Worker exposure to Hexabromocyclododecane (HBCD)

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Abstract

The aim of this study was to collect personal exposure concentration data to inform the EU risk assessment for the fire retardant Hexabromocyclododecane (HBCD). Measurement surveys were undertaken for primary production, micronising and the production of flame-retarded textile coatings, flame-retarded expanded polystyrene (EPS), flame-retarded extruded polystyrene (XPS) and Masterbatch.

The measured exposure concentrations were generally lower than UK exposure standards for respirable dust and inhalable dust (4 and 10 mgm^{-3} respectively). Micronising was associated with the highest personal exposure concentrations of HBCD with all measurements exceeding 10 mgm^{-3}. The plant has subsequently taken measures to reduce operator exposure. Other tasks associated with relatively high levels of exposure included the weighing out of HBCD prior to addition to EPS or during the production of Masterbatch, the addition of HBCD to the reaction vessel during production of EPS and handling of HBCD powder during the preparation of textile coatings. These tasks were of short duration such that shift mean exposure concentrations were generally well below 10 mgm^{-3}. Shift mean exposure concentrations for the primary production of HBCD were generally less than 1 mgm^{-3}. The production and processing of XPS with shift mean exposure concentrations that were generally less than 0.1 mgm^{-3}.

Introduction

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Methods

Six different industrial settings where HBCD exposure is possible were identified and two day measurement surveys were undertaken at 12 plants that were representative of these settings:

- Primary production (1 plant)
- Micronising (1 plant)
- Preparation of flame-retarded coatings for textiles (1 plant)
- Preparation of Masterbatch (1 plant)
- Production of flame-retarded expanded polystyrene (EPS- 4 plants)
- Production of flame-retarded extruded polystyrene (XPS - 4 plants)

Samples were collected using IOM sampling heads with foam inserts to allow the differentiation of the inhalable and respirable fractions of airborne dust[1,2]. Sampling times were generally between 4 and 8 hours, but in some plants it was only feasible to collect short period (15 minute) samples for tasks involving short periods of exposure to HBCD. The sampling protocol was in accordance with MDHS 14/3[3].

Results and Discussion

The measured exposure concentrations were generally low in comparison to UK exposure standards for respirable dust and inhalable dust (4 and 10 mgm^{-3} respectively). Only a small proportion of inhalable HBCD was within the respirable size range (Table 1).

Table 1: Summary of measured HBCD concentrations (sd = standard deviation; samples below the detection limit were attributed a value of half of the detection limit)

Industry sector	Task/other comments	Number of samples	HBCD (mgm^{-3})			
			inhalable		respirable	
			Mean (sd)	90th percentile	Mean (sd)	90th percentile
Primary production	Packing, process control, warehouse compaction	10	1.23 (0.76)	1.86	0.18 (0.16)	0.89
Production of masterbatch for XPS	Weighing and mixing – estimated 8 hour mean concentration*	Based on 10 samples	0.88 (1.69)	1.36	0.05 (0.04)	0.10
	Extruder operator	4	0.12 (0.05)	0.16	0.05 (0.02)	0.06
XPS production using masterbatch	Process operator handling masterbatch	24	0.03 (0.03)	0.03	0.01 (0.01)	0.01
	Other process operator	4	0.03 (0.01)	0.03	0.01 (0.00)	0.02
	Secondary processing	8	0.08 (0.11)	0.03	0.01 (0.01)	0.02
	Reclamation	4	0.06 (0.08)	0.22	0.05 (0.08)	0.12
XPS production HBCD powder	Process operator	12	0.03 (0.10)	0.13	0.01 (0.01)	0.02
EPS bead production	Weighing	4	7.20 (3.42)	10.59	0.42 (0.37)	0.78
	Addition of HBCD – estimated shift mean concentrations *	Based on 12 samples	0.73 (0.94)	1.15	0.08 (0.11)	0.26
	Addition of HBCD to reactor – measured shift mean concentrations	18	1.18 (3.39)	1.10	0.33 (1.21)	0.27
Micronising	Packing	4	22.71 (12.25)	34.57	1.43 (0.64)	1.98
Production of textile coatings	Laboratory staff	6	0.25 (0.34)	0.53	0.06 (0.05)	0.12
	Production staff handling HBCD	4	1.35 (1.94)	3.12	0.12 (0.11)	0.23
	Other production staff	4	0.59 (0.56)	1.04	0.23 (0.06)	0.28

*based on short period samples for specific operations; shift mean concentrations calculated from short period samples by assessing proportion of shift spent on operations giving rise to elevated exposures for which measurement data were available. No exposure to HBCD was likely during the remainder of the shift

Micronising was associated with the highest personal exposure concentrations of HBCD. One of the most notable features of this task was that workers spent a large proportion of their shift handling HBCD. The plant had not previously measured personal exposures to HBCD and since these measurements have been reported, the plant has taken measures to improve housekeeping and is planning to install appropriate ventilation to reduce operator exposure.

The preparation of textile coatings was also a dusty process, but levels of exposure to HBCD were much lower than for micronising, partly because less than 10% of the shift was spent handling HBCD. Workers shovelled HBCD from 500 kg sacks or tipped 25 kg sacks into the liquid mix releasing visible dust into the workplace

environment. The exposure of laboratory workers in the same plant who were involved in the development of formulations for coatings containing HBCD was low (Table 1).

Workers engaged in the primary production of HBCD were not routinely exposed to high concentrations of HBCD. HBCD is produced within a closed process and exposure to airborne HBCD mainly occurred during tasks of relatively short duration such as entering production vessels or the packing enclosure.

During the production of EPS, exposures to HBCD were relatively high during short episodes each shift when it was added to the reactor (Table 2). Estimated and measured full shift mean concentrations were, however, generally quite low (Table 1). Where weighing out HBCD was performed as a separate task, it was associated with relatively high shift mean concentrations of HBCD, but this task was only performed on a small proportion of shifts. Weighing and mixing were also associated with elevated exposure concentrations during the production of Masterbatch, although full shift exposures were quite low (Table 1).

Table 2: Measured personal exposure concentrations for addition of HBCD to the reactor in two EPS plants - short term measurements

Plant	Duration (minutes)	Dust Concentration (mgm^{-3})		Concentration of HBCD (mgm^{-3})	
		respirable	Inhalable	respirable	Inhalable
24101	13	<2.0	13.8	1.75	7.26
	18	<2.0	31.7	1.27	21.52
	14	<2.0	12.5	1.58	4.44
24104	23	<1.2	6.7	0.25	4.44
	20	<1.3	16.2	0.35	6.60
	40	<0.5	12.6	0.31	6.31
	14	<2.0	17.6	0.37	4.73
	15	<2.0	11.7	0.33	3.70
	43	<0.6	14.7	0.33	10.82
	56	<0.5	7.4	0.46	4.35
	30	<0.9	8.8	0.42	2.89
	35	0.7	10.1	0.51	6.65
Mean		0.69	13.65	0.98	6.98
Standard deviation		0.31	6.60	1.50	5.04
Median		0.68	12.55	0.40	5.52
90^{th} Percentile		1.00	17.46	1.55	10.46

Exposure to HBCD during the production of XPS was very low. This reflects the small proportion of the shift spent handling HBCD, the generally highly automated secondary processing of boards and the use of HBCD in the form of Masterbatch or granules.

There was very little skin contact with HBCD during primary production or the manufacture of XPS, EPS and Masterbatch. There was some skin contact with HBCD powder and extensive contact with liquid preparations containing HBCD during the preparation of textile coatings. There was extensive skin contact with HBCD during micronising despite the use of gloves. During both the preparation of textile coatings and micronising, contact with the hands and face was common. It is likely that will have increased the likelihood of exposure by ingestion. The significance of dermal exposure on skin health or uptake by the body is unknown.

The personal exposure concentrations reported here are much higher than the long term mean exposure concentrations that would be typical for individual workers as workers rotated between tasks and/or only handled HBCD intermittently. In none of the workplaces visited, were workers likely to be repeatedly exposed on a large number of successive shifts to high concentrations of HBCD.

References

1. British Standards Institution (1993) Workplace atmospheres – size fraction definitions for the measurement of airborne particles. BS EN 481 1993

2. International Standards Organization (1995) Air Quality – particle size fraction definitions for health-related sapling. ISO Standard 7708 1995

3. UK Health and Safety Executive (2000) General methods for sampling and gravimetric analysis of respirable and inhalable dust. Methods for the Determination of Hazardous Substances 14/3.