WORKING FOR A HEALTHY FUTURE

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Health, socio-economic and environmental aspects of possible amendments to the EU Directive on the protection of workers from the risks related to exposure to carcinogens and mutagens at work

Hexachlorobenzene

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SUMMARY

Hexachlorobenzene has been classified by the International Agency for Research on Cancer (IARC) as possibly carcinogenic to humans based on limited human epidemiological data and sufficient animal toxicity (IARC category 2b). Under the classification and labelling legislation in Europe it is classified as a Cat 2 carcinogen and is therefore within the scope of the EU Carcinogens Directive. However, there is no occupational exposure limit (OEL) for hexachlorobenzene specified in the Directive.

This report considers the likely health, socioeconomic and environmental impacts associated with possible changes to the Carcinogens Directive, in particular the possible introduction of an occupational exposure limit (OEL) of either 0.002 mg/m^3 or 0.025 mg/m^3.

Hexachlorobenzene is a chlorinated aromatic hydrocarbon, which was previously used as a fungicide and in some industrial processes. However, it is now banned and the only occupational sources are in a small number of processes where it may be produced as an unwanted by-product. The exact quantity of hexachlorobenzene emitted into workplaces is unknown and the number of workers who may be exposed is also unknown.

Animal toxicological studies have shown that hexachlorobenzene can cause liver and other tumours, but the information from epidemiological studies is inadequate to identify whether there is any risk of cancer in humans. We were unable to identify suitable risk estimates to undertake a health impact assessment.

Few measurements of occupational exposure to hexachlorobenzene are available, but the available evidence suggests that exposure levels are very low and probably not much higher than found in the general population (i.e. <0.0001 mg/m^3). We judge that it is unlikely that there are any workers in the EU exposed to hexachlorobenzene above the typical OELs of 0.002 and 0.025 mg/m^3.

We judge that there will be no additional costs in compliance with an OEL of either 0.002 or 0.025 mg/m^3 and no health benefits because employers are probably already in full compliance with these limits. However, it would be prudent for industry to undertake further occupational exposure measurements to confirm that this is the case.

It is not expected that there will be any important social, macro-economic or environmental impacts.

1 PROBLEM DEFINITION

1.1 OUTLINE OF THE INVESTIGATION

Exposure to hexachlorobenzene (HCB) in workplace air may be associated with increased risk of cancer, although there is limited evidence as to which type of cancer may be associated with this substance. Hexachlorobenzene has been classified as a group 2b carcinogen (Possibly carcinogenic to humans) by IARC based on the results of epidemiological and toxicological studies.[1] It is classified as a Cat 2 carcinogen in the EU under the classification and labelling legislation.[2] It is therefore already regulated as a carcinogen throughout the EU. In this assessment we consider the impacts of introducing an OEL for hexachlorobenzene within the Directive.

The key objectives of the present study are to identify the technical feasibility and the socioeconomic, health and environmental impacts of introducing a regulatory OEL for hexachlorobenzene.

1.2 OELS/EXPOSURE CONTROL

Existing national occupational exposure limits (OELs) in EU member states are presented in Table 1.1. These are expressed as long-term limits, averaged over an 8-hour working day or short-term exposure limits (STELs), i.e. 15 minutes.

Table 1.1 Occupational exposure limits in various EU member states

Country	OEL - Long-term mg/m^3	OEL - STEL mg/m^3
Belgium	0.002	
Denmark	0.025	0.05
France	0.5	
Poland	0.5	
Spain	0.002	
The Netherlands	0.03	

Source: http:www.dguv.de/bgia/en/gestis/limit_values/index.jsp

The long term OELs from the EU member states range from 0.002 mg/m^3 to 0.5 mg/m^3. Denmark has an STEL of 0.05 mg/m^3. For the purposes of this report OELs of 0.002 and 0.025 mg/m^3 are considered typical for the EU.

1.3 DESCRIPTION OF DIFFERENT USES

Hexachlorobenzene is a chlorinated aromatic hydrocarbon, which has been used in the past as a fungicide for wheat, barley, oats and rye; as a wood preserving agent; and in the manufacture of pyrotechnics, tracer bullets, aluminium, pentachlorophenol, graphite anodes and rubber. At the 1969 FAO/WHO Joint meeting it was recommended that hexachlorobenzene be substituted with other substances as a fungicide due to concerns about its toxicity. The use of hexachlorobenzene as a pesticide was therefore discontinued in the 1970s in most countries and currently does not occur in any EU

[1] Available at: http://monographs.iarc.fr/ENG/Classification/ClassificationsAlphaOrder.pdf
[2] Available at: http://ecb.jrc.ec.europa.eu/esis/

member state. The use of hexachlorobenzene in other applications has also ceased. In 1978, 8,000 tonnes of hexachlorobenzene were produced or imported in the EU each year.[3] That level is now zero. The use of hexachlorobenzene in the production of rubber in Germany ceased in 1993 and hexachlorobenzene production ceased in the Czech Republic in 1968. Hexachlorobenzene is referred to as a banned substance in EU Directive 76/769 (Barber *et al*, 2005).

Although hexachlorobenzene is no longer produced or used directly in the EU it is still produced as a by-product and infrequently as an unintended contaminant in the manufacture of chlorinated solvents, chlorinated aromatics and pesticides. In 1996 the European Chlorinated Solvent Association estimated that 4,000 tonnes of hexachlorobenzene were generated each year during perchloroethylene production and that over 99% of this was disposed of by incineration (Barber *et al*, 2005). Hexachlorobenzene residues were not detected at a detection limit of 2 µg/L solvent in tri- and tetrachloroethylene produced in Europe in 1996.

Hexachlorobenzene residues have been detected in chlorinated pesticides; however, due to regulatory pressures to reduce hexachlorobenzene emissions and exposures pesticide manufacturers have made changes to the processes and materials used in manufacturing. Current concentrations of residues in chlorinated pesticides are less than 1% and are typically orders of magnitude below the allowable regulatory limits (Barber *et al*, 2005).[4]

1.4 RISKS TO HUMAN HEALTH

1.4.1 Introduction

When hexachlorobenzene was introduced into the diet of experimental animals it caused liver tumours in female rats and male and female mice. It addition, these experiments have shown hepatomas, liver hemangioendotheliomas, and thyroid adenomas in hamsters.[5]

1.4.2 Summary of the available epidemiological literature on risk

There have been series of deaths associated with ingestion of high quantities of hexachlorobenzene. From 1955 to 1959 an estimated 3,000–4,000 people in Turkey ingested bread prepared from grain treated with fungicides composed of 10% hexachlorobenzene, at an estimated 2 kg/1,000 kg wheat. There was an extremely high rate of mortality in breast fed children of mothers known to have ingested this bread. All children born to porphyric mothers during that epidemic died (Gocmen *et al* 1989; Peters *et al* 1982) and an estimated 1,000–2,000 infants died due to a condition known as *pembe yara* or "pink sore" because of the associated skin lesions (blistering and epidermolysis and annular erythema) (Cripps *et al* 1984; Peters *et al* 1982, 1987). A 10% rate of mortality in exposed adults has been reported (Peters *et al* 1982, 1987).

[3] Environmental Health Criteria 195: Hexachlorobenzene (1997). International Programme on Chemical Safety.
[4] Hexachlorobenzene (2001). IARC Monograph Volume 79.
[5] http://ntp.niehs.nih.gov/ntp/roc/eleventh/profiles/s093hexa.pdf

Data on exposure to hexachlorobenzene inhalation are very limited, but tend to show effects on the liver and immune system of exposed individuals (Queiroz *et al* 1997, 1998a, 1998b; Selden *et al* 1999). Data on ingestion more clearly identifies the liver, skin, bone, thyroid, and central nervous system as target tissues for hexachlorobenzene in chronically exposed people (Cam and Nigogosyan 1963; Cripps *et al* 1984; Peters *et al* 1982, 1987). Ingestion of hexachlorobenzene can cause porphyria[6]; there have been suggestions that this can lead to subsequent development of liver cancer (ATSDR, 2002).

In comparison to the surrounding Province of Tarragona, the incidences of thyroid cancer and soft-tissue sarcoma were significantly increased, and brain tumours marginally increased, for the years 1980–1989 in male residents of Flix, Spain, where a nearby organochlorine factory had produced high levels of hexachlorobenzene in the ambient air for decades (40 measurements in 1989–1992 averaged 35 ng/m^3, and the researchers suspected concentrations had been higher in years past) (Grimalt *et al* 1994). Cancer incidence was not raised in female Flix residents nor was mortality raised.

The available epidemiology reports reviewed in ATSDR (2002) do not support an association between hexachlorobenzene exposure and increased cancer incidence. However, they have several limitations including small study sizes, similar tissue hexachlorobenzene levels between cancer and control groups, and potentially confounding effects of other organochlorines. Only one prospective study by Dewailly *et al* (1994) in which serum andadipose organochlorine levels were measured in 41 Canadian women (ages 40-69) undergoing breast biopsy diagnosed mammary adenocarcinoma in 20 women and benign breast tumours in 17 others; the former group had statistically significantly higher serum (but not adipose) levels of hexachlorobenzene compared to the latter group.

There have been a number of recent investigations of organochlorine exposure, including hexachlorobenzene measured in tumour tissue. Three papers by Hardell and colleagues report investigation of: adipose tissue in patients with endometrial cancer compared with controls with benign endometrial hyperplasia (OR for HCB 0.8, 95%CI 0.3, 2.1) (Hardell *et al*, 2004); blood samples from cases with testicular cancer and controls and the mothers of these men (OR for HCB in the men = 1.7, 95% CI 0.8, 3.6, OR for HCB in the mothers = 4.4, 95%CI 1.7-12) (Hardell *et al* 2003); adipose tissue of patients with prostate cancer and controls with benign prostate hyperplasia (overall OR for HCB = 2.39, 95%CI 0.81, 7.09, subgroup prostate specific antigen (PSA)<16.5 OR=1.14, 95%CI 0.35, 2.72), PSA>16.5 OR=9.84 95%CI 1.99, 48.5). However, ORs below 1 relating to hexachlorobenzene levels were found in another case-control study of prostate cancer in Japan (Swada *et al* 2010). There was also no excess risk for endometrial cancer and serum concentrations of hexachlorobenzene in a population-based case-control study in Sweden (Weiderpass *et al*, 2000). Three recent papers have reported investigations of serum samples in breast cancer patients and controls.

[6] The body produces heme in a multi-step process involving porphyrins. People with porphyria have a deficiency of certain enzymes needed for this process. This causes abnormal amounts of porphyrins or related chemicals to build up.
From: http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0002188/

All have found no association with hexachlorobenzene levels (Itoh *et al*, 2009; Iwasaki *et al*, 2010; Zheng *et al* 1999).

Howsam *et al* (2004) measured organochlorines in serum of colorectal patients and other hospital patients as controls. ORs adjusted for age, sex, energy intake and BMI for medium and high levels of hexachlorobenzene compared with low levels were 1.72 (95%CI 0.83, 3.54) and 1.60 (95%CI 0.62, 4.15) respectively. A case-control study of non-Hodgkin's lymphoma patients and matched controls found no difference between levels of hexachlorobenzene in serum (Cantor *et al* 2003).

It should be noted that all these studies measured several organochlorines in tissue in addition to hexachlorobenzene and reported statistical analyses for these; none of the studies adjusted for the concurrent exposures in their analyses nor for multiple comparisons.

There is inadequate evidence for the carcinogenicity of hexachlorobenzene in humans and there is no clear evidence about which type of tumour might be implicated in any risk.

1.4.3 Choice of risk estimates to assess health impact

Although hexachlorobenzene has been shown to be a carcinogen in animals the epidemiological evidence for carcinogenicity in humans is extremely weak with very few positive associations. Most studies are based on serum sample analysis and are unable to indicate the source of the exposure. No appropriate risk estimate can be selected for this substance.

2 BASELINE SCENARIOS

2.1 STRUCTURE OF THE SECTOR

Hexachlorobenzene was used as a fungicide in seed treatment from 1945, especially against the fungal disease 'bunt' that affects some cereal crops. Other historic uses are described in Section 1.3.

Worldwide production of pure hexachlorobenzene was estimated to be 10,000 tonnes/year for the years 1978–81 (IARC, 2001). Hexachlorobenzene was produced or imported in the European Community at 8,000 tonnes/year in 1978, and a company in Spain reportedly produced an estimated 150 tonnes/year. It is estimated that approximately 1,500 tonnes/year of hexachlorobenzene were manufactured in Germany for the production of rubber chemicals, but this production was discontinued in 1993.

Three to four thousand people were poisoned with hexachlorobenzene used to treat seed grain in Turkey in the 1950s, giving rise to a syndrome known as "porphyria" with 14% death rate. Some ill effects were passed on to children exposed in the womb (EA website[7], 2011).

[7] Available at: http://www.environment-agency.gov.uk/business/topics/pollution/162.aspx

Concerns over toxicity and environmental impacts led to restrictions at the Member State and international level. The main concerns over environmental releases are related to its persistence and ability to bioaccumulate / bioconcentrate up the food chain. The marketing and use of hexachlorobenzene as a plant protection product was banned in the European Union in 1988. Hexachlorobenzene is no longer manufactured as a commercial end product or used directly in the EU. Internationally it is also listed as a substance for priority action on its control under the Helsinki Convention and is listed as a candidate substance for selection, assessment and prioritisation under the OSPAR Convention.

Hexachlorobenzene is still being produced as an unwanted by-product or impurity in the manufacture of several industrial chemicals including carbon tetrachloride, perchlorethylene, trichloroethylene and pentachlorobenzene; and several pesticides including pentachloronitrobenzene (PCNB) chlorothalonil, picloram, PCP and DCPA. Past methods of disposal of these hexachlorobenzene wastes have included landfill, discharge to municipal sewage treatment plants, and incineration.

2.2 PREVALENCE OF HEXACHLOROBENZENE EXPOSURE IN THE EU AND CONCENTRATIONS OF HEXACHLOROBENZENE

The prevalence of exposure to hexachlorobenzene in the EU has not been estimated by CAREX. The 1981 – 1983 National Occupational Exposure Survey in the USA estimated that 1,000 workers in the US were exposed to hexachlorobenzene.[8] Since the early 1980's the volume of hexachlorobenzene used in industry has decreased to nil and the production of hexachlorobenzene as an unwanted by-product has decreased due to process and material changes.

Pacyna *et al* (2003) estimated that the most important sources of hexachlorobenzene in Europe between 1993-95 were: the application of contaminated pesticides (80%); the use of solvents and other products (13%); emission from other industrial production processes (7%); and waste treatment and disposal (<1%). Their data show dramatic decrease in the emission of hexachlorobenzene in agriculture between 1980 and 1990 (Figure 2.1).

[8] Hexachlorobenzene (2001). IARC Monograph Volume 79.

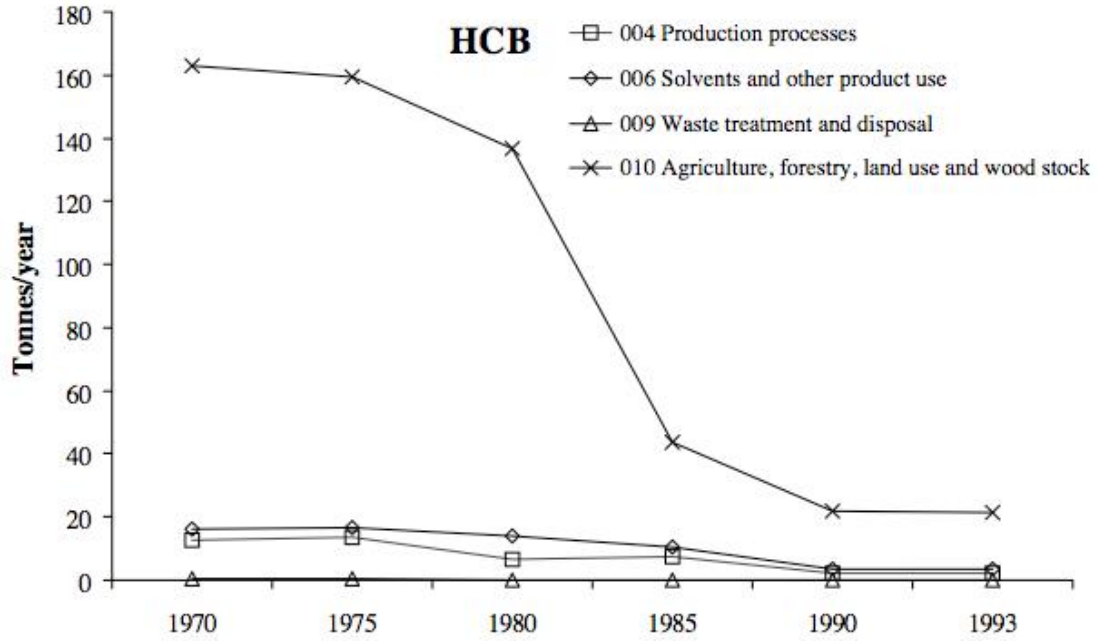

Figure 2.1 Change in hexachlorobenzene (HCB) emissions in Europe between 1970 and 1993 (source: Pacyna *et al*, 2003)

Since 1985 the European chlorinated solvent manufacturers (EuroChlor) have decreased emissions of hexachlorobenzene to water by 87% and to air by 97%[9].

Few measurements of occupational exposure to hexachlorobenzene are available. Occupational exposure to hexachlorobenzene among workers at a chlorinated solvent manufacturing plant reported by Currier *et al* in 1980 ranged from <1 – 13 ppb (<0.01 – 0.15 mg/m^3). It is likely that exposure levels at chlorinated solvent manufacturing facilities have decreased significantly since 1980 (Currier *et al*, 1980).

In 1992, Selden *et al,* (1997, 1998) measured hexachlorobenzene levels in air ranging from 0.66 to 11 ng/m^3 at an aluminium foundry in Sweden where hexachloroethane was used as a degassing agent for aluminium.

Mari *et al,* (2009) monitored hexachlorobenzene in blood plasma among workers at an incineration facility in Spain that incinerates hexachlorobenzene. The facility was opened in 1999 and baseline blood samples were taken from workers at that time. Samples were taken again in 2000, 2005, 2007. Hexachlorobenzene in plasma decreased from an average of 134 µg/kg of lipid to 35 µg/kg among workers at the plant, from 182 to 49 µg/kg among workers at the associated laboratory, and from 223 µg/kg to 31 µg/kg among administration workers. These results suggest that blood hexachlorobenzene levels have decreased due to decreases in hexachlorobenzene in the environment over the study period and also that the workers at the incineration facility are not exposed to hexachlorobenzene much higher than found in the general population (Mari *et al*, 2009).

[9] Available at: http://www.eurochlor.org/hexachlorobenzene

It is unlikely that there are any workers in the EU exposed to hexachlorobenzene above the typical OELs of 0.002 and 0.025 mg/m^3. It is judged that most workers are probably exposed around the higher levels found in the general population.

2.3 LEVEL OF EXPOSURE TO HEXACHLOROBENZENE

2.3.1 Estimation of exposure levels

We judge that occupational exposures are currently much lower than either of the potential OELs and are probably comparable with the higher levels measured in the general population, i.e. less than 0.0001 mg/m^3 (0.1 μg/m^3).

2.3.2 Temporal change in exposure

Low occupational exposures have probably existed since the early 1990s when industrial production of hexachlorobenzene ceased.

2.4 HEALTH IMPACT FROM CURRENT EXPOSURES

Because of the uncertainty about the carcinogenicity of hexachlorobenzene in humans we have not carried out a health impact assessment. It is unclear how many people may currently be occupationally exposed to hexachlorobenzene, although it is likely to be relatively small.

2.5 POSSIBLE COSTS ASSOCIATED WITH NOT MODIFYING THE DIRECTTIVE

2.5.1 Health impacts – possible costs under the baseline scenario

Health impacts are expected from past exposure which would occur regardless of any future intervention. These impacts have not been quantified but they are likely to be small given that evidence for carcinogenicity in humans is extremely weak with very few positive associations.

3 POLICY OPTIONS

3.1 DESCRIPTION OF MEASURES

The FAO (1996) recommends, “although no studies are available concerning dermal absorption, protective clothing and gloves should be worn when handling hexachlorobenzene and excessive dust should be avoided”. Another report recommends that “dressed seed should not be handled more than necessary” (FAO, 1977). However, the use of hexachlorobenzene as a plant protection product was banned in the European Union in 1988 and it is no longer manufactured as a commercial product or used directly in the EU.

Hexachlorobenzene is currently produced as an impurity in the manufacture of several industrial chemicals including perchloroethylene, trichloroethylene, and carbon tetrachloride.

3.2 LEVEL OF PROTECTION ACHIEVED (OELS)

Exposure limits in the EU range from 0.002 mg/m^3 to 0.5 mg/m^3. For the purposes of this report OELs of 0.002 and 0.025mg/m^3 are considered typical for the EU. Few measurements of occupational exposure to hexachlorobenzene are available, however it is considered unlikely that there are any workers in the EU exposed to hexachlorobenzene above the typical OELs.

4 ANALYSIS OF IMPACTS

4.1 HEALTH IMPACTS FROM CHANGES TO THE EU DIRECTIVE

4.1.1 Health information

It is judged that it is unlikely that exposure to hexachlorobenzene in EU industry exceeds either of the proposed OELs. Therefore there are no additional health benefits that will accrue from the introduction of an OEL at 0.002 or 0.025 mg/m^3.

4.1.2 Monetised health benefits

In the absence of available data it has not been possible to assess the health impacts of introducing new exposure limits. It has therefore not been possible to produce monetised health benefits. Given that it is unlikely that there are any workers in the EU exposed to hexachlorobenzene above the typical OEL, the overall benefit of an OEL is likely to be low.

4.2 ECONOMIC IMPACTS

4.2.1 Operating costs and conduct of business

Compliance Costs

It is considered unlikely that there are any workers in the EU exposed to hexachlorobenzene above the typical OELs of 0.002 and 0.025 mg/m^3. Furthermore, hexachlorobenzene is no longer produced or used directly in the EU and the volume produced as a by-product has decreased; therefore, exposure is likely to remain low. Any companies handling hexachlorobenzene are already working according to strictly controlled conditions.

Given this, it is estimated that, under the baseline scenario, most firms within affected industries are assumed to meet the more stringent OEL (0.002 mg/m^3). Most workplaces are therefore unlikely to be affected/ require further changes to their existing working practice. Therefore it is assumed there would not be a significant cost to achieve the 0.002 mg/m^3 OEL.

Conduct of employers

It is expected that appropriate risk reduction measures are already taking place and therefore no additional control measures are expected to be required.

Potential for closure of companies

There are not expected to be any significant risk of closure of companies as a result of introducing an EU-wide OEL of 0.002 and 0.025 mg/m^3.

Potential impacts for specific types of companies

The main advantage of an EU-wide OEL would be to create consistency in regulation across the EU and remove any competitive disadvantage to those Member States who previously had more stringent national OELs in place.

Administrative costs to employers and public authorities

The following table (Table 4.1) describes the administrative burden to employers already subject to the Carcinogens Directive but will now incur costs of introducing an EU wide OEL on to Annex III.

Table 4.1 Administrative burdens to employers

Type of administrative cost	Relevant article(s)	Type of cost	Significance
1. Change in practice to use closed systems when using the substance.	5 – Prevention and reduction of exposure	These costs are already estimated in the cost of compliance section - This will only affect those firms that do not have or use closed systems	Estimated elsewhere
2. Develop/update health and safety and best practice guidance for: ○ Minimising use and exposure to workers to the substance ○ Redesign work processes and engineering controls to avoid/minimise release of carcinogens or mutagens ○ Hygiene measures, in particular regular cleaning of floors, walls and other surfaces ○ Information for workers ○ Warnings and safety signs ○ Drawing up plans to deal with emergencies likely to result in abnormally high exposure	5 – Prevention and reduction of exposure 7 – Unforeseen exposure 8 – Foreseeable exposure 9 – Access to risk areas 10 – Hygiene and individual protection	Firms will already have been required to develop/update health and safety and best practice guidance. The guidance and procedures may be required to be updated as control measures may change in light of a more stringent OEL. Some firms may need to redesign work practices to minimise exposure to workers and the number of workers exposed. The costs of implementing controls on exposure (such as LEV or PPE) are already estimated in the costs of compliance section.	Low
3. Additional costs of training new and existing staff in line with requirements of the Directive 4. Additional costs of making information available to employees 5. Consultation with employees on compliance with the Directive	11 – Information and training of workers 12 – Information for workers 13 – Consultation and participation with workers	Firms will already have been required to ensure training and adequate aware of risks and control measures to reduce/minimise exposure. Largely one-off cost if the revised OEL requires a change in control measures/working practice.	Low

Note: Readers should consult the Directive for the official wording around specific requirements. This table provides only a summary of what are perceived to be the most significant administrative requirements of the Directive. Grading of the significance of impacts is subjective and is based on professional judgement.

The following table (Table 4.2) describes the administrative burden to competent authorities already enforcing the Carcinogens Directive but will now incur costs of introducing an EU wide OEL on to Annex III.

Table 4.2 Administrative burdens to Competent Authorities

Type of administrative cost	Relevant article(s)	Type of cost	Significance
1. Communication with the Commission on provisions in national law to enforce the revised OEL. 2. Time and costs of implementing revised OEL into national law (consultation process)	19 – Notifying the commission 20 – Repeal	Largely one-off cost of transposing the revised OEL into national law	Low - Medium (one-off cost)

Note: Readers should consult the Directive for the official wording around specific requirements. This table provides only a summary of what are perceived to be the most significant administrative requirements of the Directive. Grading of the significance of impacts is subjective and is based on professional judgement.

Third countries

There is not expected to be a significant change relative to the baseline to third countries.

4.2.2 Impact on innovation and research

Available literature suggests that the vast majority of investment required to control exposure from hexachlorobenzene has already occurred and exposure is being adequately controlled under the baseline. Therefore the impacts on innovation and research from introducing an EU-wide OEL are estimated to be minimal.

4.2.3 Macroeconomic impact

Since compliance with an OEL would not involve changing the current manufacturing process there is unlikely to be any significant change to macro-economic impacts.

4.3 SOCIAL IMPACTS

4.3.1 Employment and labour markets

There are not expected to be any noticeable changes to jobs skills, patterns or the numbers of workers required as a result of introducing an EU-wide OEL.

4.3.2 Changes in end products

There are not expected to be any changes to the end product since no additional control measures are expected to be required to meet either possible OEL. Since there

is not expected to be any closure of companies, there should not be any change in supply of products relative to the baseline scenario.

4.4 ENVIRONMENTAL IMPACTS

Hexachlorobenzene is a persistent chemical in the environment that bioaccumulates due to its lipid solubility and resistance to degradation. Low levels are present in most environmental media as a consequence of past uses. However, the introduction of a possible OEL is not expected to require any additional control measures or changes in work practice. Therefore it is assumed that an OEL would not increase the level of environmental harm.

5 COMPARISON OF OPTIONS

The main impacts discussed in more detail in section 4 are summarised in the tables below, which are broken down by the main types of impacts (health, economic, social, macroeconomic and environmental).

Table 5.1 Comparison of health impacts by scenario

Baseline Scenario		Intervention scenario (2) – Full compliance for OEL = 0.002 mg/m^3		Intervention scenario (3) – Full compliance for OEL = to 0.025 mg/m^3	
Health Costs	**Health Benefits**	**Health Costs**	**Health Benefits**	**Health Costs**	**Health Benefits**
Health impacts are expected from past exposure which would occur regardless of any future intervention. These impacts have not been quantified but they are likely to be small given that evidence for carcinogenicity in humans is extremely weak with very few positive associations.	Marketing and use of HCB has now been banned in the EU. Therefore whilst health impacts are expected from past exposure, there is expected to be some reduction in health costs going forward in the absence of further regulatory intervention.	None	In the absence of available data it has not been possible to assess the health impacts of introducing new exposure limits. It has therefore not been possible to produce monetised health benefits. Given that it is unlikely that there are any workers in the EU exposed to HCB above the typical OEL, the overall benefit of an OEL is likely to be low.	None	In the absence of available data it has not been possible to assess the health impacts of introducing new exposure limits. It has therefore not been possible to produce monetised health benefits. Given that it is unlikely that there are any workers in the EU exposed to HCB above the typical OEL, the overall benefit of an OEL is likely to be low.

Note: Costs and benefits under the intervention options are relative to the baseline scenario (i.e. are not absolute impacts but differences)

Table 5.2 Comparison of economic impacts by scenario

Baseline Scenario		Intervention scenario (2) – Full compliance for OEL = 0.002 mg/m^3		Intervention scenario (3) – Full compliance for OEL = to 0.025 mg/m^3	
Economic Costs	**Economic Benefits**	**Economic Costs**	**Economic Benefits**	**Economic Costs**	**Economic Benefits**
It is estimated that under the baseline scenario, firms are already achieving exposures less than 0.002 mg/m^3. Therefore there is assumed there will not be a significant cost to achieve a possible 0.002 mg/m^3 OEL.	-	It is unlikely that there are any workers in the EU exposed above 0.002 mg/m^3. Therefore there are not expected to be any significant additional costs of meeting an OEL of 0.002 mg/m^3 relative to the baseline scenario.	Having an EU-wide OEL level should remove any EU competitive distortions between EU Member States with different OELs.	It is unlikely that there are any workers in the EU exposed above 0.002 mg/m^3. Therefore there are not expected to be any significant additional costs of meeting an OEL of 0.025 mg/m^3 relative to the baseline scenario.	Having an EU-wide OEL level should remove any EU competitive distortions between EU Member States with different OELs.

Note: Costs and benefits under the intervention options are relative to the baseline scenario (i.e. are not absolute impacts but differences)

Table 5.3 Comparison of social impacts by scenario

Baseline Scenario		Intervention scenario (2) – Full compliance for OEL = 0.002 mg/m^3		Intervention scenario (3) – Full compliance for OEL = to 0.025 mg/m^3	
Social Costs	**Social Benefits**	**Social Costs**	**Social Benefits**	**Social Costs**	**Social Benefits**
There are not expected to be any noticeable social impacts under the baseline scenario at an EU level.		There are not expected to be any noticeable changes to the numbers of workers required as a result of introducing an EU-wide OEL.			

Note: Costs and benefits under the intervention options are relative to the baseline scenario (i.e. are not absolute impacts but differences)

Table 5.4 Comparison of macro-economic impacts by scenario

Baseline Scenario		Intervention scenario (2) – Full compliance for OEL = 0.002 mg/m^3		Intervention scenario (3) – Full compliance for OEL = to 0.025 mg/m^3	
Marco-economic Costs	**Marco-economic Benefits**	**Marco-economic Costs**	**Marco-economic Benefits**	**Marco-economic Costs**	**Marco-economic Benefits**
There are not expected to be any noticeable macroeconomic impacts under the baseline scenario.		Since there are not expected to be any significant economic impacts, there are not expected to be any significant change in macroeconomic impacts relative to the baseline scenario from introducing an EU-wide OEL.			

Note: Costs and benefits under the intervention options are relative to the baseline scenario (i.e. are not absolute impacts but differences)

Table 5.5 Comparison of environmental impacts by scenario

Baseline Scenario		Intervention scenario (2) – Full compliance for OEL = 0.002 mg/m^3		Intervention scenario (3) – Full compliance for OEL = to 0.025 mg/m^3	
Environmental Costs	**Environmental Benefits**	**Environmental Costs**	**Environmental Benefits**	**Environmental Costs**	**Environmental Benefits**
It is considered unlikely that there are any workers exposed to HCB above the typical OELs of 0.002 and 0.025mg/m^3 and therefore most workplaces are unlikely to be affected/ require further changes to their existing working practice. Therefore there are not estimated to be any significant changes in environmental impacts.		None – it is expected that the imposition of measures would not cause additional environmental impacts.			

Note: Costs and benefits under the intervention options are relative to the baseline scenario (i.e. are not absolute impacts but differences)

6 CONCLUSIONS

Hexachlorobenzene is not manufactured or used in European industry. It may be produced inadvertently as a by-product in some industrial processes, but current technology is designed to minimise its formation. We judge that exposure occupational levels are very low and certainly much lower that either of the proposed OELs (0.002 mg/m^3 and 0.025 mg/m^3). It has not been possible to reliably estimate the number of people who could be exposed, although we consider that the number exposed is likely to be relatively small.

Information about the hazard from hexachlorobenzene is limited. Animal toxicity studies have shown that when added to the animals' diet it can cause liver cancer and other tumours. However, the human epidemiological evidence for occupational exposure causing cancer is weak. There is no basis to identify a suitable risk estimate. We have considered it is not possible to undertake a health impact assessment, but we also do not believe there is any important risk because of the current low exposures and the limited number of people exposed.

There are no predicted health benefits from setting an OEL at either 0.002 mg/m^3 or 0.025 mg/m^3 and no significant additional costs for employers to comply with this limit. There are also no social or macro-economic costs associated with introducing an OEL at this level.

There are no significant environmental impacts foreseen.

We consider it would be prudent to confirm that occupational exposures to hexachlorobenzene are actually very low.

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