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

1,2-Dibromoethane

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SUMMARY

1,2-dibromoroethane 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 1,2-dibromoethane 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 0.1 ppm. Current OELs in the EU range from 0.00025 ppm to 0.5 ppm.

1,2-dibromoethane has been used as a scavenger for lead in gasoline, as a soil fumigant, as a pesticide for grain and tree crops, as a solvent for resins, in waterproofing preparations, and in organic synthesis. Production has declined considerably since the 1970s and some uses, e.g. as a pesticide, are now banned. It is still used in aviation and racing fuels and as intermediate for the production of some organic chemicals as a source of bromine. There is one manufacturer in the EU and up to 19 other suppliers.

Less than 8,000 people are potentially exposed in Europe, but only about 100 employed in chemical manufacturing. There are few measurement data for 1,2-dibromoethane, and that which is available dates from the 1970s and 80s. We judge that occupational exposure levels are currently low, with about 8% of workers in chemical manufacturing exposed to average levels above 0.1 ppm and workers in other sectors exposed to less than 0.1 ppm. Exposures are assumed to have been decreasing over recent years by about 7% per annum.

Information about the hazard from 1,2-dibromoethane is limited. Animal toxicity studies have shown a range of tumours induced, but 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, although we believe the impact of setting a limit at 0.1 ppm would be relatively small because of the relatively low current exposures and the small number of people likely to be exposed above the proposed OEL. The cost of compliance with a limit of 0.1 ppm, aggregated over the period 2010 to 2069, is judged to be between €0.086m and €0.29m. There are also no social or macro-economic costs associated with introducing an OEL.

There are no significant environmental impacts foreseen.

1 PROBLEM DEFINITION

1.1 OUTLINE OF THE INVESTIGATION

1,2-dibromoethane (ethylene dibromide or EDB) may cause cancer, although there is some uncertainty about the specific type or types of cancer for which risks are increased. Exposure to 1,2-dibromoethane has been classified as a group 2b carcinogen (Possibly carcinogenic to humans) by the International Agency for Research on Cancer (IARC)[1] and as Cat 2 carcinogens in the EU under the classification and labelling legislation[2]. 1,2-dibromoethane is therefore already regulated as a carcinogen throughout the EU. In this assessment we consider the impacts of introducing an exposure limit for 1,2-dibromoethane within the EU Carcinogens and Mutages 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 exposure limit for 1,2-dibromoethane of 0.1 ppm.

1.2 OELS/EXPOSURE CONTROL

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. OELs from the USA are also presented for comparison.

Table 1.1 Occupational exposure limits in various EU member states and selected countries outside the EU

Country	OEL – long term		OEL - STEL	
	ppm	mg/m^3	ppm	mg/m^3
Austria	0.1	0.8	0.4	3.2
Denmark	0.1	1	0.2	2
Hungary				0.8
Poland	0.0625	0.5		
Spain	0.5	3.9		
Sweden				
Switzerland	0.1	0.8		
The Netherlands	0.00025	0.002		
United Kingdom	0.5	3.9		
USA - NIOSH	0.045		0.13 (ceiling limit value 15 min)	
USA – OSHA	20		30	

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

The long-term OELs from the EU member states and outside jurisdictions range from 0.00025 ppm in the Netherlands to 0.5 ppm in the UK. The most common OEL was

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

0.1 ppm in Austria, Denmark and Switzerland. Austria and Denmark have set a STEL - 0.2 and 0.4 ppm, respectively. For the purposes of this report an OEL of 0.1 ppm (0.8 mg/m^3) is considered typical for the EU.

1.3 DESCRIPTION OF DIFFERENT USES

1,2-Dibromoethane is made by direct bromination of ethylene or reacting hydrobromic acid with acetylene (IARC, 1999).

1,2-dibromoethane has been used mostly as a scavenger for lead in gasoline, as a soil fumigant, as a pesticide for grain and tree crops, as a solvent for resins, in waterproofing preparations, and in organic synthesis (IARC, 1977). In the 1970s production in Belgium, France, Italy, the Netherlands, Spain, Switzerland and the United Kingdom, was estimated to be between 3,000 and 30,000 tonnes (IARC, 1977). However, production has declined considerably as its use as a fumigant was banned in the EU in 1988 (EU directive: 79/117/EEC) and its use in leaded gasoline was faded out in the EU. However, it is still used in aviation and racing fuels and as intermediate for the production of some organic chemicals as a source of bromine.

According to the chemical network site Chembook.com[3] there are 20 suppliers of 1,2-dibromoethanein the EU, i.e. manufacturers or importers (Table 1.2).

Table 1.2 Number of suppliers of 1,2-dibromethane in the EU (data 2010)

Region	Number of Suppliers
Belgium	2
France	1
Germany	9
Norway	1
Slovakia	1
Switzerland	1
United Kingdom	5
Total	**20**

Source:www.Chembook.com. Last accessed 29 June 2010.

1.4 RISKS TO HUMAN HEALTH

1.4.1 Introduction

Animal toxicity studies using gavage administration[3] squamous cell carcinomas of the forestomach in rats and mice, hepatocellular carcinomas in females, and hemangiosarcomas in males. These experiments also produced in alveolar-bronchiolar adenomas in mice. By inhalation, 1,2-dibromoethane produced tumors in the nasal cavity and hemangiosarcomas of the circulatory system and other tumors in rats. In mice, inhalation exposure induced alveolar-bronchiolar carcinomas and adenomas, and hemangiosarcomas, subcutaneous fibrosarcomas, carcinomas of the nasal cavity, and adenocarcinomas of the mammary gland in females. Topical application to the skin produced tumors in the skin, lung, and forestomach in mice.

[3] Available at: www.chembook.com

1.4.2 Summary of the available epidemiological literature on risk

1,2-dibromoethane is strongly irritant to the eyes, skin, and respiratory tract (Letz *et al*, 1984). Deaths from acute exposure to high concentrations of 1,2-dibromoethane are usually due to pneumonia following damage to the lungs. In addition, acute inhalation exposure may lead to liver and kidney damage. Six people who attempted suicide by ingesting 1,2-dibromoethane suffered from vomiting, nausea and burning throat; death followed in two cases. The characteristic pathological lesions were present in liver, lungs and kidneys. Intense jaundice was observed and was due to massive necrosis of the liver (Sarawat *et al*, 1986). It is estimated that 200 mg/kg is lethal to humans, based on the observation that 12 g caused the death of a woman weighing about 60 kg (Alexeef *et al*, 1990).

Several cases of fatalities following acute exposure of humans to 1,2-dibromoethane have been reported. Two workers died following inhalation exposure while cleaning a tank used to temporarily store fertilizer mixtures in the field during application. Neither worker had respiratory or skin protection. The air inside the tank was sampled approximately 20 h after the accident and 1,2-dibromoethane concentrations ranged from 15 to 41 ppm [115–315 mg/m^3] with an average of 28 ppm [215 mg/m^3]. The oxygen concentration inside the tank was 21%. The first worker was exposed for approximately 5 min and the second for approximately 20–30 min. The first worker died approximately 12 h after exposure and the second died 64 h after entering the tank. These two cases provided evidence that 1,2-dibromoethane can produce metabolic acidosis, acute renal and hepatic failure and necrosis of skeletal muscle and many other organs (Letz *et al*, 1984). Another fatal poisoning occurred in a woman who intentionally ingested a capsule containing 6480 mg 1,2-dibromoethane [140 mg/kg]. On admission to hospital, the patient was drowsy, disoriented and jaundiced with mild hepatomegaly. She died eight days later and a post-mortem liver biopsy revealed congestion and focal liver cell necrosis (Singh *et al*, 1993).

1,2-dibromoethane has been shown to affect fertility in exposed workers (Wong *et al*, 1979).

Mortality in employees exposed to 1,2-dibromoethane in two production units operated from 1942 to 1969 and from the mid-1920s to 1976 was investigated (Ott *et al*, 1980). The study population was 161 employees. In the first production unit two deaths from malignant neoplasms (1 respiratory and 1 digestive) were observed against 3.6 expected, and in the second unit, where there was potential exposure to various organic bromide products, there were five deaths from malignant neoplasms (2 digestive, 3 other sites (not respiratory) against 2.2 expected ($p < 0.072$); in total there were 7 deaths from malignant neoplasms (5.8 expected) and 4 digestive cancers (1.7). However, no statistically significant increase in total deaths or malignant neoplasms relatives to duration of exposure was observed. Monitoring data between 1971 and 1975 gave average TWAs (time period not stated) of between 1 and 5 ppm.

In another epidemiological study, the mortality of workers exposed to 1,2-dibromoethane in two manufacturing plants in Britain was evaluated (Turner and Barry 1979). The manufacturing operation of each plant involved the extraction of bromine from sea water and its subsequent reaction with ethylene to form 1,2-dibromoethane. Although the size of the group studied was too small to analyze mortality rates on a year-by-year basis, a comparison of rates was carried out by grouping person-years of follow-up into four age ranges over the period of the study (23 years). No increase in mortality from any cause, including malignant neoplasms, was identified in the 1,2-dibromoethane workers.

In the United States, 1,2-dibromoethane has been used as a fumigant in the grain industry since the 1940s. Alavanja *et al* (1990) analysed mortality during 1955–85 in 22 938 white men who were enrolled in the life insurance programme of the American Federation of Grain Millers. Among a subset of 9660 who worked in flour mills (where pesticides were used more frequently), 1914 deaths were recorded, giving a standardized mortality ratio (SMR) of 0.9 based on national rates (p < 0.05). These included 25 deaths from leukaemia (SMR, 1.4, not significant) and 21 from non-Hodgkin lymphoma (SMR, 1.5, not significant). In a nested case–control study, having ever been employed in a flour mill was significantly associated with mortality from non-Hodgkin lymphoma (21 cases; odds ratio, 4.2; 95% confidence interval (CI), 1.2–14.2) and pancreatic cancer (33 cases; odds ratio, 2.2; 95% CI, 1.1–4.3) but not leukaemia (25 cases; odds ratio, 1.8; 95% CI, 0.8–3.9). The trend by duration since first employment in flour mills was significant for NHL (rising to over a nine fold risk after 25 yr of follow-up) but not for leukaemia and pancreatic cancer. Risk varied by department of employment in the flour mills for pancreatic cancer but not for NHL and leukaemia. A greater number of employees from the elevator department than from other grain facilities indicated that they were involved more frequently in applying grain fumigants, including carbon tetrachloride, carbon disulfide, and phosphine. The authors note that since these chemicals tended to be applied during regular work hours, direct exposure may be more likely than for other fumigants used in flour mills, such as methyl bromide, 1,2-dibromoethane, DDT, and hydrogen cyanide, all of which tended to be used when the plant was closed for periodic general plant fumigation. The number of chemicals to which workers could potentially have been exposed makes interpretation of these results difficult.

Background automotive gasoline contains benzene, 1,3-butadiene, 1,2-dibromoethane and 1,2-dichloroethane, and the combustion products include certain polycyclic aromatic hydrocarbons, all of which have shown mammary gland carcinogenicity in long-term bioassays. A nationwide register based case control study was carried out on male breast cancer morbidity among members of a pension fund, compulsory for all employees (Hansen 2000). Employment histories were reconstructed for each of 230 cases and 12,880 controls based on computerized records. The odds ratios, adjusted for socioeconomic status, were estimated by conditional logistic regression analysis. When a lag time of at least 10 years was included, the OR for breast cancer among men with over three months of employment in trades with potential exposure to gasoline and combustion products was 2.5 (95% confidence interval 1.3, 4.5). Among men younger than 40 years at the time of first employment, the OR was 5.4 (95%CI 2.4, 11.9). However, the role of 1,2-dibromoethane is unclear in this study.

1.4.3 Choice of risk estimates to assess health impact

The epidemiological information is extremely limited regarding the carcinogenic effects of 1,2 dibromoethane. An excess has been shown in one study particularly for digestive cancer. Experimental evidence in rats also substantiates this (Ramsey *et al* 1978); other experimental work has shown increased incidence of upper respiratory cancers and cancers in other organs (ATSDR, 1992).

The data are so poor that we have been unable to identify an appropriate relative risk to undertake a health impact.

2 BASELINE SCENARIOS

2.1 STRUCTURE OF THE SECTOR

Data searches were carried out to determine manufacturing sites currently producing 1,2-dibromoethane. The European chemical Substances Information System (ESIS) (date unknown) website lists four producers/importers of 1,2-dibromoethane in Europe (Table 2.1).

Table 2.1 List of producers/importers according to ESIS website

Company	Country
Associated Octel Company Ltd.	UK
Atochem	France
Eurobrom B.V.	Netherlands
S.I.A.C S.R.L	Italy

Source: http://ecb.jrc.ec.europa.eu/esis. Last accessed 1st February 2011.

However, consultation with industry indicates that there is only one producer in the EU and that a number of importers exist[4]. Based on the available information, it can be concluded that there is only one producer currently manufacturing 1,2-dibromoethane in the EU and between 4 – 20 importers (based on the data in Table 1.2 and Table 2.1).

Consultation with industry indicates that in terms of usage, 90 per cent of 1,2-dibromoethane in the EU is used as an intermediate for brominated alkyls[4].

Table 2.2 shows the total number of people employed, number of enterprises and turnover in the chemical manufacturing sector, which includes manufacture of brominated alkyls, based on information from Eurostat.

Table 2.2 Statistics of the sectors used in this study

Sector	NACE code	Total number of employees in sector[1]	Number of enterprises	Turnover
Manufacture of chemicals and chemical products	24	1,856,966	30,990	700,000

Notes:
1) This gives the total number of employees employed in the sector and does not represent the number of personnel exposed to EDB (as shown in Table 2.4)

Source: Eurostat data for year 2006

[4] Personal communication with ICL Industrial Products, 12th November 2009

2.2 PREVALENCE OF 1,2 DIBROMOETHANE EXPOSURE IN THE EU

Information on the exposure prevalence was available in the Finnish CAREX database (for NACE codes 60, 61, 62, 73, 75 and 80) and the Italian CAREX database (for NACE codes 73 and 80). Estimates of exposure for these industries (60, 61, 62, 73, 75 and 80), was estimated to be low. Information on prevalence of exposure for the only industry where exposure was estimated to be high (manufacture of chemicals, NACE code 24) was not available, as 1,2-dibromoethane is not manufacture in Finland or Italy.

The estimated exposure prevalence for the NACE codes 60, 61, 62, 73 75 and 80 for each EU member states is shown in Table 2.3. Figures are based on 2006 employment data (unless otherwise indicated). Approximately 7,707 workers in the EU are estimated to be potentially exposed to 1,2-dibromoethane across all the industries; although, the levels of exposure are estimated to be very low.

The prevalence of exposure was estimated from the Finnish CAREX estimate of 2007 and the Italian CAREX estimate of 2000 – 2003. For those NACE codes with information from both databases (NACE codes 73 and 80) the average of both was used except for Italy and Finland, where data on the respective country was used. The average proportion of exposed workers was applied to information on the number of employees in each industry obtained from the structural business statistics (NACE codes 60, 61, 62, 63) and from the labour force survey (NACE codes 73 and 80) available on the Eurostat database[5]. The average proportion of exposed workers was multiplied by the number of workers employed in each industry in each country. For Finland and Italy the proportion of exposed workers from their respective CAREX updates were used rather than the average proportion. We assumed exposure in Italy occurs only in those industries indicated in the Italian CAREX database. Where data for 2006 was not available in the SBS database, we have used data from 2005 (NACE code 60 Denmark). When the 2005 data were also unavailable we have indicated that data were unavailable for the industry and country

The prevalence of exposure in manufacture and agriculture in the Finish CAREX database (the only source available for these industries) was 0.0%. It may be that this was not representative of the rest of EU in the 1990s. However, since 1,2-dibromoethane was banned as a pesticide in the EU we assume that no workers are currently exposed in the agricultural industry. Regarding the prevalence of exposure in the manufacturing industry data from the Finnish database might be unrepresentative of scenarios in other EU countries. A search for 1,2-dibromoethane producers in the EU found 20 suppliers in the EU, although as noted suppliers may not manufacture 1,2-dibromoethane in the EU. We took a conservative approach and assumed that there are one production plant and 19 other plants handling 1,2-dibromoethane in the EU with five people exposed at each plant. This results in a total of 100 people exposed in EU.

[5] http://epp/ec/europa.eu/

Table 2.3 Prevalence of exposure to 1,2-dibromoethane by industry and country

Country	NACE Code 60	61	62	73	75	80	Grand Total
Austria	27	1	37	6	65	11	**147**
Belgium	22	5	22	7	108	19	**183**
Bulgaria	21	15	10	No exposure	58	11	**115**
Cyprus	1	13	9	NA	8	1	**32**
Czech Republic	48	NA	NA	7	82	14	**151**
Denmark	18*	40	NA	7	43	11	**101**
Estonia	5	3	3	1	10	3	**25**
Finland	17	25	30	29	30	8	**139**
France	166	46	290	49	618	89	**1258**
Germany	152	90	222	110	739	105	**1418**
Greece	29	49	15	10	98	15	**216**
Hungary	37	3	11	7	73	16	**147**
Ireland	7	NA	NA	3	27	7	**44**
Italy	No exposure	No exposure	No exposure	53	No exposure	122	**175**
Latvia	11	2	4	1	22	4	**44**
Lithuania	15	5	3	1	19	7	**50**
Luxembourg	3	NA	15	NA	6	1	**25**
Malta	NA	NA	NA	NA	4	1	**5**
Netherlands	44	NA	NA	40	144	27	**255**
Poland	111	11	22	5	235	57	**441**
Portugal	24	6	39	1	90	16	**176**
Romania	47	11	14	27	125	21	**245**
Slovakia	14	2	3	5	42	8	**74**
Slovenia	7	1	3	3	15	4	**33**
Spain	131	20	162	20	314	54	**701**
Sweden	31	42	30	NA	65	24	**192**
United Kingdom	128	43	361	121	518	128	**1299**
Total	1,116	434	1305	513	3,556	783	**7707**

NA: Not Available
NE: No exposure in that industry
* Data from 2005
Data for NACE codes 60, 61, 62 and 73 was taken from the structural business statistics database and for codes 75 and 80 from the Labour force database

The number of employees in some industry groups and countries was not available on the Eurostat database. Where possible, missing data has been substituted with data from other years (2007 for NACE code 61 Czech Republic and NACE code 62 Denmark and data from 2007 for Sweden NACE code 73).

The estimated number of male and female employees in each industry group in each EU member state is shown in Appendix 8.1. These data were obtained by applying the average male to female employee ratio for the industry group for each country to the total number of employees. Male to female employee ratios were calculated with data from the Labour Force Survey. Managers, salespeople and office clerks were excluded from these calculations as they were assumed to be unexposed.

Classification of industries by exposure level

Industries in which exposure to 1,2-dibromoethane occurs have been classified as high or low based on estimated levels in 1975. The exposure evaluation was based on the peer-reviewed literature, and expert judgement (Table 2.4). The industries, grouped by NACE code were identified from the Finnish CAREX (2007) and Italian CAREX databases (2005).

Table 2.4 Classification of industries by exposure level

Industry	NACE (rev 1.1)	Historical Exposure Classification[1]	Number of People Exposed 2006[2]
Agriculture, hunting and related service activities	01	L	0
Manufacture of chemicals and chemical products	24	**H**	100
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	50	L	0
Wholesale trade and commission trade, except of motor vehicles and motorcycles	51	L	0
Land transport; transport via pipelines	60	L	1,098
Water transport	61	L	436
Air transport	62	L	1,330
Research and development	73	L	514
Public Administration and Defence	75	L	3,556
Education	80	L	783
Total			**7,816**

[1] Relevant to 1975 Exposure Levels
[2] Prevalence estimation methods are described in section 1.3

2.3 LEVEL OF EXPOSURE TO 1,2 DIBROMOETHANE

2.3.1 Estimation of exposure levels

No 1,2-dibromoethane exposure data were available from industry. The literature review retrieved only three studies from the 1990s with exposure data on the manufacture industry and agriculture. Data for these studies was collected in the 1970-80s and therefore are not representative of current exposure levels from the past to estimate current exposures. We applied a decline of 7% per year in exposure. Current

(2010) averaged exposure concentration (GM) in the manufacturing industry was 0.022 ppm. For the agricultural sector we assumed currently there is no exposure as 1,2-dibromoethane has been banned in the EU.

Further details of the exposure estimates are shown in the sections below, for the manufacturing and agricultural sectors, respectively.

As mentioned earlier 1,2-dibromoethane was banned in the EU as a pesticide in 1988 and therefore no exposure in the agricultural sector is currently expected. In the manufacturing industry the use of 1,2-dibromoethane is under strict control and exposure is likely not to occur, except for accident releases or leaks and non-routine activities such as maintenance.

Chemical manufacturing (NACE 24)

NIOSH (NIOSH, 1981) performed an industrial hygiene survey of two manufacturing and two user facilities of 1,2-dibromoethane in the 1970s. Samples were taken for more than 69 potentially-exposed workers in 17 job classifications. Median 1,2-dibromoethane exposures by similar job types in the manufacturing processes ranged from 0.010 to 0.5 ppm (35 personal samples), and 0.0002-0.054 ppm in antiknock blending operations (39 personal samples). General area samples collected at breathing zone heights had median levels of 0.2 ppm for 10 samples at process sites, and 0.5 ppm for three samples at laboratory sites.

Data from 1975 in a production facility in Michigan showed much higher exposure concentrations than those reported by NIOSH. TWA ranged from 0.8 to 5 ppm (Ott *et al*, 1980). Details of the exposure concentrations for the different jobs are shown in Table 2.5.

Table 2.5 Exposure concentration for 1,2-dibromoethane (EDB) in the manufacturing industry in Michigan (Ott *et al*, 1980)

Survey period	Job category	Estimated TWA (ppm)	Range of samples (ppm)	Qualifications
1949 (18 samples)	Reactor operator		1-7.4	Breathing zone
	Still operator		2.2-10.6	Breathing zone
1952 (15 samples	Still operator		19-24	Between stills
			25-31	Between stills (warm days)
			<13.4	Filing drums of EDB
			<71	After a spill while filling drums
1971-2 (continuous)	Reactor operator	2.9	0.4-38	
	Still operator	4.0	0-110	(Before shed fixed)
		3.5	0-23	
1975 (22 samples)	Reactor operator	5.0	1.8-96	Breathing zone
(2 samples)		0.8, 1.1		Personnel monitoring

TWA=Time weighted-average exposure

The weighed AM and median concentrations calculated from the estimated TWA reported in Table 5 was 4.53 ppm and 3.2 ppm, with a GSD=5.8.

From the results reported by Ott *et al* and NIOSH we estimated an overall GM=0.19ppm and GSD=5.8. Assuming a reduction of 7% a year since 1980 the exposure (GM) in 2010 would be 0.022 ppm. It is likely that the range of exposures has decreased compared to 1980. Therefore, we assumed a GSD=3, which is typical of current exposure levels in occupational settings. An exposure distribution of 10000 datapoints with a GM of 0.002 and a GSD of 3 was simulated using @Risk and from this distribution it was estimated that at these exposure levels approximately 8% of workers in the chemical industry would be exposed above the typical OEL of 0.1 ppm.

Agriculture (NACE code 01)

NIOSH (NIOSH, 1981) reported worker exposure in fruit fumigation operations (personal samples) to 1,2-dibromoethane ranging from nondetectable (8 of 29 samples) to 2.92 ppm for a post fumigation fruit loader in the transport truck trailer. Forklift operator exposures ranged from 0.06 to 2.08 ppm. Area samples of airborne 1,2-dibromoethane concentrations ranged from nondetectable (13 of 33 samples) to 2.96 ppm at the 1,2-dibromoethane introduction point into the fumigation chamber.

In another survey, conducted at three fruit packing plants, of the 14 personal samples collected, 1,2-dibromoethane was nondetectable in 13 samples, with the other indicating a concentration of 0.14 ppm for a fumigator. Area sample airborne 1,2-dibromoethane concentrations ranged from nondetectable (16 of 20 samples) up to 0.81 ppm for a sample collected at the door of the fumigation chamber (NIOSH, 1981).

Ratcliffe (1987) reported concentrations in a fumigation plant in Hawaii in 1983 in the range of ppb (Table 2.6). Full shift exposures ranged from an average of 16 ppb (forklift drivers in plant 5) to 175 ppb (forklift drivers in plant 3). The weighed GM= 0.075 ppm and GSD=2.13. Assuming a reduction of 7% per year from 1983 to 2009, current (GM) exposures would be 0.011 ppm. However, since the use of 1,2-dibromoethane as a fumigant has been banned in the EU we assumed currently there is no exposure to 1,2-dibromoethane in this industrial sector.

Table 2.6 1,2-dibromoethane (EDB) exposure concentration in a fumigation plant (Ratcliffe, 1987) – parts per billion* (ppb)

Job category	**Full shift samples**					
	Plant 1	**Plant 2**	**Plant 3**	**Plant 4**	**Plant 5**	**Plant 6**
Sorter/packer	36 (n=13)	66 (n=12)	65 (n=16)	49 (n=6)	72 (n=9)	148 (n=7)
Forklift driver	51 (n=4)	92 (n=4)	175 (n=4)	152 (n=2)	16 (n=3)	NA
Fumigator	NA	NA	116 (n=2)	NA	NA	NA

*Limit of detection for EDB is 0.02ppb.
Data shown are geometric means (n=number of men sampled).
NA=Not available (samples not taken at these plants)

2.3.2 Temporal change in exposure

We have no information about the temporal change in exposure to 1,2-dibromoethane, but we have good data that suggests that in almost all situations exposure decreases over time (Creely, 2007). In this review the annual percentage change in exposure for vapours ranged from -19% to +4% per annum, with a median reduction of 7% each year We have therefore applied a decline of 7% per year in exposure.

2.4 HEALTH IMPACT FROM CURRENT EXPOSURES

Because of the uncertainty about the carcinogenicity of 1,2-dibromoethane in humans we have not carried out a health impact assessment. It is likely that the number of people exposed to this substance is less than 8,000 and exposure levels are low. This suggests that any health impact will be small.

2.5 POSSIBLE COSTS ASSOCIATED WITH NOT MODIFYING THE DIRECTIVE

2.5.1 Health impacts – possible costs under the baseline scenario

As it was not possible to estimate a link between exposure to 1,2-dibromoethane and cancer it is not possible to estimate the number of cancer registrations, deaths and life years lost from past and future exposure. Therefore it is not possible to produce monetised health costs of not modifying the directive to include 1,2-dibromoethane.

3 POLICY OPTIONS

3.1 DESCRIPTION OF MEASURES

Methods that are effective in controlling worker exposure to 1,2-dibromoethane, depending on the feasibility of implementation, are those typical industrial hygiene control measures:

- Process enclosure;
- Local exhaust ventilation (LEV);
- General dilution ventilation; and
- Personal protective equipment (PPE), particularly respiratory protection.

OSHA guidelines recommend storing 1,2-dibromoethane containers in places protected from physical damage and stored them separately from chemically active metals such as sodium, potassium, calcium, powdered aluminium, zinc, and magnesium, liquid ammonia, and strong oxidizers.

Further specific information on existing controls on the manufacture of 1,2-dibromoethane was not found in the literature. However, it is likely that similar controls to those used in the manufacture of other volatile compounds are currently used. This includes automated production in enclosed systems with vapour capture; transportation in enclosed pipes; use of low-emission coupling connectors to minimize or eliminate emissions during transfer. In cases where emissions are not eliminated respiratory protection is used during the task. Monitoring programs and/or continuous detectors to detect emissions are also used.

3.2 LEVEL OF PROTECTION ACHIEVED (OELS)

Exposure limits in EU are typically around 0.1 ppm. Spain and the UK have a higher OEL of 0.5 ppm and the lowest OELs are in The Netherlands and Poland with limits of 0.00025 and 0.0625 ppm, respectively. We estimated that about 8% of exposures in the high exposed industry sector (chemical manufacture, affecting about 100 workers) may still be above the proposed OEL, but we judge athat all other exposures are below the proposed OEL.

4 ANALYSIS OF IMPACTS

4.1 HEALTH IMPACTS FROM CHANGES TO THE EU DIRECTIVE

4.1.1 Health information

We have not been able to estimate the health benefits from setting an OEL, although we believe the impact of setting a limit at 0.1 ppm would be small because of the relatively low current exposures and the small number of people likely to be exposed above the proposed OEL.

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.

4.2 ECONOMIC IMPACTS

4.2.1 Operating costs and conduct of business

Number of Firms Affected

In Section 2.2 it was estimated that there are approximately 100 people typically exposed to 1,2-dibromoethane in the EU in total (NACE code 24). It is estimated that about 8% of these workers are exposed above the proposed EU-wide OEL of 0.1ppm, probably as a consequence of maintenance work or occasional leaks from process equipment.

This percentage alongside the available Eurostat data on the number of enterprises has been used to estimate the number of enterprises that may be affected by the proposed OEL. This is set out below (Table 4.1):

Table 4.1 Estimates of the number of enterprises affected[6]

[6] It is recognised that there are limitations to this approach, as it assumes affected workers are distributed across the NACE code sector in the same way as the average distribution for the NACE code. For example, if the sector is predominately made up of SMEs, then most workers affected will be employed in SMEs and the number of enterprises affected will be higher than if the sector is made up of enterprise employing over 250 workers; (whereby the number of enterprises affected will be smaller). In the absence of better data, this is seen as a reasonable approach to broadly estimating the number of enterprises affected.

Number of employees	Average number of workers per class size (rounded)	Composition of enterprises	Number of workers potentially exposed	Estimated number of enterprises affected
Between 1 & 9	5	58%	5	1
Between 10 & 19	15	14%	1	0
Between 20 & 49	25	12%	1	0
Between 50 and 250	150	12%	1	0
Greater than 250	500	5%	0	0
Total	-	**100%**	**8**	**1**
Percentage of affected firms relative to total number of firms in the sector	-	-	-	**0.004%**
Notes:				

As shown above in Table 4.1 it is estimated that <1% of enterprises could be affected by the introduction of an EU-wide OEL of 0.1ppm. Furthermore, as set out in Section 2.3.1, the number of firms with exposure currently exceeding the proposed OEL is expected to fall over time as exposure is expected to decline 7% per year.

Compliance Costs

As discussed in Section 3.1 it is thought that there are a number of control measures that can be implemented to limit inhalation exposure to 1,2-dibromoethane. The specific control measures required by enterprises depend on existing measures in place and the nature of operations conducted. Using a combination of PPE, enclosure and ventilation (general dilution or local exhaust ventilation) is thought to be effective in controlling worker exposures to 1,2-dibromoethane.

Dilution ventilation is the dilution of contaminated air with uncontaminated air for the purpose of controlling potential airborne health hazards, fire and explosive conditions, odours and nuisance type contaminants. LEV systems capture and remove process emissions at or close to their source of generation and prior to their escape into the workplace environment. Cost data for ventilation units are based on estimates from ventilation suppliers. Costs per unit for 1,2-dibromoethane industries are increased as local exhaust equipment requires relatively sophisticated equipment to recover the vapour from the air before it is discharged to atmosphere, which is more costly than a standard system. The range of costs is shown in Table 4.2.

Table 4.2 Capital costs per enterprise for ventilation units for stationary LEV

Type of cost	Stationary Machinery
Capital Cost (‘000)	€42 – 252
Annual Maintenance (‘000)	€1
Annual Testing (‘000)	€1-5

Filters changes every 5 years ('000)	€5
Total annualised cost* ('000)	€5.7 - 25

Notes: It is assumed that ventilation equipment last for 20 years and filters last for 5 years. Costs are based on a 4% discount rate as recommended by the EC IA guidelines (2009)

Appropriate respiratory equipment (RPE) and personal protective equipment (PPE) also has an impact on the magnitude of worker exposure to 1,2-dibromoethane. There are not expected to be any significant costs associated with enclosure, PPE and RPE, which in any case would be considered to be good practice. It is assumed that costs range between €500-€2,000/year per enterprise.

This cost data has been used alongside the estimate of number of enterprises affected by the proposed OEL (Table 4.1) to estimate total compliance costs. Insufficient information was available to determine more accurately which measures might be required to meet each OEL for each firm size or sector. Therefore the following assumptions have been used based on expert judgement and available information:

- 33% of affected firms only incur costs of RPE to comply with the proposed OEL.
- 33% of affected firms have LEV but do not necessary use and/ or maintain their system properly. Therefore costs to properly maintain and use of their LEVs and use of RPE will be sufficient to comply with the OEL.
- 33% of affected firms will incur costs associated with purchase, maintenance and use of LEV and use of RPE

These estimates are subject to high uncertainty. The costs of compliance with an EU-wide OEL is summarised below in Table 4.3.

Table 4.3 Total costs of compliance for control of 1,2-dibromoethane with proposed EU-wide OEL of 0.1ppm

Number of enterprises affected	Action required	Average annualised cost per enterprise (2010)		Total annual cost in millions (2010)		Total cost 2010-2070 in millions	
		Low	High	Low	High	Low	High
0.33	RPE	€ 500	€ 2,000	€ 0.000	€ 0.001	€ 0.004	€ 0.017
0.33	RPE + proper use of existing LEV	€ 3,123	€ 7,123	€ 0.001	€ 0.003	€ 0.028	€ 0.062
0.33	RPE + install and use LEV	€ 6,214	€ 25,666	€ 0.002	€ 0.009	€ 0.053	€ 0.211
Total	-	-	-	**€0.004**	**€0.012**	**€0.086**	**€0.29**

As shown in Table 4.3 the total cost of compliance in present value terms (i.e. in today's price) is estimated to be €86-290k over the assessment period 2010-2069 for an OEL of 0.1ppm. Therefore, there is not expected to be any significant additional costs of meeting an OEL of 0.1ppm relative to the baseline scenario.

It is likely that these risk management measures (RMMs) would occur under the baseline and therefore the impact of introducing an EU-wide OEL of 0.1ppm is that reductions in exposure will be achieved sooner than planned (i.e. costs incurred earlier than planned.

Conduct of employers

The introduction of an EU-wide OEL of 0.1ppm may require certain companies to reorganise their workplace to ensure that exposure to 1,2-dibromoethane emissions is minimised. There may also be additional training and authorisation of personnel handling the substance required to ensure that employees minimise their exposure by adhering to good practice in order to reducing exposure (e.g. wearing protective clothing and ensuring process enclosure). However in practice, it is expected that these activities are already taking place and thus there may well be no additional change beyond the baseline.

Potential of closure for companies

There is not expected to be any potential closure of companies as a result of introducing the EU-wide OEL because no substantial compliance costs are likely to be incurred.

Potential impacts for specific types of companies

There are not expected to be any particular impacts for specific types of companies, since there are not expected to be any additional costs of meeting an OEL of 0.1ppm relative to the baseline scenario or any other substantial changes to companies' operations.

Companies that require ventilation systems and do not already have one, will be affected more.

Administrative costs to employers and public authorities

The following table (Table 4.4) 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 4.4 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

Type of administrative cost	Relevant article(s)	Type of cost	Significance
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 4.5) 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 4.5 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

Since it is not expected that the introduction of an EU-wide OEL will have any noticeable impact, there is not expected to be any significant impact on third countries such as redistribution of investment, jobs and sales.

As shown in Table 1.1 some non-EU countries have a pre-existing OEL in place. A harmonised EU-wide OEL may encourage other countries outside the EU to implement an OEL into national legislation.

4.2.2 Impact on innovation and research

Impacts on innovation and research from introducing an EU-wide OEL of 0.1ppm are estimated to be minimal.

4.2.3 Macroeconomic impact

Short-term spending on risk management measures (RMMs) may be good for the economy as equipment manufacturers (ventilation systems), installers and other will benefit with money flowing through the economy, if the alternative is that profits are retained (by shareholders or the company and not spent e.g. on R&D, meaning the wider economy would not benefit from increased spending). However, since it is expected that these RMMs would occur under the baseline, there is not expected to be any macroeconomic impacts relative to the baseline scenario from introducing an EU-wide OEL.

4.3 SOCIAL IMPACTS

4.3.1 Employment and labour markets

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

There are not expected to be any noticeable changes to jobs skills, patterns or the numbers of workers required as a result of using of ventilation systems. In terms of working conditions, the use of mechanical local ventilation may be better for workers than natural ventilation as air change rates and flow can be controlled, and thermal environmental conditions maintained at more acceptable levels. One of the disadvantages of using mechanical ventilation is heat loss, especially in colder regions. If the mechanical ventilation includes a heat exchanger with high efficiency, this might typically reduce the ventilation heat loss by 80-90% and the total heat loss by 30-60%, depending on the insulation level[7].

4.3.2 Changes in end products

There are not expected to be any noticeable changes to the end products since control measures do not change the characteristics of the product and 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.

[7] "Mechanical ventilation with heat recovery in cold climates" - http://web.byv.kth.se/bphys/reykjavik/pdf/art_157.pdf. (Note that this is in relation to housing rather than industrial buildings.)

4.4 ENVIRONMENTAL IMPACTS

The achievement of the OEL via the measures described in this report may lead to more direct emissions of 1,2-dibromoethane to the environment (through ventilation), but it is highly unlikely that this would lead to an increased overall environmental burden. Therefore it is assumed that an OEL would not increase the level of environmental harm.

5 COMPARISON OF OPTIONS

The main impacts of introducing a an OEL for 1,2-dibromoethane (EDB) that were discussed in section 4 are summarised in the tables below, which are broken down by the main types of impacts (economic, social, macroeconomic and environmental).

Table 5.1 Comparison of health impacts by scenario (Present Value – 2010 €m prices)

Baseline Scenario		Intervention scenario (2) – Assumes full compliance for OEL = 0.1ppm	
Health Costs	**Health Benefits**	**Health Costs**	**Health Benefits**
Insufficient data to estimate possible costs of health impacts.	It is assumed that exposures fall by 7% per year in the future. Therefore there is expected to be some reduction in health costs going forward in the absence of further regulatory intervention	None - There is expected to be a cost saving from avoided health care and reduced cost of illness due to reductions in cancer registrations. This has been estimated as a benefit.	Whilst it has not been possible to produce monetised health benefits it is thought that given (a) the relatively low percentage of workers are assumed to be above the possible OEL and (b) the overall relatively low number of people exposed (100), 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 (Present Value – 2010 €m prices)

Baseline Scenario		Intervention scenario (2) – Assumes full compliance for OEL = 0.1ppm	
Economic Costs	**Economic Benefits**	**Economic Costs**	**Economic Benefits**
It is estimated that under the baseline scenario, firms are already moving towards complying with the 0.1ppm OEL. Therefore there is assumed there will not be a significant cost to achieve the 0.1ppm OEL.	Having an EU-wide OEL level should remove any EU competitive distortions between EU Member States with different OELs.	The impact of introducing an EU wide OEL of 0.1ppm is that reductions in exposure will be achieved sooner than planned (i.e. investment will be made earlier than planned). Therefore it is assumed there is not expected to be any significant additional costs of meeting an OEL of 0.1ppm relative to the baseline scenario. The only issue may relate to getting access for necessary finance earlier than potentially planned for.	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 (Present Value – 2010 €m prices)

Baseline Scenario		Intervention scenario (2) – Assumes full compliance for OEL = 0.1ppm	
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 (Present Value – 2010 €m prices)

Baseline Scenario		Intervention scenario (2) – Assumes full compliance for OEL = 0.1ppm	
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 is 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 (Present Value – 2010 €m prices)

Baseline Scenario		Intervention scenario (2) – Assumes full compliance for OEL = 0.1ppm	
Environmental Costs	**Environmental Benefits**	**Environmental Costs**	**Environmental Benefits**
Only 8% of workers exposed to EDB are estimated to be exposed above the most commonly adopted OEL of 0.1ppm 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.	It is not expected that the measures for human health would lead to any additional environmental benefit.

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

6 CONCLUSIONS

1,2-dibromoethane has been used as a scavenger for lead in gasoline, as a soil fumigant, as a pesticide for grain and tree crops, as a solvent for resins, in waterproofing preparations, and in organic synthesis. Production has declined considerably since the 1970s and some uses, e.g. as a pesticide, are now banned. It is still used in aviation and racing fuels and as intermediate for the production of some organic chemicals as a source of bromine. There is one manufacturer in the EU and up to 19 other suppliers.

Less than 8,000 people are potentially exposed in Europe, but only about 100 employed in chemical manufacturing. We judge that occupational exposure levels are currently low, with about 8% of workers in chemical manufacturing exposed to average levels above 0.1 ppm and workers in other sectors exposed to less than 0.1 ppm. Exposures are assumed to have been decreasing over recent years by about 7% per annum.

Information about the hazard from 1,2-dibromoethane is limited. Animal toxicity studies have shown a range of tumours induced, but 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. The cost of compliance with a limit of 0.1 ppm, aggregated over the period 2010 to 2070, is judged to be between €0.086m and €0.29m. There are also no social or macro-economic costs associated with introducing an OEL.

There are no significant environmental impacts foreseen.

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8 APPENDIX

8.1 ESTIMATED NUMBER OF EMPLOYEES IN EACH INDUSTRY GROUP – MEMBER STATE BREAKDOWN – MALES AND FEMALES

Table 8.1.1 Number of workers exposed to beryllium by Member State and NACE code – males and females

	NACE code																				
	60			61			62			73			75			80					
Country	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**
Austria	27	22	5	1	1	0	37	31	7	6	4	2	65	41	24	11	3	8	**147**	**102**	**46**
Belgium	22	19	3	5	4	1	22	20	3	7	5	2	108	68	40	19	6	13	**183**	**122**	**62**
Bulgaria	21	19	2	15	13	1	10	9	1		Not exposure		58	42	16	11	3	7	**115**	**86**	**27**
Cyprus	1	1	0	13	10	3	9	7	2		NA		8	5	3	1	0	1	**32**	**23**	**9**
Czech Republic	48	40	8		NA			NA		7	4	3	82	44	39	14	4	11	**151**	**92**	**61**
Denmark	18*	14	3	40	33	8		NA		7	5	3	43	23	19	11	4	6	**101**	**79**	**39**
Estonia	5	4	1	3	2	1	3	2	1	1	0	0	10	4	6	3	0	3	**25**	**12**	**12**
Finland	17	14	3	25	20	5	30	24	6	29	17	12	30	14	16	8	3	6	**139**	**92**	**48**
France	166	136	30	46	38	8	290	238	52	49	32	17	618	334	284	89	30	59	**1258**	**808**	**450**
Germany	152	128	24	90	76	14	222	187	36	110	70	40	739	384	355	105	21	84	**1418**	**866**	**553**
Greece	29	26	2	49	45	4	15	14	1	10	6	4	98	66	31	15	6	10	**216**	**163**	**52**
Hungary	37	33	4	3	3	0	11	9	1	7	5	3	73	36	37	16	4	12	**147**	**90**	**57**
Ireland	7	6	1		NA			NA		3	2	1	27	18	8	7	2	5	**44**	**28**	**15**
Italy		Not exposure			Not exposure			Not exposure		53	33	20		Not exposure		122	29	93	**175**	**62**	**113**
Latvia	11	9	2	2	2	0	4	4	1	1	1	1	22	11	11	4	1	4	**44**	**28**	**19**
Lithuania	15	12	3	5	4	1	3	3	1	1			19	10	9	7	1	5	**50**	**30**	**19**
Luxembourg	3	3	0		NA		15	13	2		NA		6	4	1	1	0	1	**25**	**20**	**4**
Malta		NA			NA			NA			NA		4	2	1	1	0	0	**5**	**2**	**1**
Netherlands	44	37	8		NA			NA		40	28	11	144	91	53	27	11	16	**255**	**167**	**88**
Poland	111	98	13	11	10	1	22	20	3	5	3	2	235	125	111	57	14	43	**441**	**270**	**173**
Portugal	24	21	3	6	6	1	39	34	5	1	1	1	90	59	32	16	4	11	**176**	**125**	**53**
Romania	47	42	6	11	9	1	14	12	2	27	18	9	125	76	49	21	6	15	**245**	**163**	**82**

	NACE code																				
		60			61			62			73			75			80				
Country	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**
Slovakia	14	12	2	2	2	0	3	3	0	5	3	2	42	20	21	8	2	7	**74**	**42**	**32**
Slovenia	7	6	1	1	1	0	3	2	1	3	2	1	15	8	7	4	1	3	**33**	**20**	**13**
Spain	131	114	17	20	17	3	162	141	21	20	13	7	314	204	110	54	20	34	**701**	**509**	**192**
Sweden	31	26	5	42	35	7	30	25	5		NA		65	30	34	24	6	18	**192**	**122**	**69**
United Kingdom	128	111	17	43	38	6	361	314	47	121	82	39	518	295	223	128	37	91	**1299**	**877**	**423**
Total	1,116	953	163	434	369	65	1,305	1,111	195	513	335	178	3,556	2,016	1,540	783	218	565	**7707**	**5002**	**2706**

NA: Not Available: NE: No exposure in that industry;* Data from 2005; Data for NACE codes 60, 61, 62 and 73 was taken from the structural business statistics database and for codes 75 and 80 from the Labour force database

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