which may contain PFOS has a long shelf life (20-25 years) as well as foam insulation which may contain HBCDD.

5.1.2 Tasks for Suppliers

Suppliers are responsible for following points:

- Evaluation of their products in a detailed way
- Check on the presence of HazMats in their own products from upstream suppliers (Tier 2 to Tier n)
- Providing information on hazardous materials in form of the "Material Declaration (MD)" and Suppliers Declaration of Conformity (SDoC), see Figure 5-3 and Figure 5-4.
- MDs and SDoCs shall be provided on the required forms and include PFOS and HBCDD

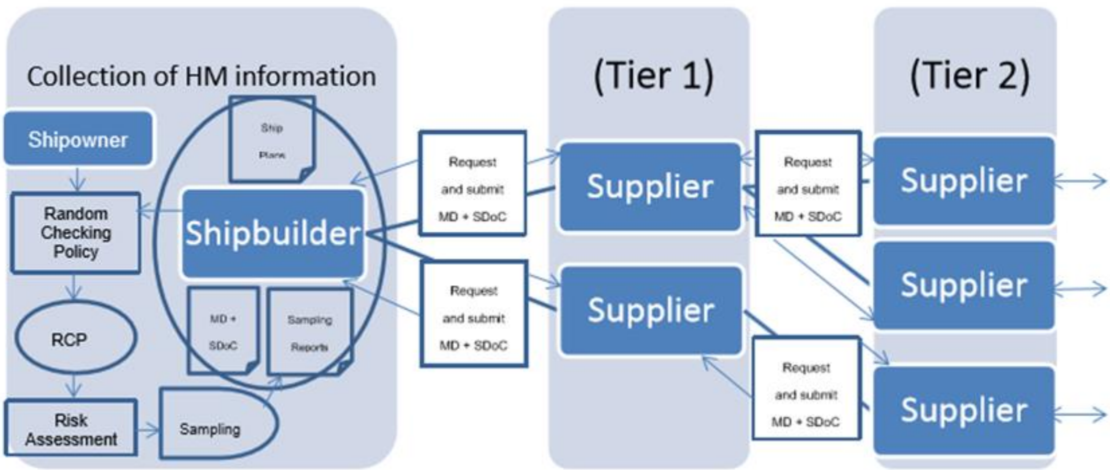


Figure 5-3. collection of MDs and SDoCs from the EMSA IHM Guideline

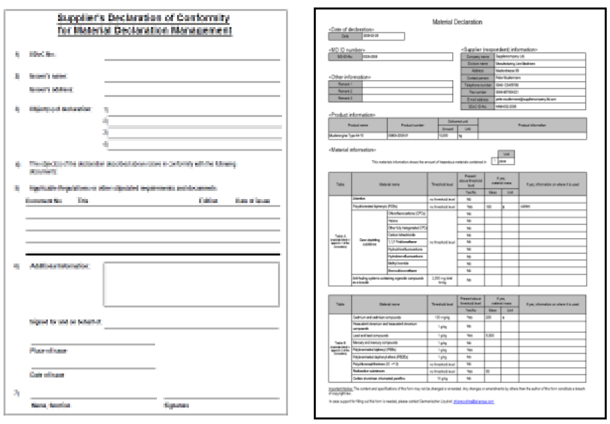


Figure 5-4. SDoC and MD

In order to provide information on the presence of Hazardous Materials in their products, it is necessary to collect information from upstream suppliers within their supply chain. All suppliers of the supply chain shall fill in MDs and SDoCs properly. The following chapter provides information on how to complete correct MDs and SDoCs.

5.1.3 Material Declaration (MD)

Suppliers to the shipbuilding industry should identify and declare whether the materials listed in Annex I or II are present above the threshold level in their products. Missing information is to be gained from their supply chain and to be completed with own information, all information should be provided to the requesting shipyards. The MD should be prepared on basis of the collected information by the Tier 1 supplier. For MD preparation, templates provided should be used.

If PFOS is found to be present in concentrations above the specified threshold level according to the MD, the product(s) which contain PFOS is prohibited to be installed on board EU-flagged vessels

If HBCDD is found to be present in product(s) in concentrations above the specified threshold level according to the MD, these product(s) shall be listed in the inventory for EU-flagged vessels

The declaration on the presence of HazMats of Annex I and II in products should be made for each "homogenous material". Figure 5-5 shows an example of four homogenous materials which constitute a cable. In this case, sheath, intervention, insulator and conductor are all individual homogenous materials.

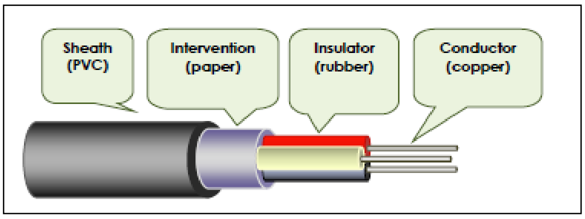


Figure 5-5. Example of homogenous material (cable)

According to the Res. MEPC.269(68), there are some exclusions from IHM & MD scope.

- Chemicals which do not constitute a part of the finished product
- Non-ship specific and widely used appliances as outlined in Table D of Guideline for the development of the IHM (MEPC.269(68).
- Metal and metal alloys – used in general construction, such as hull, superstructure, pipes or housing for equipment and machinery (e.g. bearings are not counted in this group and must be documented in MDs)

Table D in Res. MEPC.269(68) is an overview of common appliances, which neither have to be considered in Material Declarations nor in Suppliers Declaration of Conformity or in the IHM Part I. Also, these appliances are often covered and regulated by other international regulations, e.g. the Directive on the "Restriction of Hazardous Substances in Electrical and Electronic Equipment" ("RoHS"). This exclusion is only applicable if these appliances are containing only typical components, anything not falling under this exemption (e.g. specially designed electronic items) must be documented like other materials and components. Physical marking allowing easy identification of specifically designed parts, not falling under this exemption, is an option, if found to provide more clarity.

RoHS (Restriction of Hazardous substances) Directive eases the MD requirements only for electronic components. Statement for RoHS-conformity in MD preparation is helpful for materials listed in Annex II/SRR which conform with RoHS. In this case, only the investigation on existence of the three remaining HazMats becomes necessary (see Table 5-2). Non-RoHS-parts should be clearly marked in MD for distinction, when surrounded by RoHS conform parts. HazMats of Annex II must be investigated entirely for non-electronic components.

Table 5-2. HazMats covered/not-covered in RoHS

HazMats covered in RoHS & Annex II:	HazMats to be documented additionally for Annex II:
Cadmium and its Compounds	Polychloronaphthalanes (more than 3 chlorine atoms) (e.g. paint and lubricating oil)
Hexavalent Chromium and its Compounds	Radioactive Substances
Lead and its Compounds	Certain Shortchain Chlorinated Paraffin's (e.g. non-flammable plastics)
Mercury and its Compounds	
Polybrominated Biphenyls (PBBs)	
Polybrominated Diphenyl Ethers (PBDE's)	
Hexabromocyclododecane (HBCDD)	

5.1.4 Supplier's Declaration of Conformity (SDoC)

Supplier's Declaration of Conformity (SDoC) is a legal statement which must be prepared by Tier 1 Suppliers. It specifies the object of Material Declaration (MD). The purpose of the SDoC is to provide assurance that the related MD conforms with the requirements of the IMO MEPC.269(68) IHM guideline and to identify the responsible entity. The SDoC remains valid as long as the products are present on board. Please refer to section 4.4, 4.5 and 10 for further information regarding presence of PFOS and HBCDD on board vessels. According to the IMO MEPC.269(68) IHM Guideline suppliers compiling the SDoC should establish a company policy. For this a recognized quality management system may be utilized. For instance, the company policy on the management of the chemical substances in products, which the supplier manufactures or sells, should cover compliance with law and information on chemical substance content. SDoC should list organizational measures (e.g. ISO Certification) assuring correct MD-preparation, as well. If applicable, SDoC of supplier should contain statement on RoHS conformity.

Supplier's Declaration of Conformity (SDoC) should be provided to the requesting shipyard. Suppliers should provide legally solid signed SDoC. A signed hardcopy of SDoC shall be archived by the shipyard. For SDoC preparation, templates should be used (handwritten SDoCs should not be acceptable).

Provision of a unique ID-number for identification of MDs and related SDoC is necessary. This is not specified in the guidelines from IMO and the supplier is free to choose or develop an own numbering systems. However, ISO 30005 "Ship recycling management systems - Information control for hazardous materials in the manufacturing chain of shipbuilding and ship operations" provides guidance for the management, communication, and maintenance of information in an effective, standardized, and compatible manner in accordance with the requirements of the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships that could be useful.

5.1.5 IHM maintenance

The IHM should be updated according to the requirements for new ships, which means the owners shall collect MDs and SDoCs for newly added components on board. For EU-flagged vessels, the MD and SDoC should cover 15 hazardous materials; it is mandatory to list PFOS and HBCDD during the maintenance stage.

The EMSA IHM guidance suggests using a software tool to support both the IHM development and maintenance process and the management of all the relevant documents, information and data. There are various companies in the industry that offer software solutions for IHM life cycle management. A software solution may enable a ship-owner to manage the enormous amounts of information required in an efficient way, reducing the administrative work in preparation and maintenance of the IHM.

Among others, there is a software, which comprises three pillars for:

- Shipowner
- Shipyards
- Hazmat Experts

The chart IHM life cycle shows the integrated concept and the interfaces between the various involved parties.

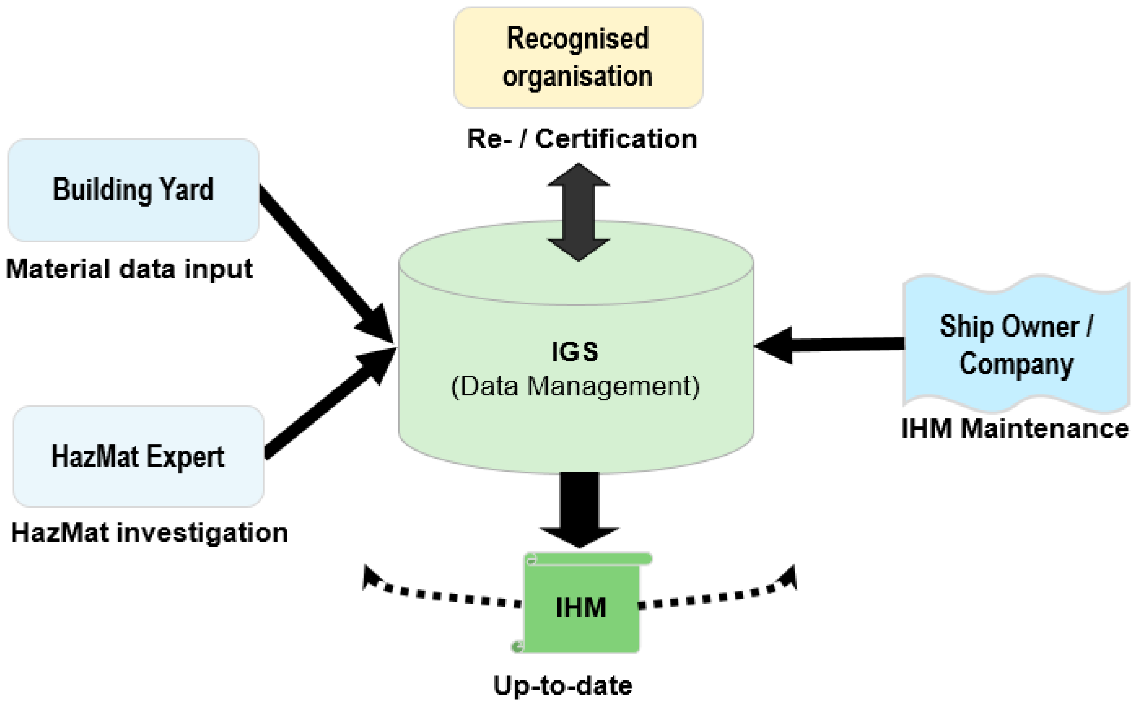


Figure 5-6. Software and lifecycle management of IHM

Software for Ship owner

The software is a web-based application for the preparation and the maintenance of the IHM. The structure of the web application follows the fleet structure of the ship owner. For each ship the opening screen shows general data of the vessel such as type, IMO number, building yard etc. The vessel is structured in different locations, materials, machinery and equipment and systems. Moreover, it provides an overview about performed IHM inspections and a list of material declarations and each single material declaration. The various data can be edited through the system. For instance, it allows adding or deleting locations, to add or delete materials and to download an always updated IHM. All different versions of IHM during the life cycle of the vessel are recorded (history filing). For reviewing purposes the user and initiator of changes and updates is continuously traced. The ship owner is working in the system by using an individual license, which ensures data safety and access to the system only for the respective designated person. The web-application supplies certified import functions for CDX, the CDX Continuous Data Exchange system of HP data management systems which enables the system to transfer and import relevant data through international data channels.

Software for Shipyards

An IHM requires information about

- kind of components installed on the vessel
- location of installed components
- kind and quantity of hazardous materials contained in installed components

While information about installed components and their position on the vessel are known by the shipyard, any information about present hazardous material in a component is given by a Material Declaration issued by the manufacturer of that component. The web-application supports collecting and managing of Material Declarations (MD) and Suppliers Declaration of Conformity (SDoC), which will be associated with installed components as well as their location. Such data is the basis for the preparation of the IHM.

Software for HazMat Experts

HazMat Experts may use the web-application to prepare Visual/Sampling Check Plan (VSCP) and the documentation of inspection and preparation of IHM for existing ships. During the preparation of the VSCP, a ship, components and locations are created and associated manually. On top of this, an inspection is created containing several checks specifying what exactly is to do on a component during an inspection (e.g. check on asbestos by taking a sample).

Software for recognised organisations

Recognised organisations such as a Classification society or a Flag State can verify the IHM electronically through the software as it is an integrated and real-time work platform for all involved parties.

6 OVERALL RECCOMENDATIONS AND SUMMARY

The EU regulation on ship recycling entered into force in December 2013 and will be implemented at various intervals. Existing EU-flagged vessels are required to have on board a verified Inventory of Hazardous Materials (IHM) with an inventory certificate at the latest by 2020-12-31 (or if the ship is to be recycled, the IHM should be on board from the date when the European list of ship recycling facilities is published). EU-flagged new ships are required to have on board a certified IHM with an inventory certificate after 2018-12-31. Non-EU-flagged vessels (third-party vessels) calling at EU ports are also required to have on board a verified IHM with a Statement of Compliance after 2020-12-31.

In addition to the 13 substances stated in the Hong Kong Convention, two substances have been added in the EU SRR, namely perfluorooctane sulfonic acid (PFOS) and the brominated flame retardant hexabromocyclododecane (HBCDD). This study has shown that the two hazardous substances PFOS and HBCDD can be found onboard ships and rigs. To gather information on these two substances, either sampling check, supplier's material declarations (MDs) or both are required.

Yards are responsible in IHM Part 1 for gathering MDs and Suppliers Declaration of Conformity (SDoC) and collocate this information in IGM Part 1. Suppliers are responsible for evaluation of their products in a detailed way, check of their own products from upstream suppliers and provide information on hazardous material in the form of MDs and SDOCs. In addition to collecting declarations, the EU SRR IHM guidance suggests a random sampling check for new buildings as a quality assurance process or if there are suspicions of existence of non-recorded hazardous materials.

6.1 PFOS

Firefighting foam is expected to have the highest concentration of PFOS and the most relevant material to analyze and check for inclusion in the IHM Part I. The amounts onboard may be substantial (range 400-19 000 liters).

Protective coatings for fabrics such as carpets, textiles, upholstery and electronics such as semiconductors not integral to ship in operation, is also relevant, however falling out of scope with regards to IHM Part I. But, for example, carpets glued to the floor is considered integral and should be included in IHM Part 1. Regular consumable goods, as provided in table D of appendix 1 in MEPC.269(68), should be listed in part 3 of the inventory if they are delivered with the ship to the ship recycling facility. A general description including the name of item, manufacturer, quantity and location should be entered in part III of the inventory. This includes electrical and electronic equipment and furniture, interior and similar equipment. Possible content of PFOS need to be addressed, whenever replaced or when vessel is due for recycling, to ensure safe and environmentally sound disposal.

Paint and coatings may be relevant but it is not expected to find PFOS in paint and coatings because other surfactants are probably used and it is not detected in paint in any samples looked at (inventories in 21 ships).

For PFOS in firefighting foam, global, regional and national legislation as well as shelf life need to be taken into consideration.

AFFF firefighting foam has a shelf life of 20-25 years. There's no requirement in SOLAS to conduct testing on board with the firefighting foam concentrate, hence firefighting foam concentrate prior to 2002 may contain PFOS and needs to be analysed/declared.

From 2002 3M stopped using PFOS in its firefighting foam concentrate and other producers followed. In the period between 2002 and 2010, when the Stockholm Convention entered force, PFOS containing firefighting foam concentrate may have been brought on board vessels.

After 2010 PFOS containing firefighting foams is less likely on board vessels at all, unless the vessel was built in China where it at that time and still is legal to produce and sell.

Having in mind that the reporting limit is set to 0,001%, incomplete emptying of tanks and hoses, previously holding PFOS containing foam concentrate, may contaminate new non-PFOS containing foam above the threshold level, hence sampling and analysis is recommended.

Possible content of PFOS need to be addressed, whenever replaced or when vessel is due for recycling, to ensure safe and environmentally sound disposal as the recycling yard need to be able to demonstrate downstream waste management broadly equivalent to international and Union standards.

Sampling should in general follow the EMSAS's Best practice guidance on the inventory of hazardous material (2016) and the IMO resolution MEPC.269(68) Guidelines for inventory of hazardous material. HSE aspects during sampling should be focused on proper ventilation, especially if working in confined spaces, use eye protection and gloves and have available Safety data sheets and eye wash bottles.

There exist standards that is used for extraction and analysis of PFOS and which have adequate level of detection (LOD) compared to a suggested hazardous waste limit of 50 mg/kg and 0.001 % in new products, which is relevant for inventories of hazardous materials. More advanced techniques such as ultra-performance liquid chromatography achieve much lower detections limits (0.015 ng/l range).

The Basel Convention technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with PFOS, its salts and PFOSF, list two methods for destruction and irreversible transformation; (a) Cement kiln co-incineration and (b) Hazardous waste incineration. Destruction and irreversible transformation methods applicable for the environmentally sound disposal of wastes with a content of PFOS, its salts or PFOSF at or above 50 mg/kg.

6.2 HBCDD

HBCDD in polystyrene foam (EPS and XPS) is the most relevant area off use. Other but less significant areas of use are in textiles and High Impact Polystyrene (HIPS). HBCDD is found in textiles (carpets) in IHM's. HBCDD can be found on board all vessels types and should in particular be considered in the IHM Part I for insulation used in the walls and ceiling of cold provision rooms. Special attention is recommended to insulation on board reefers, insulation in refrigerated containers and tank insulation of LPG, LEG and LNG cargo tanks.

HBCDD should be considered sampled for carpets and vinyl flooring, however falling out of scope with regards to IHM Part I if it is not an integral part of ship in operation, meaning that for example carpets of flooring glued to the floor should be included. High Impact polystyrene is relevant for instrument panels and computer housings and alike but not considered inside scope of IHM Part 1 in general.

Possible content of HBCDD need to be addressed, whenever replaced or when vessel is due for recycling, to ensure safe and environmentally sound disposal as the recycling yard need to be able to demonstrate downstream waste management broadly equivalent to international and Union standards.

As for PFOS, sampling should in general follow the EMSAS's Best practice guidance on the inventory of hazardous material (2016) and the IMO resolution MEPC.269(68) Guidelines for inventory of hazardous material. There is no particular HSE aspects during sampling identified because most sampling is relevant polystyrene foam.

There exist no standards for analysis of HBCDD. Existing standards used in IHMs is for brominated flame retardants in general and it is uncertain to what extent these standards are quantitative for HBCDD, and they cannot discriminate between the most common “types” of HBCDD. A standard is under development for water phase analysis, but no upcoming standards are known for solids. Based on literature review most labs prefer reverse-phase LC MS/MS to quantify HBCDD. Based on a literature review suggested hazardous waste limit for HBCDD is set to 1000 mg/kg and 0.01 % in new products.

As described for PFOS, the Basel Convention technical guidelines for the environmentally sound management of wastes list two methods for destruction and irreversible transformation; (a) Cement kiln co-incineration and (b) Hazardous waste incineration. Method (a) and (b) are applicable to HBCDD as well. Destruction and irreversible transformation methods applicable for the environmentally sound disposal of wastes with a content of HBCDD at or above 1000 mg/kg.

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APPENDIX A
Short description of industries interviewed

Company 1

A waste treatment company that treats drilling waste, drill cuttings and slop from offshore activities (vessels, rigs and platforms). Their plants process this waste through thermal treatment, where oil and water are recycled from cuttings and slop. Remaining solids go to landfill, while water is released to the sea after chemical, physical and biological purification. For some years, the company has analysed PFOS in the waste they are receiving, and for about a year they have also analysed for brominated flame retardants, including HBCDD.

Company 2

A company that works with removal, demolition and recycling of offshore installations. It has been analyzing for PFOS since 2007 and HBCDD even longer back in time.

Company 3

A forum_for environmental mapping and sanitation. This organization works mainly with demolition of buildings. They have little experience with ships and rigs.

Company 4

A division of a global analytical firm performing analysis of a range of substances in different samples. They had only analyzed 5 PFOS samples the last 1.5 years, 4 in fire-fighting foam and 1 in concrete.

Company 5

A leading provider of marine coatings to the newbuilding and dry-dock / maintenance markets.

Company 6

One of Norway’s leading recycling company offering a wide range of sustainable waste management services and providing secondary raw materials.

Company 7

This company offerA consulting, project management and human resource development within the environmental sector, specialising in inventories of hazardous materials and waste consultancy.

Company 8

A large and leading multidisciplinary consultancy firm in the Nordic region, offering inventories of hazardous materials and waste consultancy.

Company 9

One of Scandinavia ‘s largest construction and property development companies, also offering services within demolition and rehabilitation such as waste consultancy and inventories of hazardous materials.

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