Study on collecting information on substances with the view to analyse health, socio-economic and environmental impacts in connection with possible amendments of Directive 98/24/EC (Chemical Agents) and Directive 2009/148/EC (Asbestos)

Final report for asbestos

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September 2021

EUROPEAN COMMISSION

Directorate-General for Employment Social Affairs and Inclusio
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Manuscript completed in September 2021

PDF ISBN 978-92-76-41921-1 doi: 10.2767/981554 KE-01-21-288-EN-N

Luxembourg: Publications Office of the European Union, 2021

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List of abbreviations and acronyms

ACGIH	American Conference for Governmental Industrial Hygienists
ACM	Asbestos-containing material
AGS	Ausschuss für Gefahrstoffe in Germany
AIR	Asbestos Impact Ratio
AM	Arithmetic mean
APF	Assigned Protection Factor
Anses	Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail (National Agency for Food Safety, Environment and Labour, France)
ASA	ASA register of occupational exposure hazards and procedures in Finland
APR	Air Purifying Respirator
AWD	Asbestos at Work Directive
BAuA	Bundesanstalt für Arbeitsschutz und Arbeitsmedizin in Germany
BEI	Biological Exposure Indices
BG	Berufsgenossenschaft in Germany
CAREX	Carcinogen Exposure (database)
CAD	Chemical Agents Directive
CAS	Chemicals Abstracts Service
CBA	Cost Benefits Analysis/Assessment
CDB	Current disease burden
CEA	Cost Effectiveness Analysis
C&L	Classification and Labelling Inventory
CLP	Classification, Labelling and Packaging Regulation
CMD	The Carcinogens and Mutagens Directive
DG	Directorate General
DGUV	Deutsche Gesetzliche Unfallversicherung
DRR	Dose Response Relationship
EC	European Commission
EFBWW	European Federation of Building and Woodworkers
EDXA	Energy Dispersive X-ray Analysis
EEC	European Economic Community
ECHA	European Chemicals Agency
EDA	European Demolition Association
EEA	European Economic Area
EEA	European Environment Agency
EM	Electron microscopy
EMP	Elongated Mineral Particles
EPRD	Office for Economic Policy and Regional Development
E-PRTR	European Pollutant Release and Transfer Register
ERR	Exposure Risk Relationship
ETUI	European Trade Union Institute
FFP3	Type of filter
FRG	Federal Republic of Germany (former Western Germany)
FIEC	European Construction Industry Federation
FIOH	Finnish Institute of Occupational Health
GDR	German Democratic Republic (former Eastern Germany)
GM	Geometric mean
GSD	Geometric standard deviation

GVS	Gesundheitsvorsorge in Germany
HSE	Health and Safety Executive in Great Britain
EU	European Union
GM	Geometric mean
HCN	Health Council of the Netherlands
FoBiG	Forschungs und Beratungsinstitut Gefahrstoffe
GESTIS	Internationale Grenzwerte für chemische Substanzenm (International limits for chemical substances)
HEPA	High-efficiency particulate absorbing filter
HSA	Health & Safety Agency, Ireland
HSE	Health & Safety Executive, United Kingdom
HWE	Hazardous Waste Europe
IARC	International Agency for Research of Cancer
IIDB	Industrial Injuries Benefit Disablement in Great Britain
IFA	Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung in Germany
IMA	Industrial Minerals Association
INRS	l'Institut national de recherche et de sécurité pour la prévention des accidents du travail et des maladies professionnelles in France
INSPQ	Institut Nationale De Santé Publique Du Québec
ISO	The International Organization for Standardization
LEV	Local Exhaust Ventilation
LOD	Limit of Detection
LOQ	Limit of Quantification
MCA	Multi-Criteria Analysis
MEGA	IFA's workplace exposure database
MS	Member State
NACE	Nomenclature statistique des activités économiques dans la Communauté européenne, the Statistical Classification of Economic Activities in the European Community
n.e.c.	Not elsewhere classified
NPF	Nominal Protection Factor
NIOSH	National Institute for Occupational Safety and Health
NMBS	Nationale Maatschappij der Belgische Spoorwegen, in Belgium
NNLW	Notifiable Non-Licensable Work
NOAEL	No-Observed-Adverse-Effect Level
NOIE	National Occupational Inhalation Exposure
OEL	Occupational Exposure Limit
OPPBTP	French Organisation for Prevention of Occupational Hazards in the Construction Industry
OSH	Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PCM	Phase-Contrast Microscopy or Phase-Contrast Microscope
PLM	Polarised light microscopy
PIVISTEA	Programa Integral de Vigilancia de la Salud de los Trabajadores Expuestos a Amianto in Spain
PPE	Personal Protective Equipment
PTB	Persistent, Bio-accumulative, and Toxic
P50, P75, P95	The 50^{th}, 75^{th} and 95^{th} percentile
RAC	Committee for Risk Assessment
RAPEX	EU rapid alert system for dangerous non-food products
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals Regulation
RMM	Risk Management Measure

RPE	Respiratory Protective Equipment
TNO	The Netherlands Organisation for Applied Scientific Research
SAED	Selected Area Electron Diffraction
SCOLA	French occupational exposure database
SD	Standard deviation
SIR	Standardized incidence ratio
SIREP	The Italian Information System on Occupational Exposure to Carcino-gens database
SEG	Separate Exposure Group
SEM	Scanning Electron Microscopy Energy
SEM/EDXA	Scanning Electron Microscopy Dispersive X-ray Analysis
SMA-rt	Dutch asbestos management system
SME	Small and Medium-sized Enterprise (includes companies with <250 employees i.e. micro-, small- and medium-sized companies)
STEL	Short-Term Exposure Limits
STOT	Specific Target Organ Toxicity
STOT RE 1	Toxic to humans or toxic effect in animal experiments after repeated exposures
SUMER	Surveillance médicale des expositions aux risques professionnels (Medical Monitoring Survey of Professional Risks)
TAF	Thin asbestos fibre
TEM	Transmission Electron Microscopy
TMP3	Type of respirator
TLV	Threshold Limit Value
TRGS	Technische Regeln für Gefahrstoffe
TWA	Time-weighted Average
UK	United Kingdom
US EPA	Environmental Protection Agency of the United States of America
vPvB	Very Persistent and Very Bio-accumulative
VDI	Verein Deutscher Ingenieure
WHO	World Health Organisation

Executive Summary

Objective. The objective of this study is to support the European Commission's Impact Assessment of a potential lower Occupational Exposure Limit (OEL) value for asbestos under the Asbestos at Work Directive (AWD, Directive 2009/148/EC).

Use of asbestos. The manufacturing, use and production of new products with asbestos is banned at EU level via REACH Annex XVII entry 6 stating that the manufacture and use of asbestos fibres as such as well as mixtures and articles (where asbestos fibres are added intentionally) are prohibited in the EU.

Exposure sources. Occupational exposure to asbestos takes place in a number of situations where asbestos is present in articles and constructions materials. The presence of asbestos originates from its intentional application in the past or due to it being a natural contaminant in mining, tunnelling and use of construction materials. The study distinguishes between the following exposure situations:

- Exposure to asbestos in construction materials and installations. The study distinguishes between exposure situations subject to notification, not subject to notification (Article 3(3) waiver), and 'incidental' as well as passive exposure.
- Exposure to asbestos in articles such as trains, vehicles, vessels, and aircraft.
- Exposure to asbestos due to management of asbestos-containing waste.
- Exposure to naturally occurring asbestos in mining and quarrying, tunnel excavation and from the use of construction materials with low natural content of asbestos e.g. for road construction.
- Exposure to asbestos during sampling and analysis.

Exposure concentrations. The majority of workers in most of the exposure groups are likely to be already using respiratory protective equipment (RPE) to bring the breathing concentration below the OEL, and the exposure distributions used for the calculation of burden of disease have consequently been adjusted for the use of RPE. As limited data are available on exposure levels adjusted for the use of RPE, exposure distributions have been calculated from distributions that do not take RPE into account (workplace air concentrations) and adjusted for the expected use of RPE depending on the exposure concentration. Workplace air concentrations in building and construction vary by several orders of magnitude from more than 1,000 fibres/cm^3 when working with highly friable spray asbestos to the lowest levels at less than 0.1 fibres/cm^3 when working with non-friable (bounded) asbestos, e.g. in undisturbed asbestos-cement sheets. Passive exposure is typically below 0.002 fibres/cm^3 whereas workplace air concentrations when working with naturally occurring asbestos is typically below 0.1 fibres/cm^3.

Exposed workforce. The total workforce exposed within the sectors that are included in the quantitative assessment is estimated at approximately 4.1 - 7.3 million. Of these, the majority is within the exposure group 'Building and construction - exposure situations subject to Article 3(3) waiver and 'incidental' exposure' with an estimated 3.5 - 5.5 million workers. These workers will only be exposed sporadically. Potentially, more workers (millions) may be exposed at levels close to or below the lowest OEL option of 0.001 fibres/cm^3. This level is close to the reported levels of passive exposure in buildings with asbestos containing materials, as well as the ambient levels in some areas with high background concentrations and the naturally occurring asbestos exposure levels present in some areas. Due to limited data, it has not been possible to quantify the total number of workers exposed at levels slightly above the OEL option of 0.001 fibres/cm^3, but the contribution of these exposures to the total burden of disease is expected to be limited.

Analysis method. With a practical Limit of Quantification (LOQ) at approximately 0.005 - 0.01 fibres/cm^3, phase contrast microscopy (PCM) cannot be considered feasible for monitoring compliance with the assessed OEL options. Scanning electron microscopy (SEM) or transmission electron microscopy (TEM) are already the prescribed methods for compliance control in the Netherlands, Germany and France and used to some extent in other Member States, and they likely account for more than half of all measurements for compliance control in the EU27 today. The applicability of the methods at the low levels necessary for compliance control for the OEL options of 0.002 and 0.001 fibres/cm^3, is highly dependent on whether fibres thinner than 0.2 µm, which is the lower limit of the PCM method, should be included in the reference method defined in the AWD. ECHA's Committee for Risk Assessment concludes that harmonisation of the different electron microscopy (EM) methods currently used is required at EU level, and in the meantime some transitional provisions seem necessary.

Health effects. The main cancer effect of asbestos is mesothelioma (tumours of the pleura and the peritoneum, i.e., the membrane linings of the lung and abdominal cavities and lung cancer). The assessment of the future burden of disease and the estimated benefit of introducing a lower OEL is based primarily on these two cancer endpoints. However, there is evidence for carcinogenic activities in other organs as well and the results of this study have been adjusted to reflect the estimate of the RAC that cancers of the ovary and larynx account for maximally 10% of asbestos-induced cancer incidence. Based on all available data, RAC considers that asbestos is a non-threshold carcinogen. Consequently, no OEL level has been proposed by RAC. The main non-cancer effect is asbestosis, a form of pulmonary fibrosis, which occurs at higher exposure levels than the current EU OEL. Consequently, it is assumed that lowering the OEL would not have any impact on the number of cases of asbestosis.

Future burden of disease. The baseline future burden of disease (cases of mesothelioma, lung cancer) has been estimated to be 804 cases over a period of 40 years or on average 20.1 cases per year. Additionally, a further 80 cases of laryngeal and ovarian cancer are expected to occur over the next 40 years (2 cases per year) due to exposure to asbestos. Most of these are expected to occur in the exposure group 'Building and construction - exposure situations subject to Article 3(3) waiver and 'incidental' exposure'. Situations with exposure to naturally occurring asbestos account for less than 6% of cases.

Assessed OELs. This report assesses the impacts of the introduction of a lower OEL for asbestos which is currently 0.1 fibres/cm^3. Three OEL options are assessed against the baseline: 0.01 fibres/cm^3, 0.002 fibres/cm^3, and 0.001 fibres/cm^3.

Cost-benefit assessment (CBA) and Multi-criteria analysis (MCA). The estimated costs and benefits (relative to the baseline) for the different OEL options are summarised below. The table represents the core estimates developed on the basis of available data. As underlined below, the exact results should be interpreted with care as uncertainties are involved in these estimations. Large cost/benefit ratios indicate that the costs would be significantly higher than the benefits for all OEL options.

Two estimates of the cost savings from ill health avoided under the different OEL options (Methods 1 and 2) are presented in this report. These estimates rely on two different monetisation approaches. Both monetise the same number of avoided cases and use identical methods for the monetisation of direct (healthcare, informal care, disruption for employers) and indirect (productivity/lost earnings[1]) impacts. However, they use different approaches to assign monetary values to intangible effects (reduced quality of life, pain and suffering, etc.). The results of both approaches should be considered together and treated as indicative of the general order of magnitude of the cost savings. A detailed explanation of these approaches is provided in the Methodological note.

[1] This is not the case where lost earnings are already taken into account in the Willingness to Pay estimate in published literature.

Table 1.1 Cost-benefit of the OEL options

Impact	OEL options (fibres/cm³)			
	0.001 fi-bres/cm³	0.002 fi-bres/cm³	0.01 fi-bres/cm³	0.1 fibres/cm³ (baseline)
Total benefits Method 1 (M1)	€ 420 million	€ 410 million	€ 330 million	€0 million
Total benefits Method 2 (M2)	€ 220 million	€ 210 million	€ 170 million	€0 million
Total costs	€ 94,000 million	€ 76,000 million	€ 24,000 million	€0 million
Cost benefit ratio Method 1 (M1)	220	190	70	0
Cost benefit ratio Method 2 (M2)	430	360	140	0

Source: study team's calculation

The table below summarises both the monetised and qualitative impacts.

Table 1.2 Multi-criteria analysis (all impacts over 40 years and additional to the baseline)

Impact	Stakeholders affected	OEL options (fibres/cm³)			
		0.001 fi-bres/cm³	0.002 fi-bres/cm³	0.01 fi-bres/cm³	0.1 fi-bres/cm³ (baseline)
Direct costs - compliance					
Risk management measures and discontinuation costs (one-off and recurrent)	Companies	€ 58,000 mil-lion	€ 52,000 mil-lion	€ 13,000 mil-lion	€0 million
Costs of notification and health surveillance of activities currently subject to Article 3 waiver	Companies	€ 28,000 million	€ 19,000 million	€ 9,500 million	€0 million
Training costs	Companies	€ 2,000 million	€ 1,100 million	€ 530 million	€0 million
Monitoring (sampling and analysis)	Companies	€ 640 million	€ 560 million	€ 110 million	€0 million
Direct costs - administrative burdens					
Administrative burden - Monitoring (sampling and analysis)	Companies	€ 60 million	€ 30 million	€ 15 million	€0 million

<table>
<tr><th rowspan="2">Impact</th><th rowspan="2">Stakeholders affected</th><th colspan="4">OEL options (fibres/cm³)</th></tr>
<tr><th>0.001 fibres/cm³</th><th>0.002 fibres/cm³</th><th>0.01 fibres/cm³</th><th>0.1 fibres/cm³ (baseline)</th></tr>
<tr><td colspan="6">Direct costs - total</td></tr>
<tr><td>Compliance – RMMs, notifications, health surveillance, training, monitoring and administrative burden costs
<u>Average cost per company</u></td><td>Companies</td><td>€ 57,000
(varies significantly by sector: € 39,000 - € 2,600,000)</td><td>€ 46,000
(varies significantly by sector: € 29,000 - € 2,300,000)</td><td>€ 15,000
(varies significantly by sector: € 12,000 - € 355,000)</td><td>€0</td></tr>
<tr><td colspan="6">Direct costs - enforcement costs</td></tr>
<tr><td>Transposition costs</td><td>Public sector</td><td>€ 1.4 million</td><td>€ 1.3 million</td><td>€ 0.75 million</td><td>€0</td></tr>
<tr><td>Costs of changing guidelines</td><td>Public sector</td><td>€ 1.4 million</td><td>€ 1.3 million</td><td>€ 0.75 million</td><td>€0</td></tr>
<tr><td>Enforcement, monitoring, adjudication costs</td><td>Public sector</td><td>€ 4,200 million</td><td>€ 2,800 million</td><td>€ 1,400 million</td><td>€0 million</td></tr>
<tr><td colspan="6">Indirect costs - other</td></tr>
<tr><td>Firms exiting the market - No. of company closures</td><td>Companies</td><td colspan="4">A significant number of business closures is not expected.
(Companies would be able to pass on the increased costs to their clients due to the fact that it is not an option to not treat/remove/deal with asbestos.)
However, it is recognised that in some sectors, the costs of the lower two OEL options expressed as % of turnover shown in Section 7 are significant for companies in some sectors (>20%), especially SMEs. When expressed as % of profits or investment, these costs are even greater. Although these costs are likely to be, to a large extent, passed on to the customers, they may result in some companies abandoning the market and the transfer of the relevant activities to other companies. These issues may be greater for small companies.
Where this is the case, it is more likely that the relevant companies in Exposure Group 2 that cease to accept asbestos-related work would carry on operating than shut down; this is because, on average, asbestos-related work amounts to a small proportion of the activities of these companies (although there are some companies which could experience more significant impacts).
However, significant price increases may result in consumers putting off asbestos work and as a result spread the demand over greater period of time, thus reducing the market available each year. This may result in a reduction of firms in the market.</td></tr>
<tr><td>Employment – Jobs lost</td><td>Workers & families</td><td colspan="4" rowspan="2">No significant net loss of employment is being predicted at the OEL option of 0.01 fibres/cm³. However, it is possible that some jobs may move between the different Exposure Groups identified, with companies that have concentrated on carrying out notified work taking up some of the work that might previously have been carried out by</td></tr>
<tr><td>Employment – Social cost</td><td>Workers & families</td></tr>
</table>

Impact	Stakeholders affected	OEL options (fibres/cm³)			
		0.001 fibres/cm³	0.002 fibres/cm³	0.01 fibres/cm³	0.1 fibres/cm³ (baseline)
		companies operating under Article 3(3) waiver. These companies may be able to carry out the work with greater economies of scale and the net impact on employment may thus be negative.			
International competitiveness	Companies	Limited negative impact Most of the activities involving exposure to asbestos will be required to be undertaken in-situ, with limited opportunities for third country companies to compete with EU ones from a base outside the EU. There are limited sectors where activities involving exposure to asbestos could be undertaken outside of the EU (potentially some under Exposure Group 4 "Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other".			
Consumers	Consumers	It is expected that enterprises working with asbestos will be able to pass on costs arising from having to comply with all of the stricter OELs (due to the essential nature of the work being carried out), although it cannot be ruled out that some clients may delay or abandon plans to remove asbestos. Customers of companies working with asbestos in each of the sectors (e.g. developers, public authorities, landowners, building owners, travel companies etc.) are therefore likely to face rises in prices at lower OELs. There is some risk of increase in unauthorised work.			
Internal market Level playing field: range of OELs in Member States (Lowest to Highest)	Companies	Lowest/ highest OEL from 0.001 to 0.001 fibres/cm³	Lowest/ highest OEL from 0.002 to 0.002 fibres/cm³	Lowest/ highest OEL from 0.002 to 0.01 fibres/cm³	Lowest/ highest OEL from 0.002 to 0.1 fibres/cm³
Specific Member States/regions – Member States that would have to change OELs	Public sector	All MS	All MS except the Netherlands	All MS except France and the Netherlands	Not applicable
Regulation	Companies	No impacts identified			
Direct benefits – improved well-being - health					
Reduced cases of ill health (lung cancer, mesothelioma, laryngeal cancer and ovarian cancer)	Workers & families	860	830	660	0
Ill health avoided, incl. intangible costs (M2 to M1)	Workers & families	€215 – 418 million	€208 – 405 million	€166 – 323 million	€0
Avoided costs	Companies	€2.1 million	€2.0 million	€1.7 million	€0
Avoided costs	Public sector	€4.5 million	€4.3 million	€3.4 million	€0

Impact	Stakeholders affected	OEL options (fibres/cm^3)			
		0.001 fi-bres/cm^3	0.002 fi-bres/cm^3	0.01 fi-bres/cm^3	0.1 fi-bres/cm^3 (baseline)
Social policy agenda	All	Contribution to Green Deal: Chemicals Strategy towards a toxic-free environment			
Direct benefits – improved well-being - environmental					
Environmental releases	All	No impact/limited impact			
Direct benefits – market efficiency					
Level playing field	Companies	A harmonisation of the OEL leads to a level playing field, as all companies across all Member States follow a more symmetric requirement. The level-playing field increases slightly with the stringency of OEL.			
Indirect benefits					
Administrative simplification	Companies	For large, and to lesser extent medium-sized companies with facilities in different Member States will experience administrative simplification, owing to a more harmonious set of compliance requirements. As most asbestos-related activities are performed by companies working in one Member State only, the benefits will be limited.			
Collateral health benefits for the broader population	Workers & families	The measures to prevent the generation and spread of dust in demolition works can also be positive for people living or working in the surroundings. Moreover, increased prevention of the spread of asbestos and cleanliness of premises could help decrease the risk of developing mesothelioma for family members of workers heavily exposed to asbestos.			
Synergy	Companies	Synergies in terms of exposure reduction for other chemical substances used in production sectors may occur. The specific substances will vary between the sectors. The level of synergy to be harnessed will also depend on the RMMs applied in each enterprise.			
Corporate Social Responsibility	Companies	Activities with risk of exposure to asbestos may be less perceived as a risky line of work associated with health issues. As a result of such an improvement in the public image, companies may find it easier to recruit and retain staff, reducing the cost of recruitment and increasing the productivity of workers.			
No cost of setting OEL (savings for Member State for developing lower na-tional OELs)	Public sector	Benefit (some MS might consider introducing a lower OEL)			No benefit

Notes: All costs/benefits are incremental to the baseline (PV over 40 years)

Internal market shows the ratio of highest OEL to lowest OEL before and after implementing the OEL option.

Source: study team's calculation

Due to the large number of uncertainties surrounding the estimates, the final conclusion should go beyond a simple comparison of the costs and the benefits that have been monetised in this study.

Other issues to be considered in the decision-making process include:

- Although the costs are estimated to significantly outweigh the benefits for all of the policy options considered, it should be noted that the actual exposure concentrations when RPE has been taken into account are uncertain. This is because the available data mainly concern the workplace concentrations, and the use of RPE had to be modelled as part of this study. It is therefore possible that the cost savings from reduced ill health modelled in this study are underestimates and the cost-benefit ratio is thus overestimated.
- It should be noted that the total workforce exposed to asbestos is expected to increase over the coming decade.
- Companies in three Member States (France, Germany[2] and the Netherlands who collectively account for 37% of the EU-27 population) work to a limit that is lower than the current OEL in the AWD.
- A key uncertainty relates to the implications for workers with passive exposure in buildings (Exposure Group 3) at the option of 0.001 fibres/cm^3. The costs and benefits for this group are highly uncertain and the costs for this group could significantly increase the total costs estimated in this study at this option, because employees may need to take action to reduce passive exposure in buildings.
- It is expected that a large proportion of enterprises in Exposure Group 2 (exposure situation subject to Article 3 (3) waiver and incidental exposure) will opt to no longer accept asbestos related contracts and specialised asbestos removal companies in Exposure Group 1 will see their business increase. These income losses or gains can thus be seen as transfer costs with a low net impact overall, although some impacts may occur due to companies in Exposure Group 1 benefiting from greater economies of scale.
- When the costs of specialised asbestos removal companies in the construction sector increase, they are likely to pass them on to their clients without suffering any losses themselves (this is due to the relatively inelastic demand for asbestos removal). Whilst this may not always be the case where asbestos is contained in movable objects such as trains and ships, it is also unlikely that train refurbishment activities will shift outside the EU because of a lower OEL. It cannot, however, be ruled out that significant price increases would result in clients delaying or abandoning plans to remove asbestos thus resulting in a reduction in asbestos removal revenues and delays in removing passive exposure to asbestos.
- In the current directive, the likelihood of not exceeding the OEL is a key criterion for the waiver in Article 3(3) to apply. The waiver in Article 3(3) has the potential to reduce the costs of notification estimated in this study.
- Major concern has been raised about the applicability of the existing EM methods for compliance monitoring at the two lowest OEL options in settings with high dust levels and small asbestos fibre to dust ratios, e.g. by working with building materials with low asbestos concentrations or by exposure to naturally occurring asbestos.
- Monitoring compliance with the current OEL is complex and the requirements for monitoring will depend on the initial risk assessments undertaken. If the OEL is

[2] The current binding OEL in Germany is 0.1 fibres/cm^3 while the 'acceptance level' is 0.01 fibres/cm^3. The mandatory guidelines require measures that are considered in practice to bring the exposure concentration below the 'acceptance level'.

lowered, more often it will be uncertain if the exposure concentration is below the OEL, and more measurements will be needed to confirm the results of the risk assessment or to adjust the working procedures. However, the estimated increase in monitoring costs is highly uncertain.

1. Introduction

Asbestos has long been recognised as a key occupational carcinogen. Airborne fibres are very resistant when inhaled and can lead to asbestosis, mesothelioma, cancers of the lung, larynx, and ovary and other non-malignant lung and pleural disorders, including pleural plaques, pleural thickening, and benign pleural effusions. The management of asbestos in buildings and its safe removal is currently an important topic not only under EU action on prevention and protection of workers but also due to the need for Europe to improve the thermal insulation of its built environment and enable energy savings. This is in line with the ambition of the EU set in the European Green Deal to become the first climate-neutral continent by 2050 and requires full consideration of health and safety at work aspects.

The existing binding occupational exposure limit value (OEL) for asbestos is 0.1 fibres/cm^3 as an 8-hour time-weighted average (TWA) and should be reviewed to take account of the latest scientific and technical developments, and if appropriate, revised.

1.1 Relevant Legislation

The pieces of legislation of specific relevance for asbestos in the workplace are the Classification, Labelling and Packaging Regulation (CLP)[3], REACH[4], the Asbestos at Work Directive (AWD)[5] and The Carcinogens and Mutagens Directive (CMD)[6].

Beside this, work with asbestos is also within the scope of the general requirements of OSH Framework Directive[7] (89/391/EEC) and, as asbestos is classified according to CLP, also within the scope of the Chemical Agents Directive (CAD)[8]. The more general provisions of these two pieces of legislation will not be further outlined in the current report.

1.1.1 Classification, Labelling and Packaging regulation

Asbestos fibres are subject to a harmonised classification according to the Classification, Labelling and Packaging (CLP) Regulation (Index number 650-013-00):

Carc. 1A; H350: May cause cancer

STOT RE 1; H372: Causes damage to organs through prolonged or repeated exposure

1.1.2 REACH

The use of asbestos is banned in the EU according to Entry 6 in Annex XVII (Restrictions) to the REACH Regulation EC/1907/2006, stating that the manufacture and use of asbestos fibres as such as well as in mixtures and articles (where asbestos fibres are added intentionally) are prohibited in the EU. The entry concerns the six substances within the scope of the current study. The entry defines asbestos fibres as:

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[3] Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006

[4] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

[5] Directive 2009/148/EC of the European Parliament and of the Council of 30 November 2009 on the protection of workers from the risks related to exposure to asbestos at work

[6] Directive 2004/37/EC of the European Parliament and of the Council of 29 April 2004 on the protection of workers from the risks related to exposure to carcinogens or mutagens at work

[7] Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work

[8] Council Directive 98/24/EC of 7 April 1998 on the protection of the health and safety of workers from the risks related to chemical agents at work

(a) Crocidolite CAS No 12001-28-4

(b) Amosite CAS No 12172-73-5

(c) Anthophyllite CAS No 77536-67-5

(d) Actinolite CAS No 77536-66-4

(e) Tremolite CAS No 77536-68-6

(f) Chrysotile CAS No 12001-29-5 and CAS No 132207-32-0

The following conditions apply to the restriction:

> *"1. The manufacture, placing on the market and use of these fibres and of articles and mixtures containing these fibres added intentionally is prohibited.*
>
> *However, if the use of diaphragms containing chrysotile for electrolysis installations in use on 13 July 2016 had been exempted by a Member State in accordance with the version of this paragraph in force until that date, the first subparagraph shall not apply until 1 July 2025 to the use in those installations of such diaphragms or of chrysotile used exclusively in the maintenance of such diaphragms, provided that such use is carried out in compliance with the conditions of a permit set in accordance with Directive 2010/75/EU of the European Parliament and of the Council (*).*
>
> *Any downstream user benefiting from such an exemption shall send, by 31 January of each calendar year to the Member State in which the relevant electrolysis installation is located, a report indicating the amount of chrysotile used in diaphragms pursuant to the exemption. The Member State shall transmit a copy to the European Commission.*
>
> *Where, in order to protect the health and safety of workers, a Member State requires monitoring of chrysotile in air by downstream users, the results shall be included in that report.*
> *(*) Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (OJ L 334, 17.12.2010, p. 17).*
>
> *2. The use of articles containing asbestos fibres referred to in paragraph 1 which were already installed and/or in service before 1 January 2005 shall continue to be permitted until they are disposed of or reach the end of their service life.*
>
> *However, Member States may, for reasons of protection of human health, restrict, prohibit or make subject to specific conditions, the use of such articles before they are disposed of or reach the end of their service life. Member States may allow placing on the market of articles in their entirety containing asbestos fibres referred to in paragraph 1 which were already installed and/or in service before 1 January 2005, under specific conditions ensuring a high level of protection of human health. Member States shall communicate these national measures to the Commission by 1 June 2011. The Commission shall make this information publicly available.*
>
> *3. Without prejudice to the application of other Community provisions on the classification, packaging and labelling of substances and mixtures, the placing on the market and use of articles containing these fibres, as permitted according to the preceding derogations, shall be permitted only if suppliers ensure before the placing on the market that articles bear a label in accordance with Appendix 7 to this Annex".*

As can be seen, a few exceptions to this general ban apply. This is further addressed and detailed in Section 4.1.1.

1.1.3 Restriction history

The history of the restriction of asbestos at the EU level is of importance for the understanding of how the stock of asbestos-containing products in the society and the exposure from handling and removal of the asbestos from buildings and articles may evolve in the future.

Before entry into force of the REACH Regulation, some applications were restricted under Council Directive 76/769/EEC on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations of 27 July 1976 as follows (ECHA, 2021):

- Council Directive 83/478/EEC specified that the crocidolite asbestos fibre and products containing it may, with three possible exceptions (granted by the Member States), no longer be placed on the market and used;
- Council Directive 85/610/EEC specified that (any type of) asbestos fibres can no longer be placed on the market and used in toys, materials and preparations applied by spraying, retail products in powder form, smoking accessories, catalytic heaters, paints and varnishes.
- Commission Directive 91/659/EEC specified that all of the amphibole type of asbestos fibres and products containing them may no longer be placed on the market and used and that the chrysotile type of asbestos fibre and products containing it may no longer be placed on the market and used for fourteen categories of products (including those already specified by Directive 85/610/EEC).
- Commission Directive 1999/77/EC specified that the placing on the market and use of chrysotile asbestos and of products containing this fibre added intentionally shall be prohibited, except for one specific use (use of diaphragms containing chrysotile fibres for existing electrolysis installations) for which Member States could exempt the placing on the market until they reach the end of their service life, or until suitable asbestos-free substitutes become available, whichever is the sooner.

Please note that the entry into force of the directives after transposition into national law was several years after the directives were issued. For example, Commission Directive 1999/77/EC was adopted in 1999 but required that Member States bring into force the laws, regulations and administrative provisions necessary to comply with the Directive by 1st January 2005.

1.1.4 Asbestos at Work Directive

Legislation in EU against the risk from asbestos exposure exists since 1983. Council Directive 83/477/EEC of 19 September 1983 on the protection of workers from the risks related to exposure to asbestos at work laid down provisions to protect workers against asbestos and Member States should adopt the laws, regulations and administrative provisions necessary to comply with the Directive before 1 January 1987. The OELs established were 1 fibres/cm^3 for asbestos fibres other than crocidolite and 0.5 fibres/cm^3 for crocidolite.

EU regulates today the protection of workers from asbestos via the Asbestos at Work Directive (AWD) 2009/147/EC. The directive aims to protect workers against risks to their health arising from exposure to asbestos at work. The current OEL of 0.1 fibres/cm^3 was introduced in 2003 by Directive 2003/18/EC.

The AWD lays down an exposure limit, associated requirements for taking air measurements, defines prohibited activities, and sets out measures for reducing exposure in the workplace. It also sets out specific administrative requirements such as notification, creation of work plans and a register for workers involved in activities that could result in exposure to asbestos. Training is also to be given to workers likely to be exposed, medical surveillance is to be carried out, and Member States are required to register cases of asbestosis and mesothelioma.

The current limit value for asbestos exposure at work is **0.1 fibres per cm³** (equalling 100 fibres/L and 100,000 fibres per m³). For the purpose of measuring asbestos in the air only fibres with a length of more than 5 µm, a breadth of less than 3 µm and a length/breadth ratio greater than 3:1 shall be taken into consideration. As the prescribed analytical method (phase-contrast microscopy, PCM) can only determine fibres down to a breadth of 0.2 µm, in practice the AWD addresses fibres of a breadth (diameter of the fibre) in the range of 0.2 - 3.0 µm. Thinner fibres can be determined with electron microscopy methods (TEM and SEM), and a change in the definition of analytical method to be applied would in practice change the breadth range of fibres within the scope of the AWD unless a breadth range is defined.

No worker is to be exposed to an airborne concentration of asbestos above this limit. However, in cases where it is not possible to keep below this limit, the Directive sets out measures that the employer is to take, such as stopping the relevant activities and implementing further measures, or providing workers with personal protective equipment (PPE) and ensuring that asbestos dust does not spread outside the premises.

Concerning measurements and sampling of asbestos in the air, the key requirements can be summarised as follows:

- measurements are to be carried out ‘regularly’;
- sampling is to be representative of the personal exposure of the worker;
- sampling is to be carried out after consultation with workers and/or their representatives;
- sampling must be carried out by ‘suitably qualified personnel’;
- duration of sampling must be such that representative exposure can be established for an 8-hour reference period by means of measurements or time-weighted calculations; and
- wherever possible fibre counting shall be carried out using phase-contrast microscopy (PCM) in accordance with World Health Organisation (WHO) method or equivalent.

The Directive also sets out the key measures that can be taken to reduce exposure to asbestos; these can be summarised as follows:

- reducing numbers exposed or likely to be exposed to lowest possible number;
- processes designed so that they do not produce dust or where this is not possible at least avoid the release of asbestos dust into the air;
- premises and equipment must be capable of being regularly and effectively cleaned and maintained; and
- asbestos must be stored and transported in sealed packaging; and waste containing asbestos must be placed in sealed packaging, labelled and removed as soon as possible.

1.1.4.1 Asbestos as natural constituent of other minerals

As mentioned in the previous section, the REACH restriction on asbestos concerns asbestos fibres as such and articles where asbestos fibres are <u>intentionally</u> added. The restriction does not specifically address asbestos as a natural constituent of other minerals. This means that placing on the market of minerals with a content of asbestos is still allowed.

The AWD addresses any activity likely to involve a risk of exposure to dust arising from asbestos or materials containing asbestos. Materials containing asbestos is not restricted to materials where asbestos fibres are intentionally added and would consequently also include exposure to naturally occurring asbestos in other minerals.

1.1.5 Carcinogen and Mutagen Directive

The Carcinogen and Mutagen Directive (CMD) contains provisions for substances classified as carcinogenic or mutagenic Cat. 1A or 1B. As asbestos fibres are classified as Carcinogenic Cat. 1A, they are within scope this directive. However, the CMD acknowledges that the AWD provides many of the same provisions and therefore under its objective (in Article 1(4)) states the following: '*As regards asbestos, which is dealt with by Directive 2009/148/EC of the European Parliament and of the Council, the provisions of this Directive shall apply whenever they are more favourable to health and safety at work.*'

1.1.6 Other legislation

The Pregnant and Breastfeeding Workers Directive (Council Directive 92/85/EEC) provides provisions to protect pregnant workers, and workers who have recently given birth or are breastfeeding. As asbestos is classified carcinogenic, for all activities liable to involve a risk of exposure to asbestos, the employer shall assess the nature, degree and duration of exposure, in the undertaking and/or establishment in order to assess any risks to the safety or health and any possible effect on the pregnancy or breastfeeding of workers and decide what measures should be taken. The relevant workers shall be informed of the results of the assessment and of all measures to be taken concerning health and safety at work. As defined by the AWD, an assessment has to be undertaken in any case and in practice the assessment required by the Pregnant and Breastfeeding Workers Directive will be an integrated part of the overall assessment. The requirements of the Pregnant and Breastfeeding Workers Directive likely influence to what extent workers within the scope of the directive are involved in work with asbestos, but no specific data on the groups of workers has been obtained. These requirements are not considered to have any influence on the current assessment.

The Young Persons at Work Directive (Council Directive 94/33/EC) specifies that young people aged below 18 should not work with asbestos. These requirements are not considered to have any influence on the current assessment.

1.2 The study

This report is one of four reports elaborated within the framework of a study undertaken for the European Commission by a consortium comprising RPA Risk & Policy Analysts (United Kingdom), COWI A/S (Denmark), FoBiG Forschungs- und Beratungsinstitut Gefahrstoffe (Germany), and EPRD Office for Economic Policy and Regional Development (Poland).

The four reports are:

- Methodological note incl. summary of stakeholder consultation (lead editor: RPA);
- Report for Asbestos (this report, lead editor: COWI (baseline), RPA (impact assessment));
- Report for lead and its compounds (lead editor: COWI); and
- Report for di-isocyanates (lead editor: RPA).

The key aim of the study is to provide the Commission with the most recent, updated and robust information on a number of chemical agents with the view to support the European Commission in the preparation of an Impact Assessment report to accompany a potential proposal to amend Directive 98/24/EC (Chemical Agents) and Directive 2009/148/EC (Asbestos).

The objective of this specific report is to assess the impacts of lowering the current OEL for asbestos.

The methodology used for study and a summary of the stakeholder consultation are described in detail in the separate methodological note.

As regards the use of references, references to specific sources of information/data are provided throughout the report. If no specific sources of information are provided for tables or figures, this means that the results were derived by the study team on the basis of the different models and other information collected for the study.

1.3 Study scope

Under the Asbestos Worker Directive (AWD), asbestos is defined as one of the six following fibrous silicates and chemicals abstracts service (CAS) numbers:

asbestos actinolite, CAS No 77536-66-4;

asbestos grunerite (amosite), CAS No 12172-73-5;

asbestos anthophyllite, CAS No 77536-67-5;

chrysotile, CAS No 12001-29-5;

crocidolite, CAS No 12001-28-4; and

asbestos tremolite, CAS No 77536-68-6.

The REACH Annex XVII restriction (Entry 6) concerns the same substances but lists an additional CAS-no for chrysotile 132207-32-0, see section 1.1.2.

As current exposures are almost entirely related to past use of asbestos in building, installations and other articles, it is unlikely that CAS numbers will be generally specified in information sources related the current work and exposure to asbestos. This is also linked to the fact that the traditionally used method for analytically detecting asbestos – Phase contrast microscopy (PCM) – cannot distinguish between asbestos types. The literature review carried out for this study thus relied on information on 'asbestos' and was not limited to certain CAS numbers or fibre names. Wherever fibre type or CAS-No is specified, this is recorded.

1.4 Structure of the report

The report is organised as follows:

- Chapter 1 is this introduction;
- Chapter 2 sets out the problems and objectives;
- Chapter 3 sets out the options;
- Chapter 4 sets out the baseline;
- Chapter 5 sets out the benefits of the relevant measures;
- Chapter 6 sets out the costs of the relevant measures;
- Chapter 7 summarises the market effects;
- Chapter 8 describes the distribution of any impacts;

- Chapter 9 describes the environmental impacts;
- Chapter 10 provides an overview of the limitations and the sensitivity analysis; and
- Chapter 11 provides the comparing of options and conclusions.

This report is complemented with five appendixes (A – E).

2. Problems, objectives and options

2.1 Need for action as assessed by RAC

The opinion of the Risk Assessment Committee (RAC) has been available since 13 July 2021 (RAC, 2021).

RAC concludes that asbestos is a non-threshold carcinogen and consequently, no health-based OEL can be identified and no OEL has been suggested by RAC. Instead, an exposure-risk relationship (ERR) is derived, expressing the excess risk for lung cancer and mesothelioma mortality (combined) as a function of the fibre concentration in the air. The aim is to facilitate the setting of an OEL by the relevant EU bodies, taking an acceptable level of excess risk into account. The ERR established and used in the current report is further described in section 2.3.

Selected key conclusions of the opinion, of particular importance for the interpretation of results provided in the current report, are listed below (citation from RAC, 2021):

- Robust quantitative exposure-response relations are observed for lung cancer and mesothelioma in workers studied in epidemiological cohort studies and some case-control studies. In all these studies exposure to asbestos fibres has been monitored and related to disease experience.
- For other cancer sites no (precise) exposure-response relations have been described by cumulative or other quantitative exposure metric
- The current occupational exposure to asbestos in Europe is generally mixed exposure to different types of asbestos and it is not possible to estimate the current relative contributions of chrysotile and amphiboles to the exposure. Neither is the proportion of chrysotile in the available epidemiological cohorts with mixed exposure known.
- There are some indications that fibre dimensions may influence the risk of mesothelioma and lung cancer, with potency increasing with increasing length and decreasing width. However, based on human and animal data, it is not possible to exclude an asbestos associated risk of cancer for any fibre width or length category studied. These observations are nearly exclusively based on optical microscopy and thus concern fibres with dimensions detectable with that method.
- Asbestos and some other mineral fibres are still the only established causal factor identified for mesothelioma. The majority of mesothelioma cases (>90%) can be explained by occupational or environmental asbestos exposure. Smoking is not a risk factor for mesothelioma.
- Meta-regression analysis for lung cancer, considering all available quantitative exposure response studies, indicates that the exposure-response relation is not linear. The actual risk at levels around and below the current EU OEL may be higher than the risk that would be calculated with linear extrapolation from the historical industrial cohorts with much higher exposures.
- Pulmonary fibrosis (asbestosis) and pleural plagues are also well-known asbestos related disease entities. Asbestosis occurs only at higher exposure levels than current OELs and although pleural plaques may occur already at lower exposure levels their clinical relevance is unclear.
- Considering that also thinner fibres (<0.2 µm) are carcinogenic, RAC is of the opinion that these fibres should be considered when measuring exposure in the workplace. However, harmonisation work is required at EU level, covering the

dimensional fibre definitions, counting rules and other factors that influence the EM asbestos fibre counts.

- No conversion factors applicable to all situations to convert PCM derived risk estimates to EM based risk estimates can at present be given.
- No notation for 'Skin', 'Skin sensitisation' or 'Respiratory sensitisation' is warranted. Asbestos fibres are not absorbed via the dermal route and there is no reported evidence of asbestos being a skin sensitiser or respiratory sensitiser.

2.2 Summary of epidemiological and experimental data

2.2.1 Identity and classification

Asbestos fibres are naturally occurring silicate minerals made of long fibrous crystals.

The identity and classification of various forms of asbestos is given in the following table. Asbestos in general (including all these forms) is classified as human carcinogen (Carc. 1A).

Table 2.1 Asbestos fibres – identity and classification

Substance (fibre type)	EC-Number	CAS-Number	Classification
Asbestos	-	132207-32-0	Carc. 1A - H350 STOT RE 1 - H372
Actinolite	616-471-6	77536-66-4	
Amosite (grunerite)	601-801-3	12172-73-5	
Anthophyllite	616-472-1	77536-67-5	
Chrysotile	601-650-3	12001-29-5	
Crocidolite	601-649-8	12001-28-4	
Tremolite	616-473-7	77536-68-6	

Source: ECHA C&L Inventory 2021

Asbestos fibres are also grouped as

- serpentine asbestos (or white asbestos) (with the only representative being chrysotile) and
- amphibole asbestos, which includes crocidolite (or blue asbestos), and amosite (or brown asbestos) (HCN, 2010, IARC, 2012)

According to chrysotile asbestos is the form used in most asbestos applications (> 90%). Among the amphibole asbestos types, amosite and crocidolite are most widely used.

For the purposes of measuring asbestos in the air, the Asbestos at Work Directive (EU, 2009) defines relevant asbestos fibres as "fibres with a length of more than 5 micrometres, a breadth of less than 3 micrometres and a length/ breadth ratio greater than 3:1", in line with the definition used by the World Health Organisation . The Directive sets an OEL (8-hour time-weighted average) of 0.1 fibres/cm^3. The Directive lays down that fibres should be counted "*wherever possible by phase-contrast microscope (PCM) in accordance with the method recommended in 1997 by the World Health Organization (WHO) or any other method giving equivalent results"* (WHO, 1997).

The more recent quantification methods using transmission electron microscopes (TEM) are able to identify more fibres, especially smaller and narrower ones, with these fibres still falling under the definition above. HCN (2010) uses a factor of two to recalculate PCM fibre counts to TEM counts (one PCM fibre = two TEM fibres). As discussed in section 4.9, in addition to the differences in counts due to the ability of the different methods to identify thin fibres, available data indicate other major differences in the results obtained by use of PCM and TEM, respectively.

2.2.2 General toxicity profile, critical endpoints and mode of action

2.2.2.1 Toxicokinetics

Inhalation is the most relevant exposure pathway for asbestos fibres at the workplace. There is no human data indicating dermal absorption. Percutaneous absorption of asbestos fibres is considered unlikely. Depending on their density, size and geometry, inhaled asbestos fibres are deposited in various parts of the respiratory tract. Smaller fibres can reach the alveoli. Fibres deposited in the tracheobronchial regions are cleared by mucociliary transport. Then swallowed fibres are passing through the gastrointestinal tract. This clearance pathway is also relevant for fibres which are small enough (<14-21 µm of length) to be phagocytosed by macrophages and which were deposited in the deeper parts of the respiratory tract (distal airways, alveoli). Fibres not cleared fast enough can interact with lung cells, enter the interstitium, translocate to the pleura or peritoneum or other parts of the body. Clearance half-times of months to several years are reported, depending on fibre types, geometry and other factors. Asbestos fibres discussed here are not readily eliminated by physical alteration (breakage, splitting) or chemical modification and are therefore considered biopersistent (HCN, 2010, IARC, 2012, ECHA, 2021).

2.2.2.2 Target organs

Asbestos fibres are carcinogenic. Two tumour locations are predominant: lung cancer and mesothelioma (tumours of the pleura and the peritoneum, i.e., the membrane linings of the lung and abdominal cavities). However, there is evidence for carcinogenic activities in other organs as well (see section 2.2.3) (IARC, 2012).

Further, asbestosis, a form of pulmonary fibrosis, is a well-known disease condition, which occurs at higher exposure levels after prolonged occupational exposure (see section 2.2.4).

2.2.2.3 Mode of action

Multiple genetic and molecular alterations such as the promotion of cell growth, mutations and genetic instability (amplification of oncogenes), and the inactivation of tumour–suppressor genes are assumed to be involved in the tumour induction by asbestos fibres. In animal experiments, genotoxicity in vivo was observed. However, the mode of action is still not well established. Various mechanisms are under discussion: induction of reactive oxygen species, causing genotoxicity, interference with mitosis, causing chromosomal alterations, inflammation subsequent to macrophage activation. Cell proliferation and genetic and epigenetic alterations are following steps leading to tumour formation. The inflammatory processes are also responsible for the fibrotic changes in the lung and the onset of asbestosis (IARC, 2012). There is a general agreement that asbestos fibres should be treated as a non-threshold carcinogen (ECHA, 2021).

Long latency periods of at least ten years (but up to 20 – 40 years) are required for respiratory tract tumours and mesothelioma to develop (IARC, 2012, ECHA, 2021).

Tobacco smoking is an important co-factor. Co-exposure of asbestos and tobacco smoke is believed to have a multiplicative effect on lung cancer induction (IARC, 2012; Klebe et al., 2019).

2.2.3 Cancer – toxicological and epidemiological key studies (existing assessments)

2.2.3.1 Epidemiological evidence

In agreement with the EU harmonised classification, IARC concluded on sufficient evidence for the carcinogenic activity in humans for all types of asbestos fibres listed in Table 2.1. These conclusions are based on an ample epidemiological database coming from numerous cohort and case-control studies in the USA, Canada and Europe. The most relevant data are from cohorts of workers engaged in the mining and industrial use of asbestos (e.g., for production of cement, insulation materials, textiles). The database is described in detail by IARC (2012). Several meta-analyses (e.g. Hodgson and Darnton (2000) and Berman and Crump (2008)) have been published which investigate the risks for the different cancer and fibre types by integrating data from larger sets of studies. Berman and Crump (2008) plays an important role as it provides potency values (regression coefficients) for a large number of cohort studies which are used in several assessments of regulatory bodies.

Two cohorts which have been extensively studied and are the basis of the US EPA asbestos risk assessment are the workers from the South Carolina and North Carolina asbestos textile plants. These cohorts comprise about 3,500 and 5,700 workers which have been exposed to nearly exclusively chrysotile fibres for at least one month between 1940 and 1965 (South Carolina) or for at least one day between 1950 and 1973. Important publications presenting insights on mortality due to lung cancer and mesothelioma among these cohorts are e.g. Loomis et al. (2009), Hein et al. (2007) and Elliot et al. (2012), but numerous other analyses have been published using different stratifications and sub cohorts (ECHA, 2021).

HCN (2010) performed their own meta-analysis using study selection criteria resulting in a study database considerably different than the studies used in the assessment by US EPA. The selection was performed by three epidemiologists who first rated the quality of each available study regarding parameters as documentation of exposure monitoring, handling of missing data, conversion of results obtained with different measurement methods, completeness of the job and exposure history of the cohort. Subsequently, the panel narrowed down the number of remaining studies by sequentially increasing the required quality of the mentioned parameters until a smaller number of high-quality studies remained.

For lung cancer, HCN (2010) identified 21 available cohort studies of which four remained at the latest stage of the quality assessment covering cohorts from South Carolina (US), Libby (Montana, US), Rochdale (UK) and Stockholm (Sweden). For mesothelioma, the selection started with fourteen studies and after applying the same criteria as for the lung cancer assessment only two studies remained, which both cover workers primarily exposed to chrysotile fibres (cohorts from South Carolina, US and Rochdale, UK). In order to include exposure to amphibole fibres in the meta-analysis, the two identified studies analysing cohorts with exposure to this fibre type were included. The process used in HCN (2010) to derive the ERR from the meta-analysis is described in Section 2.3.2.1.

The assessment by ECHA (ECHA, 2021) builds on largely the same study database as HCN (2010) but adds studies which have since become available. For lung cancer, this is a French cohort with mixed exposure and two Chinese cohorts exposed to chrysotile fibres. For mesothelioma, Loomis et al. (2019) is added to the database which describes the North Carolina (US) cohort with exposure to chrysotiles. Additionally, studies which were superseded by more recent analyses of the same cohort were replaced by the newer data. Although the study database is therefore very similar to HCN (2010), the studies ultimately used still differ considerably as ECHA did not apply further criteria to narrow down the studies by quality. In total, 22 studies were used to model the risk for lung cancer and 13 different cohorts are used for the mesothelioma risk calculation. More details of this calculations, which are the basis for the ERR recommended in this report, are described in Section 2.3.2.1.

2.2.3.2 Tumour localisations other than lung tumours and mesothelioma

As outlined above, tumours of the **lung** and **mesothelioma** are the most prominent tumour types found in epidemiological studies. Furthermore, IARC sees sufficient evidence for tumours in the **larynx** and **ovary**. Positive associations, although with a weaker database and somewhat contradicting evidence, are seen for **pharynx**, **stomach**, and **colorectum** (IARC, 2012).

For the latter, the suggestive evidence was supported by two new meta-analyses. An evaluation of 46 cohort studies concluded on a standard mortality ratio (SMR) for colorectal cancer of 1.43 (95% CI: 1.30 to 1.56) (Kwak et al., 2019).

Huang and Lan (2020) analysed 47 mortality and incidence cohort studies and obtained a small, but significantly increased SMR of 1.07 (95% CI 1.02–1.12). In both meta-analyses, the small increase in mortality due to colorectal cancer was seen in parallel to increased lung cancer mortality.

For **oesophageal** cancer, the IARC evaluation did not find convincing or at least suggestive evidence for an association with asbestos exposure. This conclusion was confirmed by a recent comprehensive evaluation of the experimental, epidemiological and mechanistic evidence by Peterson et al. (2019).

Two recent studies raised a concern regarding an association between **prostate** cancer and asbestos exposure. In a population-based case-control study Parent and Richard (2019) found a small increase of risk with prolonged and high cumulative exposure to chrysotile. In a systematic review and meta-analysis of 33 studies (with exposure to various asbestos fibre types) Dutheil et al. (2020) also found a small but significantly increased risk (1.1, 95% CI: 1.05-1.14).

Committees evaluating asbestos cancer risks and deriving exposure-risk relationships generally agree that available dose-response data do not allow to derive separate ERRs for endpoints other than lung cancer and mesothelioma but consider the potential underestimation of risks small (HCN, 2010, US EPA, 2020, ECHA, 2021).

US EPA 2020, in an attempt to consider this uncertainty semi-quantitatively, introduced a correction or adjustment factor for their lung cancer ERR. Using data from studies of chrysotile asbestos workers they defined this factor as

Adjustment factor = (excess lung cancer + excess other cancer)/(excess lung cancer)

and derived a factor of 1.02 to correct for observed laryngeal cancer cases and a factor of 1.04 for ovarian cancer cases (the two locations for which IARC (2012) concluded on clear evidence). Lung cancer risks were multiplied by this factor, resulting in a 6% overall higher excess cancer risk. Such an increase is well within the overall uncertainties of ERRs, which can be seen as a justification for basing ERRs on lung tumours and mesothelioma only. However, the underestimation of risks due to omission of other tumour locations certainly justifies a generally conservative approach to risk assessment for asbestos.

2.2.3.3 Experimental animal evidence

Numerous experimental studies on carcinogenic effects of asbestos fibres, mainly with rats, are available. The main administration route was inhalation, however, studies were also performed with intratracheal, intrapleural and intraperitoneal administration. Some studies exist which examined tumour induction after oral or intragastric exposure of animals. An overview on available studies is given in IARC (2012).

In studies with administration to the respiratory tract bronchial carcinoma and pleural mesothelioma were the predominant tumours observed with various types of fibres, with few tumours at other locations. In contrast, after intrapleural or intraperitoneal application, mostly mesothelioma occurred.

In a series of lifetime studies of the US National Toxicology Program with different fibre types in the diet of rats (plus gavage administration to pups) did not reveal any increases of tumour numbers in the gastrointestinal tract (IARC, 2012).

In summary, experimental animal studies confirmed the carcinogenicity of asbestos fibres in the lung and the mesothelium. In light of the extensive human database, these studies were useful for investigating differences between fibre types and mechanistic studies but are not used for characterisation of risks for humans.

2.2.4 Non-cancer endpoints – toxicological and epidemiological key studies (existing assessments)

Asbestosis, fibrotic changes of the lung as a consequence of prolonged exposure to high asbestos fibres, is characterised by symptoms such as dyspnoea (shortness of breath) rales, coughs and reduced lung function, which, in severe cases might be lethal (ECHA, 2021). It occurs at concentrations of more than ten fibres/cm^3 x years, according to HCN (2010) and ECHA (2021). For life-long (40 years) occupational exposure, this would equal to an average concentration of 0.25 fibres/cm^3.

ATSDR (2001) reported NOAELs (No-Observed-Adverse-Effect Level) for fibrotic changes in various occupational cohorts in the range of 2.6 – 4 fibre x years/cm^3, equalling to 0.065 – 0.1 fibres/cm^3 under the assumption of 40 exposure years. The concentrations are for PCM-based fibre counts.

The Asbestos at Work Directive determines an OEL (8-hour time-weighted average) of 0.1 fibres/cm^3, measured by PCM. It is assumed that this limit is being complied with and it can be concluded that asbestosis only occurs at exposure levels above the range under discussion in this study. Although new cases of asbestosis may still be identified, it is believed that these are caused by higher concentrations in the past. Therefore, asbestosis is not expected to occur as an asbestos-induced health effect at the exposure levels associated with the various scenarios in this study, which aims at assessing the impact of reducing future asbestos exposure. As no health effects are expected in the exposure ranges considered, deriving a DRR for this non-carcinogenic effect of asbestos is not necessary.

2.2.5 Biological monitoring – toxicological and epidemiological key studies (existing assessments)

Asbestos fibres can be detected in sputum or bronchoalveolar lavage fluid. But such methods are not used to regularly monitor exposure. No biological monitoring methods exist for asbestos fibres (ECHA, 2021).

2.2.6 Different toxicological properties for various asbestos fibre types

No consistent differences in potency between the various asbestos fibres with regard to lung cancer have been observed.

In contrast, with regard to mesothelioma, clearly higher carcinogenic potency is ascribed to amphiboles compared to chrysotile fibres (HCN, 2010, ECHA, 2021, US EPA, 2020). HCN (2010) developed separate ERRs for amphiboles and chrysotile fibres for mesothelioma risks (see Section 2.3.2).

2.3 Exposure Risk Relationship (carcinogenic effects) and a Dose Response Relationship (non-carcinogenic effects)

2.3.1 Starting point

As described above, a broad database from human epidemiological studies is available for asbestos. These epidemiological studies form the basis of all cancer risk quantification presented in the last 20 years by various authorities.

In the following, these cancer risk estimates are concisely presented and discussed.

2.3.2 ERR for carcinogenic effects (air concentration)

2.3.2.1 Approach

Lung cancer and mesothelioma are the cancer types with by far the highest association with asbestos exposure. Although asbestos likely causes tumours at other locations, the risk is expected to be considerably lower than for the two main cancer types, therefore all existing risk assessments focus on carcinogenicity in the lung and mesothelium (See section 2.2.3.2).

US Environmental Protection Agency

The recent assessment by US EPA (2020) derives exposure risk relationships for chrysotile fibres only. Chrysotile was identified as the only fibre commercially manufactured, processed or distributed nowadays and therefore, only for this asbestos type a quantitative risk assessment was performed.

Basis of the assessment is the mortality rate among workers from two asbestos textile plants in the US: The South Carolina and North Carolina cohort, which comprise about 3,000 and 5,700 followed up workers, respectively. Extensive exposure data are available for these cohorts which are derived from fibre count using PCM. Early measurements using old measurement techniques were converted to filter samples using established conversion factors.

US EPA identified three lung cancer models and one mesothelioma model for each of the two cohorts which satisfy the criteria to be eligible for derivation of cancer risks. For both cohorts, the three models were combined to a single risk estimate for either lung cancer or mesothelioma. There was about a three-fold difference between the lowest and highest risk estimates in the combinations. This is considered a low variation by US EPA and indicative for choosing the median of 0.16 per fibres/cm^3 for the final lifetime inhalation unit risk. The resulting lifetime inhalation unit risk is 0.16 [per fibres/cm^3]. This unit risk is applicable to continuous exposure over a whole life and is adapted by US EPA to a unit risk corresponding to 40 years of exposure, starting at age 16 (taking into consideration the latency period for mesothelioma), resulting in a value of 0.0612 per fibres/cm^3. Using the correction factors given by US EPA of 0.2192 for the workplace exposure scenario (240 working days/year, eight working hours per day) and a correction factor of 1.5 to adjust for differences in breathing rate per hour (10 m^3 per 8h instead of 20 m^3 per 24h = 1.5) a final **unit risk of 0.020 per fibres/cm^3** is obtained. This applies to chrysotile fibres and exposure measurements using phase contrast microscopy.

The Health Council of The Netherlands (HCN)

HCN (2010) expresses reservations against existing meta-analyses on asbestos carcinogenicity, primarily because of absence of a quality-guided study selection. As a consequence, two new meta-analyses investigating the risk for lung cancer and mesothelioma associated with asbestos exposure were performed. In the meta-analysis for lung cancer, four studies met all of the criteria of the committee. The slope factor (gradient) of the exposure-response relationship for each of these studies was reassessed and recalculated whenever deemed necessary. Exposure data was converted to be comparable between all studies. The cohorts of these studies were exposed to different types of fibres (chrysotile, amosite and mixed fibres). The weighted (giving studies with a smaller standard error a higher weight) K_M value (corresponding to the unit risk in a linear model) obtained was 0.0164 per fibres/cm^3 and year (continuous lifetime exposure).

The exposure refers to fibres measured by TEM, if necessary, measurements by PCM were converted using a factor of two (two fibres by TEM corresponding to one fibre by PCM due to the ability of TEM to measure thin asbestos fibres). After adjusting to the workplace scenario (eight hours per day, five days per week, 40 years, no information whether a different breathing rate was considered) HCN (2010) presents a risk estimate of $4x10^{-3}$ at a concentration of 0.22 fibres/cm^3 (with a linear correlation between fibre concentration risk, all fibre types). A latency period of ten years for lung cancer is assumed by the committee. HCN (2010) recognises that smoking has an additive to multiplicative impact on lung cancer risk, but that an adjustment of the risk is not possible.

The risk for **mesothelioma** was estimated using a similar methodology than for the lung cancer assessment. In contrast to lung cancer, the type of asbestos fibres has a significant impact on the risk to develop mesothelioma, therefore the risk was assessed separately by fibre type. Furthermore, the slope of the exposure risk relationships of the individual studies was not recalculated by the committee but taken from a recent assessment (Berman and Crump, 2008).

Using the same study selection criteria as for lung cancer, only one study each for chrysotile fibres and for mixed fibres and no study for amphibole fibres remained eligible. As HCN (2010) considered exposure to amphibole fibres relevant, a risk was derived using studies meeting less stringent selection criteria. The determined K_M values of the exposure risk relationships for chrysotiles, amphiboles and a mixture of the two are $1.50x10^{-7}$, $7.95x10^{-8}$ and $1.30x10^{-8}$ per fibres/cm^3, respectively.

In order to calculate the risk from workplace exposure, it needs to be considered that the risk for mesothelioma increases exponentially with the time since first exposure. According to HCN (2010) the US EPA model for mesothelioma is appropriate, which in addition to K_M uses the time since begin of exposure, the exposure duration and the latency period as parameters. A latency period of ten years for mesothelioma was assumed in the US EPA model, which according to HCN corresponds to the “actual latency period” after exponentiation, is actually rather 30-40 years. Further, the calculation of workplace exposure uses life tables, accounting for mortality not related to mesothelioma. The risks to develop mesothelioma after exposure to the different types of asbestos fibres under workplace conditions (eight hours per day, five days per week, 40 years, no information whether a different breathing rate was considered) as calculated by HCN (2010) are given in Table 2.2.

Table 2.2 Exposure concentrations corresponding to the reference workplace risk levels for mesothelioma as given in HCN (2010)

Type of asbestos	Risk level	Exposure concentration, fibres/cm^3
Chrysotile	4×10^{-3}	2.8
	4×10^{-5}	0.028
Mixed	4×10^{-3}	0.32
	4×10^{-5}	0.0032
Amphibole	4×10^{-3}	0.068
	4×10^{-5}	0.00068

Source: HCN (2010)

HCN (2010) also presents **combined risk levels** to develop either of the two cancer types.

Table 2.3 Exposure concentrations corresponding to the reference workplace risk levels for either lung cancer or mesothelioma as given in HCN (2010)

Type of asbestos	Risk level	Exposure concentration, fibres/cm^3
Chrysotile	4×10^{-3}	0.2
	4×10^{-5}	0.002
Mixed	4×10^{-3}	0.13
	4×10^{-5}	0.0013
Amphibole	4×10^{-3}	0.042
	4×10^{-5}	0.00042

Source: HCN (2010)

Converting these risks to linear exposure risk relationships results in unit risks for workplace exposure of **0.02 per fibres/cm^3, 0.031 per fibres/cm^3 and 0.095 per fibres/cm^3 for exposure to chrysotile fibres, mixed fibres and amphibole fibres**, respectively. The exposure concentration refers to measurements by TEM.

For completeness, it is noted that the Danish authority recently reviewed their Asbestos risk assessment (AT, 2019). This assessment uses the Dutch risk calculations which are merely modified to be more adequate for the situation specific to Denmark. We therefore did not further discuss the Danish risk assessment in this report.

French Agency for Environmental and Occupational Health Safety (AFSSET)

The French evaluation by AFSSET (which became ANSES shortly after publication of the report) from 2009 (AFSSET, 2009) assessed the exposure risk relationships available at that time and concluded that the existing models for lung cancer and mesothelioma used in France are still the most adequate. The two models have the same form as the models in the US EPA assessment from 1986 (Nicholson, 1986) which is a linear increase of the risk with exposure for lung cancer and a risk for mesothelioma increasing linearly with the concentration, but exponentially with duration since start of exposure. AFSSET used the slopes from the US EPA assessment. For lung cancer, the heterogeneity of reported slopes in the study database is acknowledged by AFSSET and for reasons of practicality, a slope corresponding to a 1% increase in relative risk per fibres/cm^3 and year is chosen for all fibre types. Regarding mesothelioma, the risk was determined to be three times higher after amphibole exposure and 1.5 times higher after exposure to mixed fibres compared to chrysotile exposure.

In order to derive excess risks for workplace exposure, these are adjusted to the workplace scenario (48 weeks/year, 40 hours/week, exposure from age 20 to 65, no information regarding breathing rate adjustments). Life tables for a French population were used to account for other causes of mortality. This leads to the excess risk levels as given in Table 2.4.

Table 2.4 Exposure concentrations corresponding to the reference risk levels after lifelong occupational exposure for lung cancer, mesothelioma or either of the two as given in (AFSSET, 2009)

Type of cancer	Risk level	Exposure concentration, fibres/cm^3
Lung cancer	$1x10^{-4}$	$4.7x10^{-3}$
	$1x10^{-6}$	$4.7x10^{-5}$
Mesothelioma	$1x10^{-4}$	$1x10^{-2}$
	$1x10^{-6}$	$1x10^{-4}$
Lung cancer or mesothelioma	$1x10^{-4}$	$3x10^{-3}$
	$1x10^{-6}$	$3x10^{-5}$

Source: AFSSET (2009)

Converting these numbers to linear exposure-response relationships results in unit risks (as fractions of 1) of **0.021 per fibres/cm^3, 0.01 per fibres/cm^3 for mesothelioma and 0.033 per fibres/cm^3 for lung cancer and mesothelioma combined**. These risks apply to exposures to predominantly or exclusively chrysotile fibres. Risks for exposure to amphiboles or mixtures of fibres are not described. The exposure refers to measurements by PCM. (AFSSET, 2009) considers it impossible to adjust the risks for lung cancer by cancer attributable to smoking.

World Health Organisation – Air Quality Guidelines for Europe

WHO Europe (2000) summarises studies which derived risk estimates for lung cancer and mesothelioma and briefly describes the methodological choices to derive exposure risk relationships from the available data. For the lung cancer assessment, a risk estimate of 0.01 per fibres/cm^3 and year is described as a reasonable choice given the range of published risk estimates. WHO Europe (2000) differentiates between smokers and non-smokers, with the former assumed to have a ten times higher risk to develop asbestos-related lung cancer. Assuming a lifetime environmental exposure (50 years) to $1x10^{-4}$ fibres/cm^3 and taking into consideration different baseline cancer incidences of smokers and non-smokers, the risk for lung cancer was calculated to be 0.2 per $1x10^5$ exposed persons for non-smokers and 2 per $1x10^5$ exposed persons for smokers. Converting this into a linear exposure risk relationship corresponds to a unit risk (in fractions of 1) of 0.02 per fibres/cm^3 for non-smokers and 0.2 per fibres/cm^3 for smokers.

For mesothelioma, a risk estimate of $2x10^{-5}$ for a lifetime exposure to $1x10^{-4}$ fibres/cm^3 is suggested as a reasonable choice among published estimations. Details on the calculation are lacking (e.g. assumed duration of exposure). Conversion to a linear risk relationship results in a unit risk of 0.2 per fibres/cm^3. Smoking is not known to interact with the risk to develop mesothelioma. A combined cancer risk (for developing either lung cancer or mesothelioma) was estimated by adding the two risks together. For smokers, the risk is (2+2) x 10^{-5} at a concentration of 100 fibres/m^3, corresponding to a unit risk of 0.4 per fibres/cm^3. For non-smokers, the risk is (2 + 0.2) x 10^{-5} at a concentration of 100 fibres/m^3, which corresponds to a unit risk of 0.22 per fibres/cm^3.

For both cancer types, the derived risk applies to an environmental exposure (continuous, lifetime) and a calculation for the workplace scenario was not presented. No differentiation between fibre types was made, but WHO acknowledges that amphiboles are associated with higher risks than chrysotiles and that, as a precaution, chrysotiles have been attributed the same risk as amphiboles in the assessment. Exposure concentrations refer to PCM, and a factor of two is suggested to convert from TEM measurements to PCM, if necessary (WHO, 2000).

If standard assumptions for an occupational scenario according to ECHA (2019) are used (assuming occupational exposure in 48 weeks per year at five days/week, over 40 years of exposure instead of 75: factor 2.8, see chapter R.8.5 in ECHA (2019) and a breathing rate of 10 m^3 per day for workers compared to 20 m^3 per day for the general population, resulting in a reduction of risk by a factor two) to recalculate the risks for workers, the following values result:

- Non-smokers: 0.22 per fibres/cm^3 / (2.8 x 2) = 0.039 per fibres/cm^3
- Smokers: 0.4 per fibres/cm^3 / (2.8 x 2) = 0.095 per fibres/cm^3

Ausschuss für Gefahrstoffe (AGS, Germany)

The AGS (2008) exposure-risk relationship started with the unit risk for lung cancer or mesothelioma from US EPA (1988): $2.3x10^{-1}$ per fibres/cm^3. This risk refers to continuous lifetime exposure and is converted to a workplace risk (40 years versus 70 years exposure, 240/365 days per year, 10/20 m^3 daily breathing volume) of 0.043 per fibres/cm^3. No differentiation between fibre types or smoking status is made. No conversion factor for different measurement techniques is envisaged, i.e. the same unit risk applies to exposure concentrations measured by TEM as well as by PCM.

European Chemicals Agency (ECHA)

ECHA performed risk calculations separately for lung cancer and mesothelioma, which are then later combined to a single ERR. For lung cancer, ECHA extracted 124 relative risk estimates (relative risk for lung cancer at a given exposure level) from the 22 identified studies (Section 2.2.3.1) which covered a cumulative exposure from 0.11 to 4710 fibre–years/cm^3. A regression analysis was performed on this data using a linear model with and without intercept and a natural spline with and without intercept. The natural spline with intercept had the best fit and was used for lung cancer risk calculations. The risk remaining with no asbestos exposure (intercept), e.g. due to smoking which was not adjusted in some of the studies in the meta-analysis, was subtracted from the total risk.

For mesothelioma, ECHA used the EPA model which was also used by many other risk assessments and considered a latency period (10 years) and the time since first exposure to asbestos. This model relies on the potency factor (or slope factor) K_M. K_M values from the 13 identified cohorts (see section 2.2.3.1) were pooled to a single K_M value for each group of cohorts exposed to chrysotiles, amphiboles or a mixture of the fibre types by weighted averaging based on the individual K_M standard errors. With the same procedure, an overall K_M value for all studies, regardless of the fibre type was obtained (Table 2.5).

Table 2.5 Pooled meta K_M values for the assessment of mesothelioma mortality with the EPA model according to ECHA (2021). Pooling was performed by type of fibres and for all studies together, based on standard error-weighted K_M values from the individual studies.

Type of fibre the study cohort was exposed to	Number of studies	Pooled K_M value ($\times10^8$ (f-y/cm^3)$^{-1}$) (95% C.I.)
all fibre types	13	0.337 (0.246-0.429)
Chrysotile only	5	0.017 (0.004-0.031)
Amphibole only	2	7.953 (0.015-15.891)
Amphibole and chrysotile	6	1.076 (0.330-1.821)

Source: ECHA (2021)

ECHA then proceeded to calculate the risk for cancer (lung cancer and mesothelioma combined) for workplace exposure conditions (40 years exposure starting at an age of 20, five days per week and eight hours per day; no information on a correction for breathing volume and yearly workdays). Life tables (averaged across all EU countries) were used to correct for other causes of mortality.

The mesothelioma risk was calculated with the K_M value derived from all study cohorts (0.337×10^8 (f-y/cm^3)$^{-1}$), regardless of the type of fibre because a mixed exposure is expected in the EU and the precise share of fibre types is unknown. The resulting excess risk (both cancer types combined) is given in Table 2.6. The risk calculation is based on exposures relating to measurements by PCM. ECHA proposes that the same risk calculation, without a correction factor, should be used for measurements by electron microscopy.

Table 2.6 Excess risk for cancer (lung cancer and mesothelioma combined) by concentration of workplace exposure according to ECHA (2021).

Concentration of asbestos fibres/cm^3	Excess cancer risk cases per 100,000 workers
0.001	1.2
0.002	2.5
0.005	6.2
0.01	12

Concentration of asbestos fibres/cm³	Excess cancer risk cases per 100,000 workers
0.02	25
0.05	62
0.1	125

Source: ECHA (2021)

2.3.2.2 Conclusions

The following table provides an overview on the ERR derived by various committees (Table 2.7).

Table 2.7 Overview on published cancer risk estimates for the workplace scenario

Organisation	Fibre type	Risk per fibres/cm³	Fibre counting method	Remarks
US EPA (2020)	Chrysotile	0.02	PCM	
HCN (The Netherlands)	Chrysotile	0.02	SEM	
	Amphibole	0.095	SEM	
AFSSET (France)	Chrysotile	0.033	PCM	
WHO	All fibres	0.039	PCM	Non-smokers, recalculated for occupational scenario
	All fibres	0.095	PCM	Smokers, recalculated for occupational scenario
AGS (Germany)	All fibre types	0.043	SEM[9]	
ECHA	All fibre types	0.0125	PCM	

The ERR derived by the ECHA is similar to the other available ERRs, but it is the lowest among the available ERRs. The ECHA ERR is also the most recent one which takes into consideration studies that were not available when the other ERRs were derived and it is geared towards the situation in Europe. There is no reason to deviate from the ERR by ECHA in this report. A formula of the ERR (as excess risk in fractions of one) is given below.

$$\mathrm{ER(conc)} = 0.0125 * \mathrm{conc}, \qquad \mathrm{conc} > 0 \qquad \textit{Equation 1}$$

where conc refers to the exposure in fibres/cm³ (8-h TWA) and the resulting ER is in fractions of one (e.g., an ER of 0.1 means 10% of exposed workers develop cancer due to asbestos exposure).

[9] According to TRGS (Technical Rule for Hazardous Substances) 519, https://www.baua.de/DE/Angebote/Rechtstexte-und-Technische-Regeln/Regelwerk/TRGS/TRGS-519.html .

RAC's in its opinion on asbestos, available since 13 July 2021, confirmed and adopted ECHA's ERR described above (RAC, 2021).

2.3.3 DRR for non-carcinogenic effects

As asbestosis (fibrotic lung changes due to long-term asbestos exposure are expected at concentrations only above the current limit value set by the Asbestos at Work Directive of 0.1 fibres/cm^3, no DRR for asbestosis is derived.

2.3.4 Discussion

The available ERRs are relatively similar and are all of a similar order of magnitude. The ERR proposed by ECHA is the one with the lowest risk. Asbestos is a carcinogen with a good epidemiological database. Nevertheless, across the available studies, there is heterogeneity regarding the estimated potency of asbestos to drive the development of lung cancer and mesothelioma. As the bodies who derived ERRs used different study selection criteria, differences in the calculated risks are to be expected.

Comparing the ERR derivation of ECHA (2021) with HCN (2010), which is the most comparable in terms of study selection and calculation method, it appears that the lower risk of the ECHA ERR is a result of both the study selection criteria (affecting primarily the mesothelioma risk estimation) and the statistical procedure to determine the lung cancer risk. The impact of study selection criteria is evident in the case of the mesothelioma assessment, as the remaining methodology is identical between ECHA (2021) and HCN (2010), yet the risk determined by ECHA is a factor of three to ten lower, depending on the fibre type. Regarding the lung cancer assessment, in the regression performed by ECHA the best fit was observed for models with an intercept. The intercept likely represents a cancer risk present across all workers which is not related to the asbestos exposure and ECHA adjusted the excess risk accordingly. Such a correction is not included in the excess risk calculation by HCN (2010), yet the potency factors (K_L) of the underlying studies might already include an adjustment for cancer not related to asbestos exposure.

The cancer risk estimation is based on lung cancer and mesothelioma only. Asbestos exposure leads to other types of cancer as well, which are not covered by the incidence rates used for the ERR. However, the contribution of other cancers to the cancer risk is most likely low in comparison to the two major cancer types (see section 2.2.3.2).

The ECHA ERR applies to all fibre types. As the mesothelioma risk is higher after exposure to amphiboles than after exposure to chrysotile, using a single ERR may under- or overestimate the risk depending on the actual share of fibre type workers are exposed to. As ECHA pointed out, it is expected that occupational exposure in Europe is primarily to chrysotile, but the exact share of fibre types is not known. The K_M value used for calculations reflects this expected situation, as it is higher than obtained from studies with only chrysotile exposure and lower than K_M from studies with amphibole exposure.

ECHA's ERR is derived from exposure estimates which were measured by PCM. The agency recommends using the same ERR for exposure measurements obtained by EM. EM is able to detect fibres thinner< than can be detected using PCM. Thus, EM will produce higher exposure estimates, however the ratio between the concentrations obtained with both methods depends on the sampled asbestos material. Regulatory bodies have used a pragmatic factor of two to convert between the detection methods. It therefore seems reasonable to assume that using the ECHA ERR with exposure data obtained with EM will, on average, lead to a higher predicted risk than if the fibres in the same sample would have been counted using PCM. RAC in its opinion also did not provide a specific conversion factor for measurements performed with EM methods (RAC, 2021).

2.4 Objectives

The key aim of the study is to provide the Commission with the most recent, updated and robust information on asbestos to support it in the preparation of an Impact Assessment report to accompany a potential proposal to amend the AWD.

The general objective with regard to this chemical agent includes a detailed assessment of the baseline scenario (past, current, and future), as well as the assessment of the impacts of introducing a new OEL.

3. Options

At the start of the current project, no RAC opinion was available which could inspire the choice of OEL options.

However, based on dialogue with the ECHA OEL secretariat and discussion with the Steering Group, the OEL options of 0.01 and 0.001 fibres/cm^3 were agreed to be included in the stakeholder questionnaires during the 7 December 2020 inception meeting. The OEL option of 0.002 fibres/cm^3 was added in agreement with the Steering Group at the 28 May interim meeting.

It is assumed the fibres within the scope of the AWD are those which in practice are in the scope of the Directive today, i.e. fibres with a diameter in the range of 0.2 - 3.0 µm. **Consequently, it is assumed that lowering the OEL from 0.1 to 0.01 fibres/cm^3 corresponds to lowering the exposure concentrations of fibres in the workplace by a factor of ten.**

The AWD does not define a lower limit for the diameter but this is in practice set by the prescribed analytical method (PCM or any other method giving equivalent results). As discussed in section 4.9, lowering the current OEL to the different reference values under consideration in this study would require that electron microscopy methods are applied. With the Transmission Electron Microscopy (TEM) method, in practice, fibres with diameters down to 0.01 µm can be measured. A decrease from 0.1 fibres/cm^3 measured by PCM to a concentration of 0.01 fibres/cm^3 measured by TEM, unless a minimum diameter is defined, would require a decrease by more than a factor of 10 in exposure concentrations; rather a factor of 20.

Table 3.1 OEL options for asbestos

OEL option	Reason for inclusion
0.1 fibres/cm^3 (100 fibres/L, 100,000 fibres/m^3)	Current EU OEL
0.01 fibres/cm^3 (10 fibres/L, 10,000 fibres/m^3)	Equal to the OEL in France* and "acceptance level" in Germany
0.002 fibres/cm^3 (20 fibres/L, 20,000 fibres/m^3)	Equal to the OEL in the Netherlands, the lowest in Member States **
0.001 fibres/cm^3 (1 fibres/L, 1,000 fibres/m^3)	Half of the current Dutch OEL

* The OEL in France differs in practice from the current EU OEL as it is defined that the concentration should be analysed by the use of TEM and thereby in practice address both the fibres within the scope of the AWD (with the defined analytical technique in practice fibres with diameter in the range of 0.2-3.0 µm) and 'thin asbestos fibres' (TAF, with diameters of 0.01 - 0.2 µm). Studies indicated that the number of fibres when the TAF are included would typically be a factor of 2 to 3 times higher than the number if the TAF are excluded. As consequence, the OEL in France correspond to at least a 2 times lower value if only the fibres addressed by the AMD was counted.

** According to the Dutch legislation, asbestos fibres of the chrysotile type and amphibolic asbestos fibres, respectively, should not exceed this value. For exposure to a mixture of the two types, the OEL correspond to a slightly higher OEL value if the OEL addressed all asbestos fibre in common as is the situation for the EU OEL.

It could be argued that an even lower OEL might be considered. The main arguments for not including policy options below 0.001 fibres/cm^3 (half of the current Dutch OEL) are that:

- A lower limit seems not to be feasible given the current thinking among experts about the limit of detection. Already the feasibility of measuring at the 0.001 fibres/cm^3 level is challenged by several Steering Committee members and experts. This issue is further addressed and discussed in Section 4.9.
- The lowest level suggested is already half of the lowest national OEL

Based on discussion with the ECHA OEL secretariat, it is not expected that a STEL would be toxicologically relevant for asbestos.

Although different asbestos fibres vary in potency, no Member States have opted for defining different OELs for different types of fibres. The OEL in the Netherlands, however, has a specification of different fibres as it is specified that the concentration of chrysotile-type asbestos fibres should not exceed the limit value of 0.002 fibres/cm^3 and the concentration of the amphibole asbestos fibres actinolite, amosite, anthophyllite, tremolite and crocidolite should not collectively exceed this limit value (in practice this means that the total asbestos concentration could exceed the limit value). Also, in Belgium OELs are established for chrysotile-type asbestos and other asbestos fibres, respectively.

4. The baseline analysis

4.1 Existing national limits for asbestos

The existing national occupational exposure limits for asbestos are summarised in the table below.

Two Member States have implemented binding OELs below the EU OEL:

- The Netherlands: 0.002 fibres/cm^3
- France: 0.01 fibres/cm^3

All listed limit values for EU Member States are binding limit values, except for the 0.01 fibres/cm^3 for Germany, which is the 'acceptable concentration' in addition to the 'tolerable concentration' (binding limit value) of 0.1 fibres/cm^3.

Table 4.1 OELs (fibres/cm^3, 8-h TWA) and STELs (fibres/cm^3, 15 min) in EU Member States and selected non-EU countries for asbestos‡ (status: 28.06.2021)

Country	OEL fibres/cm^3	Specification of OEL	STEL fibres/cm^3	Specification of STEL
Austria[2]	0.1[#,*]	-F; K1	-[*]	
Belgium[1,3,29]	0.1	-F; K Asbestos fibres of the chrysotile type and amphibolic asbestos fibres, respectively, should not exceed this value	-	
Bulgaria[4,28]	0.1	-F	-	
Croatia[5,28]	0.1	-K1	-	
Cyprus	0.1	-F	-	
Czech Republic[6]	0.1†	-F	-	
Denmark[7,28]	0.1	-F; K	0.2[*]	-F; K
Estonia[8]	0.1	-K	-	
Finland[1,9,29]	0.1 (R)	-K1	-	
France[1,10,29]	0.01	-F Measured by TEM and include thus 'thin asbestos fibres'.	-	
Germany[1,11,28,29]	0.1†[§] 0.01[$]	-F; K1 -F; K1	0.8[§]	-K1
Greece	0.1	no data	-	
Hungary[1,12,28,29]	0.1	-K1	-	
Ireland[1,13,29]	0.1	-K1	-	
Italy[1,14,29]	0.1	-F	-	
Latvia[1,15,29]	0.1	-F	-	
Lithuania[16]	0.1 (R)	-F, K	-	
Luxembourg[17,28]	0.1	-K1	-	
Malta[18]	0.1	no data	-	
Netherlands[1,19,29]	0.002	Asbestos fibres of the chrysotile type and amphibolic asbestos fibres, respectively, should not exceed this value	-	

Country	OEL fibres/cm^3	Specification of OEL	STEL fibres/cm^3	Specification of STEL
Poland[20]	0.1	-F	-	
Portugal[21]	0.1	-F	-	
Romania[22]	0.1	-F; K1	-	
Slovakia[23]	0.1	-K1	-	
Slovenia[24]	0.1	-F	-	
Spain[1,25,29]	0.1	-K1	-	
Sweden[1,26,29]	0.1	-F; K	-	
European Union[1,28,29]	0.1	-F	-	
Non-EU countries				
Australia[30]	0.1 (R)	-all fibrous forms; F; K1	-	
Brazil[31]	no data identified		-	
Canada, Ontario[1,32]	0.1 (R)	-all fibrous forms; fibres length > 5 µm; aspect ratio ≥3:1	-	
Canada, Québec[1,33]	1 (R) 0.2 (R)	-actinolite, anthophyllite, chrysotile, tremolite; fibres: length > 5 µm; aspect ratio ≥3:1; K1 -amosite, crocidolite; fibres length > 5 µm; aspect ratio ≥3:1; K1	5 (R) 1 (R)	-actinolite, anthophyllite, chrysotile, tremolite; fibres: length > 5 µm; aspect ratio ≥3:1; K1 -amosite, crocidolite; fibres length > 5 µm; aspect ratio ≥3:1; K1
China[1]	0.8 (I)		-	
India[34]	0.5 1.0 0.2	-amosite -chrysotile -crocidolite	-	
Japan[1,35]	0.15	-fibres longer than 5 µm	-	
Japan - JSOH[1,36]	0.03^{+} 0.003^{++} 0.15^{+} 0.015^{++}	- except chrysotile; fibres length > 5 µm; aspect ratio ≥3:1; K -chrysotile, fibres length > 5 µm; aspect ratio ≥3:1; K	-	
Norway[1,37]	0.1†	-all forms; K	-	
Russia[38]	0.1 (R) 0.5 (R)	-amphibole group (e.g., crocidolite, amosite, anthophyllite, tremolite); with an average concentration > 0.01 F/cm^3; K -amphibole group (e.g., crocidolite, amosite, anthophyllite, tremolite); with an average concentration < 0.01 F/cm^3; K	-	
South Korea[39]	0.1	-all forms; K1	-	
Switzerland[1,40]	0.01	-F; K1	-	
Turkey[41]	0.1			
United Kingdom[1,27,29]	0.1	-all fibrous forms; 4 h	0.6	-all fibrous forms, 10 min

Country	OEL fibres/cm³	Specification of OEL	STEL fibres/cm³	Specification of STEL
USA, ACGIH[39]	0.1	-all forms; K1	-	
USA, NIOSH[1,29,40]	0.1	-fibres length > 5 µm; aspect ratio ≥3:1; 100 min; K	-	
USA, OSHA[41]	0.1	-fibres length > 5 µm; aspect ratio ≥3:1; K	-	

Notes:

‡ for asbestos as well as actinolite, amosite, anthophyllite, chrysotile, crocidolite, tremolite

(R) = respirable fraction/fibres

(I) = inhalable fraction/fibres

K = carcinogenicity notation assigned

K1 = assigned as Carc. Category 1A or 1B

- no value available

F = fibres length > 5 µm, diameter < 3 µm, aspect ratio ≥3:1

TRK value ("Technische Richtkonzentration", Technical Guidance Concentrations), based on technical feasibility

§ Workplace exposure concentration corresponding to the proposed tolerable cancer risk 4:1,000

$ Workplace exposure concentration corresponding to the proposed preliminary acceptable cancer risk 4:100,000

+ Reference value corresponding to an individual excess lifetime risk of cancer 10^{-3}

++ Reference value corresponding to an individual excess lifetime risk of cancer 10^{-4}

* Sources reported different OELs/STELs and thereby deviated from the OELs/STELs listed in the national OEL list. The discrepancy was noted for the following countries:

For Austria, GESTIS database[1] and ECHA[29] reported an OEL of 0.25 fibres/cm³ and a STELs of 1 fibres/cm³

For Denmark, GESTIS database[1] reported an OEL and STEL of 0.3 F/cm³ as ceiling limit

Sources:

1: Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA) GESTIS – International Limit Values. Available at: http://limitvalue.ifa.dguv.de/, accessed on 30.11.2020

2: Austria (2020) Grenzwerteverordnung 2020 – GKV 2020. Available at: https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20001418, accessed on 16.12.2020

3: Belgium (2020) A. Lijst van de grenswaarden voor blootstelling aan chemische agentia. Available at: https://werk.belgie.be/sites/default/files/content/documents/Welzijn%20op%20het%20werk/grenswaardentabel.pdf, accessed on 16.12.2020

4: Bulgaria (2020) list of limit values Available at: https://www.lex.bg/laws/ldoc/2135477597; carcinogenic/mutagenic/reprotoxic substances: https://www.lex.bg/bg/mobile/ldoc/2135473243, accessed on 16.12.2020

5: Croatia (2018) Nařízení vlády č. 361/2007 Sb. kterým se stanoví podmínky ochrany zdraví při práci. Available at: https://narodne-novine.nn.hr/clanci/sluzbeni/2018_10_91_1774.html, accessed on 16.12.2020

6: Czech Republic (2020) List of limit values. Available at: https://www.tzb-info.cz/pravni-predpisy/narizeni-vlady-c-361-2007-sb-kterym-se-stanovi-podminky-ochrany-zdravi-pri-praci , accessed on 16.12.2020

7: Denmark (2020) List of limit values. Available at: https://www.retsinformation.dk/eli/lta/2020/698, accessed on 16.12.2020

8: Estonia List of limit values. Available at: https://www.riigiteataja.ee/aktilisa/1060/3201/8009/16m_lisa.pdf# (2018) https://www.riigiteataja.ee/akt/106032018009, accessed on 16.12.2020

9: Finland (2020) List of limit values. Available at: https://julkaisut.valtioneuvosto.fi/handle/10024/162457, accessed on 16.12.2020

Country	OEL fibres/cm^3	Specification of OEL	STEL fibres/cm^3	Specification of STEL

10: France (2016) List of limit values. Available at: https://www.inrs.fr/media.html?refINRS=ED%20984, accessed on 16.12.2020.

11: Germany (2019) TRGS 910 https://www.baua.de/DE/Angebote/Rechtstexte-und-Technische-Regeln/Regelwerk/TRGS/TRGS-910.html; List of carcinogenic/mutagenic/reprotoxic substances: https://publikationen.dguv.de/forschung/ifa/allgemeine-informationen/3517/liste-der-krebserzeugenden-keimzellmutagenen-und-reproduktionstoxischen-stoffe-kmr-stoffe, accessed on 16.12.2020

12: Hungary (2020) List of limit values. Available at: https://net.jogtar.hu/jogszabaly?docid=a2000005.itm, accessed on 16.12.2020

13: Ireland (2020) Health and Safety Authority Code of Practice. Available at: https://www.hsa.ie/eng/publications_and_forms/publications/codes_of_practice/chemical_agents_cop_2020.pdf, accessed on 16.12.2020

14: Italy (2020) List of limit values. Available at: https://www.ispettorato.gov.it/it-it/strumenti-e-servizi/Documents/TU%2081-08%20-%20Ed.%20Novembre%202020.pdf, accessed on 16.12.2020

15: Latvia (2020) List of limit values. Available at: https://likumi.lv/doc.php?id=157382&from=off, accessed on 16.12.2020

16: Lithuania (2018) List of limit values. Available at: https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/f5030cc06fbd11e8a76a9c274644efa9 (2011) https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.405920?jfwid=-19qec2s1fi, accessed on 16.12.2020

17: Luxembourg (2020) List of limit values. Available at: (2016) http://data.legilux.public.lu/file/eli-etat-leg-memorial-2016-235-fr-pdf.pdf (2018) http://legilux.public.lu/eli/etat/leg/rgd/2018/07/20/a684/jo (2020) http://legilux.public.lu/eli/etat/leg/rgd/2020/01/24/a37/jo, accessed on 16.12.2020

18: Malta (2018) List of limit values. Available at: https://legislation.mt/eli/sl/424.24/eng/pdf, accessed on 16.12.2020

19: Netherlands (2020) List of limit values. Available at: https://wetten.overheid.nl/BWBR0008498/2020-12-02/0/Hoofdstuk4/Afdeling5/Paragraaf3/Artikel4.46/informatie, accessed on 16.12.2020

20: Poland (2018) List of limit values. Available at: http://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20180001286 (2020) http://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20200000061, accessed on 17.12.2020

21: Portugal (2007) Available at: https://dre.pt/pesquisa/-/search/636752/details/maximized, accessed on 17.12.2020

22: Romania (2020) List of limit values. Available at: http://legislatie.just.ro/Public/DetaliiDocument/222984, accessed on 17.12.2020

23: Slovakia (2020) List of limit values. Available at: http://www.epi.sk/zz/2006-355 carcinogenic/mutagenic/reprotoxic substances: http://www.epi.sk/zz/2006-356, accessed on 17.12.2020

24: Slovenia (2018) List of limit values. Available at: https://www.uradni-list.si/glasilo-uradni-list-rs/vsebina/2018-01-3783?sop=2018-01-3783, accessed on 17.12.2020

25: Spain (2019) List of limit values. Available at: https://www.insst.es/documents/94886/188493/L%C3%ADmites+de+exposici%C3%B3n+profesional+para+agentes+qu%C3%ADmicos+2019/7b0b9079-d6b5-4a66-9fac-5ebf4e4d83d1, accessed on 17.12.2020

26: Sweden Hygieniska gränsvärden AFS 2018:1. Available at: https://www.av.se/globalassets/filer/publikationer/foreskrifter/hygieniska-gransvarden-afs-2018-1.pdf; Hygieniska gränsvärden AFS 2020:6 Available at: https://www.av.se/globalassets/filer/publikationer/foreskrifter/andringsforeskrift/afs-2020-6.pdf, accessed on 17.12.2020

27: United Kingdom (2020) List of limit values. Available at: https://www.hse.gov.uk/pubns/priced/eh40.pdf and https://www.hse.gov.uk/asbestos/regulations.htm, accessed on 17.12.2020 and 26.11.2020

28: EU Directive 2009/148/EC of the European Parliament and of the Council of 30 November 2009 on the protection of workers from the risks related to exposure to asbestos at work (Text with EEA relevance). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32009L0148, accessed on 16.12.2020

29: ECHA, European Chemicals Agency (2021) Scientific report for evaluation of limit values for asbestos at the workplace. 1 February 2021. European Chemicals Agency (ECHA), Helsinki, Finland. Available at: https://echa.europa.eu/documents/10162/d5f8d584-5e7d-bc97-3a98-4e9a39715f41, accessed on 08.02.2021

Country	OEL fibres/cm^3	Specification of OEL	STEL fibres/cm^3	Specification of STEL
30: Australia (2019) List of limit values. Available at: https://www.safeworkaustralia.gov.au/system/files/documents/1912/workplace-exposure-standards-airborne-contaminants.pdf, accessed on 18.12.2020				
31: Brazil List of limit values. Available at: http://www.guiatrabalhista.com.br/legislacao/nr/nr15_anexoXI.htm, accessed on 18.12.2020				
32: Canada, Ontario (2020) List of limit values. Available at: https://www.ontario.ca/laws/regulation/900833, accessed on 18.12.2020				
33: Canada, Québec (2020) List of limit values. Available at: http://legisquebec.gouv.qc.ca/en/showdoc/cr/S-2.1,%20r.%2013, accessed on 18.12.2020				
34: India (2020) List of limit values. Available at: https://dgfasli.gov.in/book-page/permissible-levels-certain-chemical-substancesin-work-environment, accessed on 18.12.2020				
35: Japan (2020) List of limit values. Available at: https://www.nite.go.jp/en/chem/chrip/chrip_search/intSrhSpcLst?slIdxNm=&slScNm=RJ_04_061&slScCtNm=&slScRgNm=&ltCatFl=&slMdDplt=0&ltPgCt=200&stMd, accessed on 18.12.2020				
36: Japan - JOSH (2020) List of limit values. Available at: https://www.sanei.or.jp/images/contents/310/OEL.pdf, accessed on 18.12.2020				
37: Norway (2021) List of limit values. Available at: https://www.arbeidstilsynet.no/globalassets/regelverkspdfer/forskrift-om-tiltaks--og-grenseverdier, ac-cessed on 28.06.2021				
38: Russia (2021) List of limit values. Available at: http://publication.pravo.gov.ru/Document/View/0001202102030022?index=21&rangeSize=1, accessed on 28.06.2021				
39: South Korea (2020) List of limit values. Available at: https://www.moel.go.kr/skin/doc.html?fn=20200114154602 02ae79b648784733aac25448f202f783.hwp&rs=/viewer/BBS/2020/, accessed on 18.12.2020				
40: Switzerland (2019) List of limit values. Available at: https://www.suva.ch/de-CH/material/Richtlinien-Gesetzestexte/erlaeuterungen-zu-den-grenzwerten, accessed on 18.12.2020				
41: Turkey (2013) List of limit values. Available at: https://www.ilo.org/dyn/natlex/docs/ELECTRONIC/107861/133007/F1509677780/TUR107861%20Tur.pdf, accessed on 28.06.2021				
42: USA, ACGIH, American Conference of Governmental Industrial Hygienists (2020), TLVs and BEIs Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices.				
43: USA, NIOSH (2020) List of limit values. Available at: https://www.cdc.gov/niosh/index.htm, accessed on 18.12.2020				
44: USA, OSHA (2020) List of limit values. Available at: https://www.osha.gov/dsg/annotated-pels/tablez-1.html, accessed on 18.12.2020				

4.1.1 Groups at extra risk

Most workers in the sectors where exposure to asbestos occurs are men and the key cancer endpoints (mesothelioma and lung cancer) that account for 90% of cancer incidence from occupational exposure to asbestos affect both male and female workers. Laryngeal and ovarian cancer are estimated to account for 10% of cancer incidence associated with occupational exposure to asbestos with one of these two cancer sites being relevant to female workers only.

4.2 Relevant sectors, uses, and operations

4.2.1 The legal context

4.2.1.1 Where is asbestos still allowed?

The manufacturing, use and production of new products with asbestos has practically been banned since the early 2000s in most EU countries and, as set out in section 1.1.2, it is banned at EU level via REACH Annex XVII entry 6 stating that the manufacture and use of asbestos fibres as such as well as mixtures and articles (where asbestos fibres are added intentionally) are prohibited in the EU. In line with this, there are no REACH registration data for asbestos.

However, a few derogations/conditions apply. According to paragraph 1 in the restriction entry, the use in diaphragms for electrolysis installation already in use by 2016 are allowed until 2025. This derogation was revisited during 2013-2016 and it appears from the ECHA committee opinions that only two companies (AarhusKarlshamn Sweden AB and Dow Deutschland Anlagengesellschaft mbH) still benefit from this derogation (ECHA, 2021b).

Due to the number of companies benefitting from this derogation (two companies), the low likelihood of exposure in this application (in a diaphragm matrix) and the fact that the use according to this derogation will have to cease by 2025, this use is not be further investigated in the current study.

According to paragraph 2 in the restriction entry (see section 1.1.2), the continued use of some asbestos-containing articles on the market before 2005 can still be allowed. The paragraph sets out how Member States can restrict this or allow placing on the market of such 'old articles' under certain circumstances. As noted in the derogation, such national measures should be communicated to the European Commission by June 2011 and the Commission should in turn publish these. Six Member States reported such measures[10]. The European Commission has informed that most other Member States informed the Commission (by June 2011) that they had not adopted national measures/had not made use of the derogation possibility foreseen by entry 6 paragraph 2, second subparagraph[11]. Thus, older articles on the market before 2005 can continue to be used in those Member States.

In the context of the REACH restriction, it shall be noted that buildings are not considered articles. This has been communicated by the Commission in a reply to a Parliamentary Question (European Parliament, 2019). Entry 6 on asbestos thus prohibits, since 1 January 2005, the incorporation of new asbestos into buildings, but it does not regulate asbestos already incorporated in buildings before that date. The presence of asbestos in buildings, if incorporated before 1 January 2005, is not governed by any provisions of REACH Restriction entry 6. Thus, even if six Member States have restricted nationally pre-2005 articles via REACH restriction entry 6, paragraph 2, those restrictions do not apply to asbestos in buildings.

In summary, manufacture and use of asbestos fibres as such as well as in mixtures and articles (where asbestos fibres are added intentionally) is banned with the following exemptions:

- Two companies benefit from a derogation (until 2025) for the use of asbestos in diaphragms for electrolysis installation. Due to the number of companies benefitting from this derogation (two companies), the low likelihood of exposure in this application (in a diaphragm matrix) and the fact that the use according to this derogation will have to cease by 2025, this use is not further investigated in the current study.
- The continued use of asbestos-containing articles on the market before 2005 is still to some extent allowed. By June 2011 most Member States had not implemented national restrictions on the use of such articles, whereas six Member States had some national restrictions.
- In this context, buildings are not considered articles and the presence of asbestos historically incorporated in buildings is not restricted in any Member State via REACH.

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[10] Exemptions to the Asbestos Restriction, available at: https://ec.europa.eu/docsroom/documents/13166/attachments/1/translations/en/renditions/native

[11] This information was by the authors in an email from a DG EMPL desk officer 3 December 2020.

As part of the stakeholder consultation for this study, ETUI pointed to the fact that cases of illegal asbestos imports have been reported. As examples, reference is made to a Letter sent by the National Asbestos Observatory to the Italian Senate and to the results from an EU/EEA inspection campaign (ONA, 2015). Concerning the latter, it is however noted on the ECHA web-site: "*The products containing asbestos – for example, catalytic heaters, thermos flasks, brake pads - were mostly second-hand and probably produced before the restrictions prohibiting the sale of products containing asbestos came into force.*"

Thus, the latter uses might benefit from paragraph 2 in the REACH restriction discussed above. In the stakeholder consultation, Member States reported a few examples of illegal import of asbestos-containing articles. The EU's Rapid Exchange System for information on dangerous non-food products – RAPEX also include examples of illegal import of asbestos-containing products.

In any case, as the introduction of lower OELs to be assessed in the current study will not affect possible illegal imports, the current study does not attempt to map or quantify illegal asbestos imports and the possible occupational exposure.

4.2.1.2 Article 3(3) of the AWD

Article 3 (3) of the AWD includes a possibility that some requirements concerning notification of the competent authorities, registering and health surveillance may be waived under certain circumstances:

'*Provided that worker exposure is sporadic and of low intensity, and if it is clear from the results of the risk assessment referred to in paragraph 2* [of Article 3 of the AWD] *that the exposure limit for asbestos will not be exceeded in the air of the working area, Articles 4, 18 and 19 may be waived where the work involves:*

- *(a) short, non-continuous maintenance activities in which only non-friable materials are handled;*
- *(b) removal without deterioration of non-degraded materials in which the asbestos fibres are firmly linked in a matrix;*
- *(c) encapsulation or sealing of asbestos-containing materials which are in good condition;*
- *(d) air monitoring and control, and the collection of samples to ascertain whether a specific material contains asbestos.*'

For the exemption, both conditions should be met: the exposure limit for asbestos should not be exceeded and the activities should be within the listed types of activities.

The exemption has influence on the interpretation of data on exposure concentrations and exposed workforce from national databases, as these databases would generally not include data for the exempted activities. Furthermore, lowering the OEL could have some consequences on which activities would be exempted and thereby increase the number of notifications and workers under medical surveillance. The exempted activities are therefore addressed separately from the activities in the building sector subject to notification.

The exemption is assessed mainly to include activities in building and construction sector as well as air monitoring and control.

Exposure to naturally occurring asbestos is not within the listed activities and would in general be subject to notification even in cases where the concentration in the air is below the OEL.

For the current assessment, it is assumed that the wording of the Article 3 (3) is not changed, i.e. lowering the OEL could impact on the determination of whether a specific activity is covered by the waiver.

4.2.2 Asbestos in buildings and in articles placed on the market before 2005

The properties of asbestos fibres have historically been used in many applications (more than 3,000 applications/products in the era of peak use) including roofing, insulation (thermal and electrical), cement pipes and sheets, flooring, gaskets, brakes, shoes, coating, plastics, textiles, paper, mastics, thread, fibre jointing and millboards. Asbestos is still to a large extent present in buildings (and in building installations), as well as other infrastructures such as transmission tubes, where it has historically been used for isolating and/or insulation properties. This includes presence in the following building materials and articles (EHS UK, undated):

- Floor tiles
- Boiler insulation
- Ceiling tiles
- Fireproofing
- Linoleum
- Tank insulation
- Adhesives
- Acoustical finishes
- Floor tile mastic
- Gaskets
- Fume hood liners
- Plaster
- Pipe insulation
- HVAC duct wrap, lab countertops
- Roofing
- Pipe fittings
- Fire doors
- Chalkboard glue
- Siding shingles.

In the practical guidelines for information and training of workers involved with asbestos removal or maintenance work (European Commission, 2012), the most important uses are identified as:

- Asbestos cement products (asbestos content approx. 15 %)
- Sprayed asbestos (asbestos content up to 85 %)
- Loose asbestos lagging (asbestos content up to 100 %)
- Asbestos fabrics, tapes and cords (asbestos content variable; 3 – 90 %)
- Asbestos panels (asbestos content 5-50 %)
- Asbestos papers, cardboards, and gaskets (asbestos content 50-90 %)

- Asbestos-containing construction chemical products such as bitumen/tar products, coatings, paints, sealants and casting products (asbestos content up to 20 %)
- Asbestos-containing floor coverings (asbestos content 15 – 90 %)

The derogation specified in paragraph 2 of REACH Restriction Entry 6, allows continued use of articles already installed and/or in service before 1 January 2005. From the six Members States which somehow restricted the use of such historical articles, it appears that the following types of articles might still be relevant to consider:

- Historical/veteran vehicles
- Ethylene/acetylene bottles (containing filters with asbestos)
- Various spare parts
- Shafts used for glass drawing
- Certain offshore installations
- Brakes
- Insulation or lagging for e.g. cooling water in trains
- Fire resistant materials and fire blankets in laboratories
- Lift shafts and lift doors
- Boilers and tanks and tanks at certain power stations
- Certain military uses

4.2.2.1 Friable vs. nonfriable ACMs

The AWD and many guidelines distinguish between friable vs. nonfriable ACMs; the synonymous terms un-bound and bound are used in some contexts. In general, friability means that an ACMs is less resistant to mild abrasion or damage and is more likely to release inhalable fibres. So the type of material and asbestos fibre type and condition are critical to determine friability.

The table below was derived from the guidelines from the Health and Safety Authority in Ireland to provide general guidance on friable vs. non-friable ACMs.

Table 4.2 Friable vs. nonfriable ACMs

Friable ACMs	Non-friable ACMs
• Asbestos-containing dust (ACD) • Sprayed coatings, laggings and loose asbestos fill • Millboard • Insulating Boards • Ropes, yarns and cloths • Paper products • Vinyl flooring backed with asbestos paper • Compressed Asbestos Fibre (CAF) gaskets • Asbestos cement products in degraded state	• Asbestos cement products in non-degraded state • Asbestos bitumen roofing felts & damp proof courses, semi-rigid asbestos bitumen products and asbestos bitumen-coated metals • Unbacked vinyl & vinyl floor tiles •Textured decorative coatings and paints containing asbestos on plasterboard • Mastics sealants, putties and adhesives • Asbestos-reinforced PVC and plastics

Source: (HSA, 2013)

As indicated from the table, the state of degradation also influences the degree to which the ACM is friable, e.g. for asbestos cement.

Spaan et al. (2019) have summarised how notifiers in the Netherlands have classified the different materials as friable and non-friable based on 632,346 notifications to the Dutch asbestos management system (SMA-rt)). According to the authors, it should be noted that determining the degree of friability of the material, and thus making the distinction 'friable' and 'non-friable' material, is optional in the analysis of materials, and is generally assessed visually.

The overall pattern is well in accordance with the general view presented in the table above, but for some material/application groups, the data demonstrate that the division between friable and non-friable is not clear-cut, but depends on various factors such as the specific material and the state of degradation. Overall, the following division into three groups can be derived:

- Non-friable - Less than 10 % friable ACMs: Asbestos cement, glue, kit, bitumen, vinyl tile, polymer bound ornamental stone and imitation asbestos cement;
- Friable - More than 90 % friable ACMs: insulation materials, spray asbestos, board, asbestos paper, asbestos felt, asbestos chord; and
- In between - More than 10 % of both friable and non-friable: Polymer bound coatings, asbestos-containing dust, stucco work, gaskets, friction materials.

The asbestos cement materials accounted for about 50% of the notifications.

In Spain in 2017, asbestos cement represented 94.6 % of the materials handled by companies notifying the activities, the remaining part consisted of sprayed asbestos and asbestos coatings on walls, ceilings and structural elements (0.26%), heat insulation (1.05%), other friable materials: panels, fabrics of asbestos, cardboard, felts, etc. (3.21%), and other non-friable materials: putties, paints, adhesives, etc. (0.02%) (MTMSS, 2018). In total, the friable materials accounted for about 5%.

4.2.3 Naturally occurring asbestos

Asbestos is a naturally occurring mineral and exposure can occur during activities related to work in bedrock and soil in areas where asbestos fibres naturally occur. As described in section 4.3.4 - 4.3.6 on exposure to naturally occurring asbestos in mining, quarrying, tunnel construction, and construction materials has gained attention in a number of Member States (among these Finland, Germany, Austria, Italia, and France) but exposure may also occur in many other Member States.

As noted in ECHA (2021), asbestos fibres are widespread in the environment, and are found in many areas where the original rock mass has undergone metamorphism. Whereas rock types in Scandinavia in general have not undergone metamorphism, such rock types are widespread in other parts of Europe.

According to the German technical rule TRGS 517 (BAuA, 2015) in the mineral deposits found when mining in Germany, for particular types of rock the occurrence of the asbestos minerals, chrysotile, tremolite, actinolite and to a lesser extent also anthophyllite needs to be taken into account[12]. The occurrence of asbestos minerals is limited to particular rock types but this does not mean that they always occur in them. The following rock types should in particular be considered to be asbestos-containing:

- Ultrabasite/peridotite (e.g. dunite, lherzolite, harzburgite),

[12] Terminology used here is based on the unoffical English translation of the technical rule at BaUA's website

- Basic effusives (e.g. basalt, spilite, basanite, tephrite, phonolite),
- Basic intrusives (e.g. gabbro, norite, diabase),
- Metamorphic and metasomatically influenced rocks (e.g. metasomatic talc occurrences, green schist, chlorite and amphibole schist/bedrock (e.g.: nephrite), serpentinite, amphibolite).

In special geological circumstances in individual cases other rocks can possibly contain asbestos. Asbestos or asbestos minerals (fibrous and non-fibrous) can occur in the rock formations in two distinct forms (BAuA, 2015):

- Asbestos/asbestos minerals in crevices,
- Asbestos/asbestos minerals in "compact" undisturbed rocks. The first form of occurrence is easy to recognise in quarry inspections.

The asbestos minerals contained in the rock itself can, as a rule, only be identified by petrographic studies. Frequently, the asbestos fibres "come about" in the second form mentioned only due to mechanical loads on the rock (processing) from non-fibrous asbestos minerals (BAuA, 2015).

In Italy, exposure to asbestos in serpentine rock (Cattaneo et al., 2012; Cavallo and Rimoldi, 2013) and feldspar (Cavariani, 2016) has been reported and several studies have demonstrated that dust containing asbestos minerals generated from tunnelling in various rock types is a major issue with impacts upon the environment, human health, worker safety and productivity of underground construction (Gaggero et. al, 2017; Barietto et al. 2020).

In a Finnish geological survey, fibrous minerals, including asbestos (e.g. tremolite and actinolite), were detected in many limestone mines and rock aggregate quarries (Junttila et al., 1994). As described in section 4.5, Finnish guidelines on the management of asbestos in mining and quarrying have recently been developed (Kahkonen et al., 2019).

According to Anses (2017), the main geological areas in France in which rocks containing one or the other of the asbestos species are known; they correspond to the chain of the Western Alps and its extension into Corsica, to the external crystalline massifs of the Alps, the Massif Central, the Vosges, the Armorican Massif and the Pyrenees chain.

A guideline from the Health and Safety Security in the UK (HSE, 2020) on asbestos in some types of marble and other stone indicates that these materials include some sources of dolomite, basalt, marble (including green marbles or ‘Verde’ stones) and vermiculite.

As stated by ECHA (2010), even if intentional commercial uses are banned and handling of past commercially used products is regulated, exposure is possible when handling other minerals (e.g. talc, dolomite and olivine) where asbestos occurs as an impurity. Some of these minerals are in granular or powder form and they relatively easily aerosolise during handling. Therefore, caution is needed in such industries.

A Dutch investigation of talc in cosmetic products analysed 232 cosmetic products for the presence of asbestiform talk. Two of the products were found to contain asbestiform tremolite fibres in concentrations up to 230 mg/kg and 40 mg/kg product, respectively (NVWA, 2018).

A German investigation of 57 talc powders (technical and cosmetic) with regard to asbestos, asbestos fibres were detected in 13 samples (Mattenklott, 2007). In ten of the samples the weight content of asbestos ranged from 0.001 to 0.073%. In one talc powder analysed at two occasions, weight contents of 0.18 and 0.19% respectively. The report notes that it is essential to request sellers of talc and soapstone to furnish proof that no asbestos can be detected in the material with the specified analytical methods.

According to Eurotalc, the talc industry's representative body, "*Thanks to high standards of quality control and selective mining methods where necessary, the commercial talcs* *supplied by EUROTALC Members do not contain asbestos as defined by the European directive 2009/148/EC, when analysed by conventional methods*." (Eurotalc, 2021)

4.2.4 Volumes / Tonnage

As described in previous sections, 'new' asbestos is no longer legally manufactured or imported.

Historical use of asbestos

Exposure to asbestos from buildings, installations and older (<2005) articles is linked to historical use of asbestos. Various Member States have banned asbestos in various years before it was generally banned in the EU via various Council Directives and later the REACH Annex XVII entry 6 from 2006. The historical use of asbestos as well as the status of national bans in fourteen EU Member States and in the UK is summarised in Table 4.3. The indication of ban year is somewhat simplified as bans were generally introduced stepwise as also described for the EU restrictions in section 1.1.2. Based on data published by Kameda et al. (2014), asbestos was banned by thirteen[13] European countries before the year 2000 and further fifteen[14] countries have adopted the ban between the years 2001 and 2013.

One conclusion to draw is that the consumption varied by Member State with a tendency to higher consumption in Western Europe in the 1950-1970s and higher consumption in Eastern European Member States in the 1990-2000s. For some of the Member States, the ban on asbestos followed their accession to the EU. The differences may be reflected in difference in the presence of asbestos in e.g. means of transport (trains, vessels, vehicles, etc.) today as articles produced in countries where asbestos was banned 20-35 years ago to a higher extent would have reached their end-of-life than articles produced in countries where asbestos was banned after 2000.

Table 4.3 Historical trend in use of asbestos (kg per capita/year) and status of national bans in 15 EU countries

Country	1950s	1960s	1970s	1980s	1990s	2000s	Ban year **
Austria	1.16	3.19	3.92	2.08	0.36	0.00	1990
Denmark	3.07	4.80	4.42	1.62	0.09	NA	1986
Croatia	0.39	1.13	2.56	2.36	0.95	0.65	2013 *
Czech Republic	1.62	2.36	2.91	2.73	1.30	0.14	2005 *
Finland	2.16	2.26	1.89	0.78	ND	0	1992
France	1.38	2.41	2.64	1.53	0.73	0.00	1996
Germany	1.84	2.60	4.44	2.43	0.10	0.00	1993
Hungary	0.76	1.23	2.87	3.29	1.50	0.16	2005 *
Lithuania	ND	ND	ND	ND	0.54	0.06	2005 *

[13] These are Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Poland, Slovenia, Sweden and the United Kingdom.

[14] These are Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Luxembourg, Malta, Portugal, Romania, Slovakia and Spain.

Country	1950s	1960s	1970s	1980s	1990s	2000s	Ban year **
Luxembourg	4.02	5.54	5.30	3.23	1.61	0.00	2002
Netherlands	1.29	1.70	1.82	0.72	0.21	0.00	1994
Romania	ND	ND	1.08	0.19	0.52	0.55	2007 *
Spain	0.32	1.37	2.23	1.26	0.80	0.18	2002
Sweden	1.85	2.30	1.44	0.11	0.04	NA	1986
United Kingdom	2.62	2.90	2.27	0.87	0.18	0.00	1999

Sources: IARC, 2012; Kameda et al., 2014

ND: No data available; NA: not applicable because of negative use data; 0.00 when the calculated data were <0.0005.*

* The date follow the countries accession to the EU. A simplified view as some forms or applications may have been restricted before that day.

It can be noted that while asbestos has long been banned in the EU, it is still used in other parts of the world. According to the US Geological Survey (USGS, 2021), the estimated worldwide consumption of asbestos fibre has decreased from approximately 2 million tons in 2010 to roughly 1.2 million tons per year in the past several years. World production of asbestos in 2020 is estimated at approximately 1.2 million tonnes with Russia, Brazil, Kazakhstan, and China as the largest producer countries. Asbestos-cement products, such as corrugated roofing tiles, pipes, and wall panels, are expected to continue to be the leading global market for asbestos (USGS, 2021).

Asbestos in use today

A key question for the assessment of the future trend in exposed workforce is how much of the asbestos used in the past still remains in buildings, installations and products.

Data on products still in use has been obtained by the stakeholder consultation from Germany, Poland and Lithuania.

Germany. According to stakeholder consultation response from the German authorities, it is estimated that approx. 25-30 % of the building products containing asbestos are still installed. If there is no risk for the users of the building, there is no obligation to remove the materials. The national asbestos profile for Germany (BAuA, 2020) contain information on asbestos-cement still in use in Germany as summarised in the table below. The table, however, indicates that in 2016 up to 86% of the produced asbestos cement was still in use in the society. The national asbestos profile notes that the sum will overestimate remaining asbestos cement since also before 2001 some asbestos waste disposal took place.

As indicated in the table, 70% of the asbestos was used for asbestos cement production. According to the profile about 90% of the asbestos was used in buildings. For the part of asbestos used for other materials than asbestos cement, estimates on remaining amounts are not available.

Table 4.4 Estimated tonnage of remaining asbestos cement products

Import of asbestos (GDR & FRG):	**5.7 million tonnes asbestos**
70% used for asbestos cement production:	4.3 million tonnes asbestos
Asbestos cement production (10% crude asbestos):	43 million tonnes asbestos cement

Asbestos waste disposal: Asbestos-containing building materials (waste code 17 06 05):	6.1 million tonnes asbestos cement (2001 – 2016)
Asbestos cement - remaining*	37 million tonnes asbestos cement (2016) **

* This sum will overestimate the remaining asbestos cement since also before 2001 some asbestos waste disposal has prevailed. **BAuA 2020 indicates the year to be 2011, but this seems to be a missing update from previous profile, so it is here corrected to 2016.

Source: based on BAuA (2020)

The estimated remaining volume of asbestos cement products is in the profile used to estimate the remaining roof area containing asbestos in 2016. Using different assumptions regarding the share of the asbestos cement used for corrugated roofing it is estimated that in 2016 between 223 million m^2 and 1,308 million m^2 was still in use corresponding to 4 to 22% of the total corrugated roof area in Germany (BAuA, 2020).

As a result of the ban of asbestos in 1993, the use of asbestos in brake pads and clutches for the production of new vehicles on the roads in Germany was prohibited. In the former GDR, production of asbestos-containing brake pads and their use continued until 1989/90. Due to the nearly complete renewal of the vehicle fleet over a time span of about 20 years, it is expected that asbestos almost no longer occurs in vehicles (BAuA, 2020).

Poland. According to Pawelec (2017), it is estimated that from 1952 to 1997 1.75 million tonnes of raw asbestos were used in the manufacture of asbestos-containing products and in industrial installations in Poland. The largest share of asbestos (some 65%, mostly chrysotile) was used for asbestos-cement products assigned for the construction industry (such as flat and corrugated roofing sheets and wall linings). According to the author, some 1.2 billion m^2 of these products still existed in 2017. Crocidolite was used mostly for the manufacture of pressure pipes, one of more than 1,500 asbestos-containing products. In 2002, there was 15 million tons of inventoried asbestos in Poland. In addition, only 30 percent of asbestos-containing products in Poland are thought to have been inventoried, meaning that it is uncertain as to where the asbestos is located (Pawelec, 2017). Most of asbestos was used as roofing in private households.

According to the current statistics of the Polish database on asbestos-containing products, 8.3 million tonnes of products have been inventoried; of these 7.1 million tonnes remain to be neutralised (removed and disposed) corresponding to 85% of the inventoried asbestos-containing products, see table below. Flat and corrugated sheets for construction account for 97% of the inventoried and remaining asbestos-containing products. The percentage accounted for by the sheets may be over-represented as inventories of other asbestos-containing products likely are more difficult to survey.

Table 4.5 Data from the Polish asbestos database extracted 15 March 2021

Product code	Description	Weight of products in 1,000 tonnes			Percent remaining
		Inventoried	Neutralized	Remaining	
W01	Flat asbestos-cement plates used in construction	665.94	164.60	501.33	75%
W02	Corrugated asbestos-cement sheets for construction	7,405.84	1,017.01	6,388.86	86%
W03.1	Asbestos-cement pipes and joints for removal	106.04	6.83	99.22	94%
W03.2	Asbestos-cement pipes and joints to be left in the ground	79.46	4.63	74.83	94%

Product code	Description	Weight of products in 1,000 tonnes			Percent remain-ing
		Inventoried	Neutralized	Remaining	
W04	Spray insulations with asbestos-containing agents	21.44	7.73	13.71	64%
W05	Asbestos-rubber friction products	0.03	0.01	0.01	56%
W06	Special yarns, including processed asbestos fibres (protective fabrics and clothing)	0.12	0.08	0.05	37%
W07	Asbestos sealants	0.37	0.20	0.17	45%
W08	Woven and braided tapes, cords and strings	0.59	0.07	0.52	88%
W09	Asbestos and rubber products, except friction products	0.01	0.00	0.01	98%
W10	Paper, cardboard	0.21	0.06	0.15	72%
W11.1	Asbestos-cement covers	10.68	2.14	8.54	80%
W11.2	Asbestos-cement construction fittings (venti-lation ducts, window sills, flue gas covers)	0.32	0.17	0.15	47%
W11.3	Asbestos-cement electrical insulating fittings	0.00	-	0.00	100%
W11.4	PVC tiles	0.05	0.03	0.02	46%
W11.5	Fireproof boards	0.57	0.04	0.53	93%
W11.6	Roofing felt, putties and waterproofing com-pounds	0.02	0.00	0.02	95%
W11.7	household appliances	0.00	0.00	-	0%
W11.8	Work clothes, masks, filters contaminated with asbestos	0.04	0.01	0.03	82%
W11.9	Other not mentioned above	5.40	0.67	4.73	88%
W12.1	Secured roads	0.15	0.15	0.00	0%
W12.2	Unsecured roads	0.01	0.01	0.00	34%
	Total	8,297	1,204	7,093	85%

Source: Baza Azbestowa (2021)

According to the database on asbestos-containing products in **Lithuania**, some 1.2 million tonnes of asbestos-containing products in buildings were present in the country in 2018 (AAA, 2021)

The technical lifespan of the ACMs can be used as an indicator of when the materials are expected to be removed. According to the Spanish association of asbestos-removal com-panies (Anedes), 65% of the ACM would have reached the end of their technical life in 2020, 87% in 2030 and 100% in 2040. (AAA, 2021)

The past trend in the quantities of waste containing asbestos may be used as an overall indicator of the past trend in activities involving removal of asbestos and may be used as background for the estimate on future trends. Data from the Danish Waste statistics for the five specific asbestos-containing waste categories, for which data are reported, show for the period 2011 to 2019 an increasing trend in the total quantities from 73,000 tonnes in 2011 to 97,000 tonnes in 2019. For brake pads containing asbestos a decreasing trend is observed and in 2019 asbestos-containing brake pads still accounted for approximately 20% of the total registered amount of brake pads. In addition to the listed categories some ACMs may incorrectly be disposed of in other waste categories, but no data are available on the asbestos content of other categories. If the *per capita* remaining quantities of asbestos cement in Denmark is similar to the quantities reported for Germany above (the overall consumption in the countries was similar), then it would take about 25 years at the 2019 level of activity to dispose of all remaining ACMs in Denmark.

A similar increasing trend in total quantities in asbestos-containing building waste is observed in Germany, but for brake linings the registered tonnage in Germany has been zero since 2007 (BAuA, 2020). In 2017 the total amount of asbestos-containing waste was 475,000 tonnes. The remaining quantities of asbestos-cement in 2016 correspond to disposal for a period of 77 years at the 2017 level. As quoted above, according to the Spanish association of asbestos-removal companies, nearly 100% of the ACMs would have reached the end of their lifespan in 2040 and it is expected that the majority of the remaining asbestos will have been removed within the next 20 years.

Table 4.6 Development in the quantities of asbestos-containing waste in 1,000 tonnes/year

Waste code	Description	2011	2012	2013	2014	2015	2016	2017	2018	2019
06 13 04	Wastes from asbestos processing	0.001	0	0	0	0	0	0	0	0.002
16 01 11	Brake pads containing asbestos	0.09	0.04	0.06	0.04	0.06	0.11	0.05	0.02	0.02
17 06 01	Insulation material containing asbestos	0.04	0.00	0.04	0.14	0.27	0.04	0.67	0.60	0.48
17 06 05	Construction material containing asbestos	58	53	62	73	75	76	84	85	90
17 06 06	Construction material containing asbestos - dusty	14	9	8	8	8	4	3	4	6
Total		73	62	70	81	82	80	88	89	97

Source: extract of raw data from the Danish Waste Statistics (2019)

4.2.5 Where can workers be exposed to asbestos today?

Based on the above discussion, current critical exposure is related to process-generated airborne asbestos fibres. These can originate from natural sources (asbestos being a mineral in some soils and bedrock) or from ACM due to historical use of asbestos.

4.2.5.1 Exposure to asbestos in buildings and infrastructure materials and installations

Exposure to *in situ* asbestos in buildings and infrastructure materials and installations is assumed to be the main source of asbestos exposure today.

The French Agency for Food, Environmental and Occupational Health & Safety (ANSES) lists the following as the main professions at risk of inhalation of asbestos dust (ANSES, 2021):

Workers in asbestos removal companies;

Building and public works employees;

Building and public works (construction sector) personnel involved in demolition or refurbishments;

Light work building professionals, repair and maintenance staff (plumbers, electricians, heating installers, painters, etc.);

Workers in waste treatment activities;

- Workers at asbestos-bearing sites.

Levels of exposure will depend on the activity around the asbestos and the applied risk management measures will depend on whether the involved workers are aware of the presence of exposure. The exposure situations most relevant for the EU workforce are therefore divided into the following categories:

Exposure situations during renovation and demolition of buildings and other infrastructure with ACMs which are **subject to notification** to the authorities. Potentially exposed workforce includes workers in companies specialised in demolition or more specifically in asbestos removal, but especially for renovation activities, also general construction workers and other craftsmen can be involved. Data on these activities (concentrations and exposed workforce) are available from databases with notified asbestos work.

Exposure situations during renovation and demolition of buildings and other infrastructure **subject to the Article 3(3) of the AWD exemption**. In these situations, the authorities are not notified and data for these exposure situations would not be included in databases of notified asbestos work. Potentially exposed workforce could be almost any type of craftsman, including plumbers, carpenters, electricians and bricklayers, as well as general caretakers of buildings.

'Incidental' exposure. In these situations, the worker might not beforehand be aware that asbestos is present, and some workers might not know when they encounter asbestos. Examples of 'incidental' exposure could be drilling through insulation materials of ceilings containing asbestos. Potentially exposed workforce could be the same occupations mentioned under the bullet above. In the case where the worker becomes aware of the asbestos-containing products, the work should be stopped, and a risk assessment should be undertaken to clarify which of the two situations mentioned above applies. 'Incidental' exposure is in this assessment included in exposure situations during renovation and demolition of buildings and other infrastructure subject to the Article 3(3) of the AWD exemption.

'Passive' exposure. Working in structures/buildings with asbestos-containing products may lead to exposure to asbestos from ACMs.

The three situations within the scope of the study are summarised in Table 4.7.

4.2.5.2 Exposure to asbestos in trains, cars, vessels, aircraft and other articles

Occupational exposures to asbestos releases from old (<2005) articles may still be relevant in some situations. This could be, for example, during repair work of brakes in old vehicles.

There might also be release of asbestos from brakes in old trains leading to passive exposure of train personnel. Exposure to asbestos in trains and ships might resemble the above situations, although it shall be noted that demolition of ships will normally not take place in Europe.

Guidelines from The Industry's Work Environment Council in Denmark on asbestos in ships (I-Bar, 2010) describe the various ACMs in ships and the exposure situations. The guidelines note that asbestos and ACMs have been used extensively on ships. It was used in particular as insulation against heat, cold, moisture and fire. Furthermore, it was also used for sound insulation and vibration inhibition. It was used in engine parts, in flooring, oil and water pipes and as a spark arrestor in electrical switchboards, in fire doors and as elevator brakes, surface cladding in relation to constructive fire protection of crew hatches, on the bridge, in galleys and to an extensive extent as parts in engines (friction linings, gaskets, impellers, liners, etc.). Finally, asbestos is seen in relation to all kinds of pipe systems, boilers and containers. The guidelines note that asbestos in many Eastern European countries, and in particular in Russia, was used in ships until 1990.

Contrary to the uses in buildings, asbestos cement was not used in significant amounts in ships and other means of transport and the exposure situations when removing asbestos from articles are estimated mainly be similar to high-exposure situations in buildings.

4.2.5.3 Exposure by waste management

Council Decision No. 573 of 23 July 2001, amending Commission Decision 2000/532/EC as regards the list of wastes, classifies construction waste containing asbestos as a hazardous. This includes construction waste containing asbestos that is embedded in the binder matrix (e.g. asbestos cement).

Exposure may take place during collection of the waste (e.g. in waste collection points), handling of the waste before transport, transport to collection point and disposal facility and handling at disposal facility.

The actual handling and exposure situations will be different for the different waste types and depend on to what extent the waste is properly packed before handed over to the waste collection points and disposal facilities.

Waste containing asbestos should according to the AWD be packed in suitable sealed packing with labels indicating that it contains asbestos (does not apply to mining activities). The waste is to be kept separate from other wastes so as to avoid mixing with other materials that would enlarge the amount of asbestos containing waste or that would result in the asbestos content remaining unknown. In this process, local waste disposal regulations are to be adhered to.

In principle, when the asbestos waste is packed correctly, the exposure of workers involved in waste management would be minimal, but available data, e.g. from the Italian SIREP database, indicate that some exposure still occurs.

Exposure may, among others, take place when the waste is not packaged properly, when the package is broken e.g. in waste collection containers, whilst cleaning in areas where asbestos waste is stored and where packaging had been broken, and during landfilling of the asbestos-containing waste.

For example, the procedures for disposal of asbestos-containing waste at local waste collection centre in Denmark changed from 1 January 2021 in order to further protect the employees at the centres because the exposure levels had been too high with the practice used until 2021.

4.2.5.4 Exposure to naturally occurring asbestos

As noted by ECHA (2021) asbestos fibres are naturally occurring minerals, are widespread in the environment, and "*are found in many areas where the original rock mass has undergone metamorphism. Therefore, even if intentional commercial uses are banned and handling of past commercially used products is regulated, exposure is possible when handling other minerals (e.g. talc, dolomite and olivine) where asbestos occurs as an impurity. Some of these minerals are in granular or powder form and they relatively easily aerosolise during handling. Therefore, attention is needed in such industries. In experimental studies mixtures of asbestos in dry soils with asbestos content as low as 0.001% were able to produce airborne respirable asbestos concentrations greater than 0.1 fibres/cm^3 in dust clouds where the overall respirable dust concentrations were less than 5 mg/m^3 (Addison et al., 1988). However, occurrence of asbestos as an impurity is not limited to the above granular or powder type minerals. In a Finnish geological survey, fibrous minerals, including asbestos (e.g. tremolite and actinolite), were detected in many limestone mines and rock aggregate quarries (Junttila et al., 1994). More recently, airborne asbestos concentrations of 10-50% of the current national OEL (0.1 fibres/cm^3) have been measured in some mines in Finland (FIOH, 2020a). Compared to asbestos removal work, the awareness of potential asbestos-related risks is lower in the mining industry and related activities; consequently risk management guidelines were recently published (Kahkonen et al., 2019). Depending on the mineralogical characteristics of the bedrock and soil, situations similar to the Finnish example may occur also in other countries*."

It is important to stress that 'mining' is not asbestos mining but mining of other materials which might contain asbestos as a naturally occurring 'impurity'.

Exposure to naturally occurring asbestos may take place in the following activities:

- Mining and quarrying;
- Tunnel construction;
- Road construction and similar activities where raw materials with asbestos impurities are used; and
- Work with raw materials with asbestos impurities (stones, etc.).

4.2.5.5 Persons carrying out asbestos sampling and measurements

Exposure to asbestos may occur when samples are taken in order to determine the asbestos concentration in materials and air. When samples are taken of materials e.g. by use of a knife, small amounts of dust may be formed. In the laboratory, staff may be exposed to dust in particular when working with the samples.

Samples of asbestos in air are taken both for monitoring of asbestos exposure and for site clearance check. In order to set up for the stationary sampling the person responsible for the sampling needs to enter the contaminated site and would be exposed for the asbestos is the air at the site.

4.2.5.6 Summary table

The grouping of activities for the analysis is summarised in the table below. The table furthermore summarises the main NACE activity codes for each group. As asbestos may potentially be found in any type of house or industrial installation build before asbestos was banned, the list of potential NACE codes would be quite extensive. Maintenance workers in all kind of industries, utility companies, institutions, residential houses, etc. may occasionally be exposed to asbestos. The listed NACE codes represent the main NACE codes on the basis of databases of notified activities and the occupational groups expected to be exposed at a level above the assessed OEL options.

Table 4.7 Overview of worker exposure situations and main NACE codes

#	Exposure group	Worker population	Main NACE codes
1	Building and construction - exposure situations subject to notification	Workers in asbestos removal companies, demolition companies, entrepreneur companies, craftsmen, workers in industries where asbestos occurs	F41.20 Construction of residential and non-residential buildings F43 Specialised construction activities: F43.11 Demolition F43.12 Site preparation F43.21 Electrical installation F43.22 Plumbing, heat and air conditioning installation F43.29 Other construction installation F43.33 Floor and wall covering F43.34 Painting and glazing F43.39 Other building completion and finishing F43.91 Roofing activities F43.99 Other specialised construction activities n.e.c.
2	Building and construction - exposure situations subject to Article 3(3) exemptions. 'incidental exposure'	Largely craftsmen such as plumbers, carpenters, electricians and bricklayers, as well as general caretakers of buildings	F41.20 Construction of residential and non-residential buildings F43 Specialised construction activities: F43.22 Plumbing, heat and air conditioning installation F43.29 Other construction installation F43.33 Floor and wall covering F43.34 Painting and glazing F43.39 Other building completion and finishing F43.91 Roofing activities F43.99 Other specialised construction activities n.e.c.
3	Building and construction - passive exposure in buildings	Workers in old office buildings, schools, industry, etc. with ACMs (e.g. wear from ceilings)	In principle, a large number of NACE codes (see further discussion on exposure levels)
4	Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	Workers in asbestos removal companies, renovation and refurbishment of means of transport, sailors, etc. In general, the activities would be subject to notification	C33.14 Repair of electrical equipment C33.15 Repair and maintenance of ships and boats C33.16 Repair and maintenance of aircraft and spacecraft C33.17 Repair and maintenance of other transport equipment G45.2 Maintenance and repair of motor vehicles repair of motor vehicles and motorcycles

#	Exposure group	Worker population	Main NACE codes
5	Waste management and remediation activities	Workers involved in transport and disposal of asbestos-containing waste The activities may be subject to notification or exempted	E36.00 Water collection, treatment and supply E38.11 Collection of non-hazardous waste E38.12 Collection of hazardous waste E38.22 Treatment and disposal of hazardous waste E38.31 Dismantling of wrecks E38.32 Recovery of sorted materials E39.00 Remediation activities and other waste management services (includes asbestos, lead paint, and other toxic material abatement)
6	Mining and quarrying - naturally occurring asbestos	Workers in extraction of asbestos-containing minerals Use of tack powder in manufacture of rubber	B08.11 Quarrying of ornamental and building stone, limestone, gypsum, chalk and slate C22.19 Manufacture of other rubber products
7	Tunnel naturally occurring asbestos	Workers involved in tunnel construction (drilling in asbestos-containing rocks)	F42.11 Construction of roads and motorways F42.12 Construction of railways and underground railways F42.13 Construction of bridges and tunnel
8	Road construction - partly naturally occurring asbestos	Workers involved in use of asbestos-containing construction materials Workers involved in maintenance of roads intentionally added asbestos in the past Mixing of asphalt	F42.11 Construction of roads and motorways F42.12 Construction of railways and underground railways C23.99 Manufacture of other non-metallic mineral products n.e.c. (mixing of asphalt)
9	Sampling and analysis	Workers involved in sampling of ACMs or asbestos in air Not subject to notification if the exposure is below the OEL	M71.20 Technical testing and analysis

Sources: Eurostat; developed by the study team

4.3 Exposure concentrations

As discussed in various sections of Chapter 2, there are significant differences in potency among the different types of fibres.

The past use of the different types of asbestos can be summarised as follows (Pira et al., 2018):

- Chrysotile (also known as white asbestos) was the most commonly used; accounting for 95% of all uses;
- Other types which have been used are crocidolite (blue asbestos), amosite (brown asbestos) and anthophyllite; all having stronger mechanical and chemical resistance than chrysolite;

- Actinolite and tremolite may be only present as natural pollutant.

According to stakeholder consultation from DGUV, tremolite was also used as a fibrous raw material ("asbestine") for the production of anti-corrosion paints e.g. for ships.

As only one common ERR used for the calculation of cases has been established and the broader datasets used for the estimation of exposure concentrations generally aggregate all data and do not provide specific datasets for each type of asbestos, the analysis in this section does not differentiate between different fibre types.

The AWD specifies that Phase Contract Microscopy (PCM) or another method giving equivalent results should be applied. As is further described in section 4.9, the sensitivity of different measurement techniques (especially the analytical method applied) varies. Where the information is available, the description in the sections below indicates which of the the analytical method that have been applied for measuring asbestos exposure: Phase Contrast Microscopy (PCM), Scanning Electron Microscopy (SEM) or Transmission Electron Microscopy (TEM). As discussed in section 4.9, no simple conversion factor for conversion of results between the different analytical method exists (this varies e.g. by concentration and interfering fibres) and no attempt has been done to convert the results obtained by TEM or SEM into the expected PCM concentration. In some legislative contexts, a conversion factor of 2 between PCM and TEM is used because TEM measurements usually include thinner fibres, but the available data (as discussed in section 4.9) indicate that the actual differences between the methods depend on a number of factors.

Exposure concentrations are available from various sources: the questionnaire for this study's survey, Member State surveillance programmes (German, French, Italian and Finnish exposure databases), scientific papers, the IARC monograph on asbestos, and other sources. A wealth of data on exposure concentrations in the past, where asbestos was still intentionally used, are available, but these data are in general considered outdated except for those exposure situations where exposure to asbestos still occurs.

In total, 107 responses have been obtained through stakeholder consultation for this study. These can be divided by Member State as follows: Austria (1), Cyprus (2), France (97), Germany (1), Greece (1), Hungary (1), Spain (1), Romania (1) and Brazil (2). The data from Brazil are not further evaluated. The responses from France represent companies with a total of 8,769 employees of which 43% are exposed to asbestos. The responses for other Member states represent in total 52 employees of which 90% are exposed to asbestos (except for a chemical company with 2,900 employees, but none of the employees are exposed to asbestos as all asbestos work is outsourced). In terms of number of exposed employees, the responses from France represent 99% of the total. The responses first of all provide input for the further impact assessment and the assessment of the actual RMMs used. Most responses are within sectors where data on exposure concentrations are available from published sources.

For the presented datasets, the OELs in the relevant Member States during the measurement period are indicated as the OEL in force has some influence on the representativity of the data in an EU-wide context.

As asbestos is no longer intentionally used, the exposure pattern for asbestos is much different from many other hazardous substances such as those assessed in previous studies of the impact of establishing new OELs under the CMD. The same workers may over time be involved in many different exposure situations with different asbestos exposure concentrations depending on the materials handled. This means that the same worker may be involved in activities ranging from the lowest to the highest exposure concentrations. The same exposure situations may occur when the same materials are removed from buildings, industrial installations, trains, ships, etc. The work may be undertaken by specialised companies or by workers where the asbestos is located, e.g. maintenance and repair workers in the industrial installations. Consequently, the workers may be within different sectors although the actual activities are the same. This means that it is challenging to establish a distinct relationship between exposure situations, exposure concentrations and sectors.

Practically all workers involved in the management of ACMs wear RPE and, for the estimation of cases and benefits, it is consequently necessary to take the protection factor of applied RPE into account. However, no comprehensive and representative datasets, where the use RPE is indicated are available from Member States' national databases or from industry associations. In order to establish realistic exposure distributions, it has therefore been necessary to estimate the most likely statistical parameters by combining various information from different existing sources. For each exposure group, the following sections first present the available data and afterwards for each exposure group establish what is considered the most likely EU-wide distribution of exposures when RPE has been taken into account.

The presented exposure concentrations represent the average figures for all Member States. France, Germany and the Netherlands (representing 37% of the total population) are considered to have lower concentrations than the remaining Member States as a consequence of lower current OELs. However, no actual data are available that allow for estimating Member State specific exposure concentration distributions. By estimating the distributions of the concentrations where RPE is taken into account, it has been assumed that the majority of companies are in compliance with the national legislation and it has been taken into account that the companies in the three above-mentioned Member States have to comply with lower limit values.

4.3.1 Exposure to asbestos in buildings and construction

Exposure to asbestos in buildings, infrastructure materials and installations is divided into three exposure groups. It should be noted that activities within this category may not necessarily be undertaken by companies registered within the building and construction sector but some activities may be undertaken by the building owners' own staff and consequently, the activities may be registered within many sectors. As shown in Table 4.12, about 5% of all notifications in France were within a large number of sectors such as 'Real estate activities', 'Activities of head offices management consultancy activities', 'Manufacture of basic metals', and 'Electricity, gas, steam and air conditioning supply'. As data are not available at sector level, this report provides a more robust aggregate estimate across all activities within building and construction. However, for the further impact assessment under this study, it has been taken into account that activities involving exposure to asbestos are undertaken within a large number of sectors.

4.3.1.1 Building and construction - Exposure situations subject to notification

Exposure data from national databases have been identified from Italy, France, and the Netherlands. According to the AWD, activities with exposure to asbestos must be covered by a notification system administered by the responsible authority of the relevant Member State. The data in the databases are based on notifications to national databases and the major part of these represent exposure situations in the building and construction sector.

Italy. The OEL for asbestos in Italy is 0.1 fibres/cm^3. Scarselli et al. (2020) present data centrally collected and stored in the SIREP database by the Italian workers' compensation authority (INAIL) on exposed workers that firms involved in activities entailing the risk of asbestos exposure are required to register. The data presented are collected from the companies' registries of workers exposed to asbestos over the period 1996–2016. Overall, 19,704 measurements of asbestos fibres in the air were selected for the analysis, corresponding to 8,938 asbestos exposure situations. The full datasets are shown in the table below, but data for other sectors are discussed in the subsequent sections.

Overall, 46,422 workers (86% male) were estimated potentially at risk of exposure to asbestos in the selected industrial sectors in Italy. The data on exposed workforce by sector are further described in section 4.4.1.

The overall GM (geometric mean) of the airborne asbestos fibre concentration measured in the period 1996–2016 was equal to 0.0079 fibres/cm^3 (n=19,704, GSD = 0.0096 fibres/cm^3), while the AM (arithmetic mean) was equal to 0.046 fibres/cm^3 (SD = 0.145 fibres/cm^3).

For measurements (n=1,333) that were below the analytical limit of detection (LOD), the <LOD measurements was replaced with estimated values based on their rank among the set of detected values. All air sampling measurements were collected over an 8-h work shift (full shift time-weighted average). The type of sampling methodology (personal or stationary) was reported in a limited number of measurements (less than 4%), thus not usable for the analysis. Most of the measurements were carried out using PCM (60% of measurements), that is one of the analytic methods indicated by the Italian law as the standard technique to count airborne asbestos fibres per unit volume. Only sectors and occupations having more than 50 measurements were considered for the analysis. The authors of the study note that most firms voluntarily reported the levels of asbestos fibre to the SIREP, whereas notification of the register is mandatory by law only for exposures exceeding 0.01 fibres/cm^3, leading to an inhomogeneous data coverage.

The asbestos exposure by economic activity sector and calendar period is shown in Table 4.8. The paper shows the data for seven time periods; of these only the first, last and medium of the periods and the overall data (data from all periods) are shown in the table. The number of measurements is indicated for the entire period and not presented for each period. The historic data are used later in the discussion of the past trend in exposure concentrations for the estimation of current disease burden in section 4.13. The results are not adjusted for the use of RPE.

Notably, for many of the sectors the concentration did not decrease significantly over the reporting period. The study does not indicate to what extent RPE is used and if the use of RPE may have improved over time, so the effective exposures of the workers have decreased.

All data presented by job-task are within the overall NACE rev 1[15] codes 45 (Construction, NACE rev 2: 43) and 90.00 (Sewage and refuse disposal, sanitation and similar activities; NACE rev 2: 36-39). Please note that the study uses the older NACE rev 1 codes in order to compare historic and more recent data whereas NACE rev 2 is used for the estimation of workforce described in section 4.4.1. The NACE rev 1 cannot be converted to NACE rev 2 as one-to-one and has therefore not been converted. Notably, the data on exposure do not include technical testing and analysis of products (NACE rev 2: 71.20), which represent about 8% of the exposed workforce in Italy (see section 4.4.1). The data on waste management are further discussed in section 4.3.3, but shown here for comparison.

Table 4.8 Descriptive statistics of asbestos exposure by economic activity sector and calendar period (SIREP, 1996–2016). Data in fibres/cm^3.

Economic activity sector (NACE Rev 1 code)	Overall (1996-2016)			1996–1998		2005–2007		2014–2016	
	n	GM (GSD)	AM (SD)	GM (GSD)	AM (SD)	GM (GSD)	AM (SD)	GM (GSD)	AM (SD)
Demolition and wrecking of	1,677	0.0036 (0.003)	0.0081 (0.0033)	no data	no data	no data	no data	0.006	0.016

[15] List of NACE Rev1 codes, available at: https://ec.europa.eu/eurostat/documents/3859598/8634073/CA-80-93-436.pdf/bd973dfc-cb58-478e-ae7f-2b0b5763a491?t=1517396135000

Economic activity sector (NACE Rev 1 code)	Overall (1996-2016)			1996–1998		2005–2007		2014–2016	
	n	GM (GSD)	AM (SD)	GM (GSD)	AM (SD)	GM (GSD)	AM (SD)	GM (GSD)	AM (SD)
buildings; earth moving (45.11)									
General construction of buildings engineering works (45.21)	1,149	0.047 (0.0044)	0.017 (0.097)	no data	no data	0.0035 (0.008)	0.027 (0.076)	0.013 (0.003)	0.020 (0.015)
Erection of roof covering and frames (45.22)	1,454	0.0017 (0.0088)	0.014 (0.045)	0.0017 (0.0088)	0.0136 (0.0447)	0.0033 (0.0146)	0.0230 (0.0410)	0.0057 (0.0174)	0.134 (0.391)
Other construction work involving special trades (45.25)	8,824	0.0208 (0.0079)	0.0758 (0.183)	0.0098 (0.0368)	0.636 (1.305)	0.008 (0.0047)	0.0403 (0.165)	0.0615 (0.0035)	0.086.1 (0.033.4)
Insulation work activities (45.32)	1,239	0.0016 (0.0086)	0.0067 (0.0143)	no data	no data	0.0045 (0.0092)	0.0090 (0.020.7)	0.0002 (0.0066)	0.0011 (0.0020)
Other building installation (45.34)	87	0.0088 (0.0043)	0.0227 (0.0316)	no data	no data	0.0175 (0.0017)	0.0209 (0.016.2)	0.0188 (0.0048)	0.0459 (0.0506)
Other building completion (45.45)	194	0.0028 (0.178)	0.0341 (0.0450)	no data	no data	0.0009 (0.0136)	0.0207 (0.039.7)	0.0051 (0.0284)	0.0413 (0.0470)
Sewage and refuse disposal, sanitation, similar activities (90.00)	4,926	0.0037 (0.0093)	0.0224 (0.0991)	0.0244 (0.0050)	0.0487 (0.0475)	0.0027 (0.0049)	0.0126 (0.0704)	0.0460 (0.0065)	0.0815 (0.0371)

** GSD: geometric standard deviation. SD: Standard deviation.*

Source: Scarselli et al. (2020)

Note: Original dataset include data from the time periods in-between.

The trend in exposure levels by overall job task over the period from 1996 to 2016 is further illustrated in the table below. The paper includes a further sub-division on job task; only the overall groups are shown in the table below. For two main job tasks, asbestos fibre-cement and insulation removal operators, the GM halved over the period while the AM decreased from 0.597 fibres/cm^3 in 1996-98 to 0.054 fibres/cm^3 in 2014-16. For the two other job tasks, a less clear reduction pattern can be established. For ACMs disposal workers, the highest GM was recorded for 2014-16. The data on waste management are further discussed in section 4.3.3 but shown here for comparison.

Table 4.9 Descriptive statistics of asbestos exposure by job task and calendar period (SIREP, 1996–2016). Data in fibres/cm³.

Job task	Overall (1996-2016)			1996–1998		2005–2007		2014–2016	
	n	GM (GSD)	AM (SD)	GM (GSD)	AM (SD)	GM (GSD)	AM (SD)	GM (GSD)	AM (SD)
Asbestos fibre-cement removal operators	14,595	0.0081 (0.0118)	0.0544 (0.173)	0.0196 (0.0273)	0.597 (1.252)	0.0045 (0.0092)	0.0283 (0.143)	0.0077 (0.0194)	0.0543 (0.0935)
Insulation removal operators	3,666	0.0062 (0.0048)	0.0234 (0.0671)	no data	no data	0.0067 (0.0059)	0.0205 (0.0316)	0.0153 (0.0085)	0.0545 (0.0504)
Asbestos-containing materials disposal workers	882	0.0113 (0.0078)	0.0452 (0.0479)	0.0051 (0.0019)	0.0065 (0.0058)	0.0084 (0.0064)	0.0353 (0.0463)	0.0118 (0.0084)	0.0459 (0.0489)

** GSD: geometric standard deviation. SD: Standard deviation. The paper indicates standard deviation and geometric standard deviation as well for each period.*

Source: Scarselli et al. (2020)

The size of companies is not indicated but summarised in a previous study of Scarselli et al. (2016) who summarises the results of 15,860 asbestos measurements from the same database for the period 1996-2013. According to this study 78% of these measurement data were sent by micro (<10 employees) and small-sized (10-20 employees) companies. The percentages for other size classes are not reported. In addition to the statistical parameters presented in Scarselli et al. (2020), also P75 (75% percentile) and 95% confidence intervals to the GM are presented in Scarselli et al. (2016). These are further considered in the assessment of representative exposure concentrations in this study.

France. The current OEL for asbestos in France of 0.01 fibres/cm³ went into force 1 July 2015; the previous limit was 0.1 fibres/cm³. Since 1 July 2012, the prescribed method for compliance testing in France has been TEM where the fibres counted include also thin asbestos fibre.

Data on exposure to asbestos in France as reported to the SCOLA database have been summarised by the French National Research and Safety Institute for the Prevention of Occupational Accidents and Diseases (INRS, 2020). The data cover the period 1 July 2012 to 31 December 2019. The data thus cover periods where the OEL has been 0.01 and 0.1 fibres/cm³, respectively. During this period, 273,000 analytical results from 5,327 enterprises have been entered into the database. The summary of the results is provided in an excel file. The data file summaries the data divided on 2 overall activities ('retrait/encapsulation' or 'intervention'), different materials, different techniques used, different types of wet work, and different categories of capture at the sources. In total, the data are summarised in 2,227 different processes (combinations of parameters). It is not possible to assess concentrations in relation to sector and categories applied in this report. The spreadsheet consists of 98,000 data, aggregated by process categories which does not allow further analysis on groups and sectors.

All fibre counts were performed by transmission electron microscopy (META in French = TEM) as recommended by standard NF X 43-269 of December 2017 and in accordance with standard NF X 43-050. The results using TEM may differ from the results using PCM as further discussed in section 4.9.

At the end of a quality control process excluding 65% of results, 98,172 of the 273,118 results were selected for analysis. The overall descriptive statistics is shown in the table below.

RPE was used in 93% of the reported measurements while for 3% it was reported that RPE was not used, for 1% it was reported that the RPE was not adequate and in 3% it was not reported whether RPE was used. It is not indicated if the exposure concentrations were lower in those instances where RPE was not applied.

The results are not weighted for the use of RPE.

The descriptive statistics of the results of individual samples from the most recent and the previous report is shown in the table below. Notably the AM is higher than the P75 showing the high contribution to the AM from a relatively few measurements at very high concentrations. Due to the use of RPE, situations with very high concentrations have a higher protection factor, the distribution of the data will be significantly different if the concentrations are adjusted for the use of RPE.

Table 4.10 Overall descriptive statistics of the results of individual samples from the French SCOLA database; in fibres/cm³.

Years	n	AM	Min	P25	Median, P50	P75	Max
2012-2018	76,681	399	<0.000001	0.0058	0.0025	0.118	204.274
2012-2019	98,172	365	<0.000001	0.0039	0.0018	0.093	204.274

** GM and P95 is not provided for the full dataset, but available for each of the 2,227 different processes.*

Source: (INRS, 2020; INRS 2019a)

The breakdown of notifications by company sizes shows that 22% of notifications were from companies with <10 employees, 18 % from companies with 10-19 employees, 56 % from companies with 20-249 employees and 4% from companies >249 employees. In total, SMEs represented 96 % of the notifications. The distribution in terms of number of companies is not provided.

The data are divided into two subsections: Sub-section 3: removal or encapsulation, and sub-section 4: Intervention (i.e. where the material is not removed or encapsulated but otherwise disturbed).

The overall distribution of the measurements by concentration classes is shown in the table below. Data are shown for two periods 2012 - 2016 and 2012 - 2019. The data for 2012 - 2019 do not seem to fit with the distributions shown above (more than 50% should be below 0.1 fibres/cm³), whereas the 2012-2016 data are more in line with the distributions. The data for 2012 - 2019 seems not to be in accordance with the distributions shown above, but it has not been possible to obtain an explanation for the inconsistencies. It has neither been possible to obtain an explanation for the significant increase in concentrations from 2012-2016 to 2012 - 2019.

Table 4.11 Distribution of measurements 2012-2016 by concentration classes and sub-sections

	2012 - 2016		2012 - 2019	
Level *	Sub-section 3 % of all measurements	Sub-section 4 % of all measurements	Sub-section 3 % of all measurements	Sub-section 4 % of all measurements
N1 (< 0.100 fibres/cm³)	68.3%	76.4%	14%	41%
N2 ([0.1 - 6.0[fibres/cm³)	30.1%	22.4%	75%	56%

	2012 - 2016		2012 - 2019	
Level *	**Sub-section 3 % of all measurements**	**Sub-section 4 % of all measurements**	**Sub-section 3 % of all measurements**	**Sub-section 4 % of all measurements**
N3 ([6.0-25.0[fibres/cm^3)	1.4%	1.2%	9%	3%
>N4 (>=25.0 fibres/cm^3)	0.2%	0.0%	2%	0%

** The levels refer to the French risk levels until 1 July 2015 - information on recommended RMMs for the risk levels is provided in section 4.5.*

Sources: (Lesterpt and Leray, 2017) and 2012-2019 (INRS, 2020).

Exposure concentrations by sector are not reported but number of companies, notifications and measurements are reported. The table below shows number of companies and notifications by sector. The number of notifications gives an indication of the extension of the asbestos removal activities in the different sectors.

Table 4.12 Number of companies and dossiers compiled in the French SCOLA database 2012-2020

NAF	Activity	Number of companies	% of total	Number of dossiers	% of total
43	Specialised construction activities	2,528	45%	90,849	46%
39	Remediation activities and other waste management services	603	11%	67,615	34%
42	Civil engineering	458	8%	7,101	4%
41	Construction of buildings	274	5%	5,923	3%
38	Waste collection, treatment and disposal activities; materials recovery	149	3%	5,738	3%
71	Architectural and engineering activities; technical testing and analysis	324	6%	3,331	2%
64	Financial service activities, except insurance and pension funding	40	1%	1,899	1%
81	Services to buildings and landscape activities	99	2%	2,059	1%
49	Land transport and transport via pipelines	85	2%	1,457	1%
74	Other professional, scientific and technical activities	37	1%	1,909	1%
33	Repair and installation of machinery and equipment	123	2%	1,584	1%
46	Wholesale trade, except of motor vehicles and motorcycles	60	1%	1,062	1%
25	Manufacture of fabricated metal products, except machinery and equipment	64	1%	783	0.4%
08	Other mining and quarrying	29	1%	505	0.3%

NAF	Activity	Number of companies	% of total	Number of dossiers	% of total
68	Real estate activities	82	1%	442	0.2%
70	Activities of head offices; management consultancy activities	41	1%	458	0.2%
37	Sewerage	23	0.4%	406	0.2%
24	Manufacture of basic metals	10	0.2%	464	0.2%
35	Electricity, gas, steam and air conditioning supply	93	2%	324	0.2%
28	Manufacture of machinery and equipment n.e.c.	29	1%	343	0.2%
20	Manufacture of chemicals and chemical products	20	0.4%	281	0.1%
52	Warehousing and support activities for transportation	35	1%	330	0.2%
84	Public administration and defence; compulsory social security	77	1%	180	0.1%
30	Manufacture of other transport equipment	26	0.5%	203	0.1%
94	Activities of membership organisations	16	0.3%	193	0.1%
82	Office administrative, office support and other business support activities	22	0.4%	172	0.1%
36	Water collection, treatment and supply	22	0.4%	127	0.1%
66	Activities auxiliary to financial services and insurance activities	4	0.1%	233	0.1%
ZZ	Not classified	20	0.4%	165	0.1%
45	Wholesale and retail trade and repair of motor vehicles and motorcycles	12	0.2%	131	0.1%
23	Manufacture of other non-metallic mineral products	22	0.4%	113	0.1%
77	Rental and leasing activities	9	0.2%	103	0.1%
	Other	185	3%	543	0.3%
	Total	**5,621**		**197,026**	

Note: (translated from French, based on INRS 2020).

Eypert-Blaison et al. (2018) have summarised the results of a large field-study using TEM to characterise occupational exposure to asbestos fibres during work on ACMs. The dataset is the only larger dataset identified where exposure concentrations when RPE is taken into consideration is reported. The primary objective of the study was to establish a method and to validate the feasibility of using TEM for the analysis of airborne asbestos of individual filters sampled in various occupational environments and compare the results to those obtained by PCM, the WHO-recommended reference technique. A total of 265 results were obtained from 29 construction sites where workers were in contact with ACM. No simple relationship was found between results by PCM and TEM counting methods. The study showed that the TEM/PCM ratios vary depending on the nature of the asbestos fibres considered, the material, and the technique used. Depending on the process used, RPE with assisted ventilation was worn (overpressure), e.g. TM3P-type devices with an assigned protection factor (APF) of 60, or external air-supply devices with an APF of 250. Each measurement was divided by the APF of the RPE worn on the site. The average protection factor for each material/removal technique is shown in the table, calculated on the basis of the reported data.

The data were collected in 2009-2010 and represented the situation at a time in which the OEL in France was 0.1 fibres/cm^3, the same as the EU OEL.

The data in the table represent the sum of WHO fibres (addressed in practice by the AWD, diameters down to 0.2 µm) and 'thin asbestos fibres' (TAF, with diameters of 0.01 - 0.2 µm). Consequently, the reported concentrations are higher than the concentrations of fibre in practice addressed by the AWD. The data in the table cannot be easily converted to WHO fibres. Overall, the number of TAF was approximately the same as the number of WHO fibres, and the reported concentrations are approximately two times the concentration if only the WHO fibres were included. For some values, where the paper also presents the AM (arithmetic mean) expressed in WHO fibres, the WHO fibre values are indicated in brackets. The paper presents in other tables where data are aggregated differently both WHO and WHO + TAF data by process and materials. Please consult the paper for more details.

For processes with high air concentrations, RPE with a protection factor of 250 was used. Notably for processes involving materials such as asbestos-containing plaster or sprayed-applied asbestos, even with the use of RPE with a protection factor of 250, the maximum exposure concentration (WHO + TAF) is above 0.1 fibres/cm^3. For many of the processes with medium exposure levels, where RPE with APF of around 60 was applies, the maximum values when APF is considered are higher than 0.01 fibres/cm^3. Even when the conversion to WHO fibres is considered, for many processes the maximum concentration when APF is taken into account would be higher than the OEL options assessed in the current study of 0.01, 0.002 and 0.001 fibres/cm^3.

The results represent various exposure situations but cannot be considered representative as some of the processes are more common than others. However, the results illustrated the RPE typically used in the different exposure concentration and this information together with data from French companies from the stakeholder consultation is intended to be used for estimating the realistic use of RPE for estimating actual exposure concentrations on the basis of the comprehensive SCOLA dataset 2012-2019.

Table 4.13 Statistical description of results by material and removal technique with and without weighted for the use of RPE. WHO+TAF with WHO fibre concentrations in brackets for those materials where they were reported. Data collected 2009-2010.

Material	Removal techniques	n	the use of RPE, fibres/cm³ *			Modified for the use of RPE, fibres/cm³ *			Average protections factor (rounded) **
			Median	AM (WHO) ***	Max	Median	AM	Max	
Sites containing asbestos	Earthmoving-shovelling	4	0.009	0.0088	0.0088	0.0001	0.0001	0.0001	60
Landfill for asbestos wastes big bag unloading and dismantling before inerting	Miscellaneous – mechanical or manual	8	0.006	0.0060 (0.0030)	0.0090	0.0045	0.0045	0.0090	1
Accidental situations – case by case (tornado, fire, …)	Miscellaneous – mechanical or manual	4	0.006	0.0064 (0.0015)	0.0100	0.0002	0.0002	0.0003	40
Asbestos cement pipe	Cutting – sawing – chain sawing (cutting by bucket)	6	0.018	0.0160	0.0210	0.0004	0.0005	0.0009	30
Asbestos cement pipe – covering	Dismantling – loosening – pulling	16	0.009	0.0130	0.0290	0.0005	0.0006	0.0013	20
Pipe thermal insulation/Joints	Cutting – sawing – chain sawing	8	0.014	0.0190	0.0470	0.0001	0.0001	0.0003	170
Floor covering adhesive (excluding adhesive mortar)	Chemical removal	4	0.041	0.050 (0.010)	0.0890	0.0007	0.0008	0.0015	60
Coatings containing asbestos	Miscellaneous – mechanical or manual (removal by brushing or planing, milling)	4	0.007	0.033 (0.0079)	0.1160	0.0001	0.0006	0.0019	60
Wall tile adhesive	Planing – milling – shot blasting – sand blasting	4	0.072	0.072 (0.055)	0.129	0.0003	0.0003	0.0005	250

Material	Removal techniques	n	the use of RPE, fibres/cm³ *			Modified for the use of RPE, fibres/cm³ *			Average protections factor (rounded) **
			Median	AM (WHO) ***	Max	Median	AM	Max	
Floor covering adhesives (excluding adhesive mortar)	Grinding – sanding	20	0.073	0.104	0.421	0.0012	0.0017	0.0070	60
Floor covering adhesives (excluding adhesive mortar)	Chiselling – chipping	8	0.087	0.169	0.449	0.0014	0.0028	0.0075	60
Asbestos cement: roofs, sheets and panels	Dismantling – loosening – pulling	28	0.036	0.089	0.473	0.0008	0.0025	0.0120	40
Asbestos cement pipe – covering	Cutting – sawing – chain sawing	10	0.009	0.057	0.498	0.0003	0.0012	0.0083	50
Pipe thermal insulation/Joints	Scraping with a spatula	8	0.133	0.327	0.719	0.0011	0.0046	0.0120	70
Pipe thermal insulation/Joints	Dismantling – loosening – pulling	8	0.412	0.429	0.795	0.0016	0.0017	0.0032	250
Suspended ceilings – cardboard tiles	Dismantling – loosening – pulling	18	0.153	0.355 (0.188)	1.593	0.0026	0.0059	0.0270	60
Wall tile adhesives	Chiselling – chipping	12	0.022	0.323	1.849	0.0004	0.0054	0.0310	60
Asbestos cement: roofs, sheets and panels	Cutting – sawing – chain sawing	2	2.033	2.033	2.973	0.0081	0.0081	0.0120	250
Asbestos cement pipe – covering	Chiselling – chipping	3	5.150	4.135	5.369	0.0310	0.0460	0.0860	90
Asbestos cement: roofs, sheets and panels	Drilling – screwdriving – grinding – pulling cables – stripping	4	3.018	3.337 (1.340)	5.422	0.0120	0.0130	0.0220	250
Vinyl floor tiles	Scraping with a spatula	16	0.109	0.574	5.566	0.0018	0.0100	0.0930	60

Material	Removal techniques	n	the use of RPE, fibres/cm³ *			Modified for the use of RPE, fibres/cm³ *			Average pro-tections fac-tor (rounded) **
			Median	AM (WHO) ***	Max	Median	AM	Max	
Interior and exterior paints and coat-ings	Chiselling – chipping	4	4.060	4.073	6.356	0.0160	0.0160	0.0250	250
Interior and exterior paints and coat-ings	Grinding – sanding	16	2.320	3.055	8.58	0.0093	0.0120	0.0340	250
Damaged building (fire, tornado, ex-plosion, former industrial site)	Earthmoving – shovelling	12	0.009	2.631 (0.714)	21.241	0.0002	0.0440	0.3540	60
Asbestos-containing plaster	Hydroblasting VHP – UHP	10	7.364	11.414 (1.381)	28.461	0.0290	0.0460	0.1140	250
Sprayed-applied asbestosing	Scraping with a spatula	16	2.129	6.289 (5.084)	29.304	0.0085	0.0250	0.1170	250
Asbestos-containing plaster	Chiselling – chipping	4	17.772	22.24	49.767	0.0710	0.0890	0.1990	250
Asbestos-containing plaster	Grinding – sanding	8	31.909	31.115	60.443	0.1280	0.1240	0.2420	250

* Measured with TEM sum of the two types of fibres: 'WHO' (fibres: length(L)> 5µm; 0.2 µm< diameter(D) < 3µm; L/D ≥ 3; and TAF (Thin Asbestos Fibre, L > 5 µm; 0.01 µm < D < 0.2 µm; L/D ≥ 3)

**Average protection factor has been calculated as part of the current study on the basis of the reported data. Has been rounded for facilitating the readability.

*** WHO fibre concentrations adapted from another table from the same paper.

Source: (Eypert-Blaison et al, 2018)

The Netherlands. The current OEL for asbestos in the Netherlands is 0.002 fibres/cm³ introduced 1 January 2017; until that time it was 0.01 fibres/cm³. In the Netherlands, TNO manages the Dutch exposure database, in which data are collected from exposure studies performed by TNO and data voluntarily shared by other parties. Data from the database have been summarised by Spaan et al. (2019) in a study with the aim of assessing reference points for differentiation in risks associated with activities involving asbestos. The assessment includes a summary of 365 personal measurements from the database with sufficient data to be used for the context. Data has been obtained from various studies as reported by Voogd et al. (2017) and Franken et al. (2019) (as cited by Spaan et al., 2019) and used for calibration of exposure models. The summary is provided in the table below, whereas the detailed dataset is shown in Appendix C. The use of RPE by the processes is not indicated. Measurement method is not indicated but SEM/EDXA (Scanning Electron Microscopy Dispersive X-ray Analysis) is generally applied in the Netherlands.

The data cannot be considered to be representative for the overall exposure situation in the Netherlands.

The results clearly demonstrate major differences between the material groups with high exposure concentration (both AM, GM and P90) for processes involving woven/ pressed asbestos cloth, spray asbestos and light-bound boards.

Table 4.14 Summary of personal measurements in the TNO database based on nominal asbestos fibre concentrations (in fibres/cm³). Data apparently from the period where the OEL was 0.01 fibres/cm³.

Overall product group	Product group	n	n <DL	AM	GM	Median	P75	P90	Max
Bound in plastic / imitation marble	Window sill	33	21	0.0003	0.0002	0.0002	0.0004	0.0005	0.0010
Elastic	Bitumen	33	20	0.0014	0.0012	0.0015	0.0019	0.0023	0.0029
	Glue	56	47	0.0006	0.0002	0.0003	0.0005	0.0009	0.0066
Asbestos cement	Asbestos cement	85	58	0.0008	0.0002	0.0001	0.0005	0.0011	0.0330
Woven / pressed	Asbestos cloth	4	0	0.3160	0.1580	0.1280	0.5620	0.9660	0.9660
	Asbestos chord	33	17	0.0053	0.0008	0.0007	0.0027	0.0190	0.0630
	Gasket	13	6	0.0003	0.0003	0.0002	0.0003	0.0005	0.0009
Moderately bound asbestos	Board	96	17	5.0630	0.0280	0.0340	0.3050	17.0200	126.9600
	Stucco	7	4	0.0011	0.0009	0.0011	0.0017	0.0018	0.0018
Not bound	Spray asbestos	5	0	11.0390	2.1730	0.9840	1.9590	50.7800	50.7800

Source: Translated from Spaan et al. (2019).

Germany. The current binding OEL in Germany is 0.1 fibres/cm³ while the acceptance level is 0.01 fibres/cm³. In Germany, exposure data are collected by the German social accident insurance, DGUV. No exposure data from recent years are published. Detailed data on exposed workforce from a national asbestos profile for Germany (BAuA, 2014) are provided in section 4.4.1, but the profile does not provide exposure data from recent years.

DGUV (2013) has summarised typical exposure concentrations for historic exposure situations. A few of the exposure situations concern dismantling of asbestos-containing building materials which would still be relevant. Data are presented as P90 (90% percentile) only. The report indicates the following P90 values for relevant processes, even though the levels are likely lower today due to better risk management practices:

- Dismantling of asbestos-cement corrugated sheets and small format panels: 1.0 fibres/cm^3;
- Careful dry removal of weathered plates: 0.35 fibres/cm^3;
- Dismantling of asbestos-cement facade panels: 0.01 fibres/cm^3;
- Cleaning of weathered asbestos-cement surfaces by means of grinding or high-pressure cleaning (dry blasting): 5.0 fibres/cm^3;
- Dismantling of asbestos-containing mats and pillows: 10 fibres/cm^3;
- Dismantling of fire protection, wall and ceiling panels: 5.0 fibres/cm^3;
- Dismantling of coated asbestos-cement artificial slate (from 1991 following BGI 664): 0.015 fibres/cm^3;
- Dismantling of coated asbestos-cement panels (from 1991 BGI 664): 0.015 fibres/cm^3;

Poland. The current OEL in Poland is 0.1 fibres/cm^3. Sąkol and Muszyńska-Graca (2019) performed workplace air monitoring, during the period 2000-2005, of exposure to asbestos of construction workers. The study was accomplished according to the NIOSH phase-contrast microscopy method 7400 for asbestos. Workplace air was sampled over 6 hours which represented full-shift exposure. The dataset consists of 153 personal samples performed at residential buildings (76) and at industrial cooling towers (77). All samples of flat asbestos-cement sheets from blocks of flats contained only chrysotile asbestos (10-12% of mass), whereas corrugated sheets used in industrial construction were admixed with ~10% chrysotile and ~3% crocidolite asbestos. The use of RPE during the processes is not indicated. Significantly higher concentrations were found for the processes on the blocks as compared to the demolition of the cooling tower.

Table 4.15 Total respirable asbestos fibre concentrations during renovation of blocks of flats and cooling towers. In fibres/cm^3.*

Name of workplace	Type of work with asbestos-cement sheets	n	GM	GSD ***	Min	Max
Block of flats	During stripping	33	0.20	2.74	0.03	0.90
	Transfer into container	43	0.18	2.77	0.24**	0.84
	Total	76	0.14	3.02	0.03	0.90
Cooling tower	During removal	34	0.04	1.87	0.01	0.20
	Transfer into container	43	0.05	2.25	0.01	0.29
	Total	77	0.05	3.40	0.01	0.29

** Fibre length (L) > 5 µm; diameter (D) < 3 µm; aspect ratio (L/D) > 3:1.*
*** The paper actually indicates min to be higher than GM. AM not reported. *** The paper actually reports GSD at this size.*
Source: (Sąkol and Muszyńska-Graca, 2019)

Bujak-Pietrek and Szadkowska-Stańczyk (2012) performed analysis of asbestos fibres in different types of buildings with asbestos-containing elements under normal operation, as well as during demolition, renovation and maintenance work in Poland. Air samples were collected using stationary samplers and individual aspirators from the breathing zone of people at different locations. The concentration of respirable fibres was determined by optical microscopy in accordance with Polish Standard PN-88 Z-04202/02. Air sampling was carried out inside buildings before and during removal of asbestos products, as well as in ambient and indoor air after completing dismantling and repair works. The analysis included 2,925 measurements carried out during 2003-2010. Concentrations of respirable asbestos fibres in buildings containing asbestos installations, during their normal operation ranged from 0 to 0.004^3 fibres/cm^3. Measurements taken at the work site during removal of asbestos-cement materials showed the average (AM) asbestos fibre concentrations of 0.065 fibres/cm^3 and 0.014 fibres/cm^3 for work carried out inside and outside the buildings, respectively.

Szeszenia-Dąbrowska et al. (2011) notes that the occupational exposure to asbestos in Poland in 2012 concerned workers involved in the maintenance and removal of ACMs. According to the authors, studies on asbestos fibre concentration in the breathing zone of workers employed at removal of various types of asbestos cement goods indicated concentration levels ranging from 0.001 fibres/cm^3 to 0.080 fibres/cm^3 (analytical method not reported). According to the authors, these results should however be approached cautiously as the studies covered only the workers of the leading and perfectly operating companies with relevant technical equipment.

Ireland. The practical guidelines for management of ACMs from the Health and Safety Authority in Ireland (HSA, 2013) list typical concentrations by different removal processes (the data are shown in section 4.5 under current risk management activities). The HSA notes that for spray products the average fibre levels during poorly controlled dry removal are about 360 fibres/cm^3, and for asbestos insulation boards, about 15 fibres/cm^3 which is some 3,600 and 150 times, respectively, the OEL in Ireland of 0.1 fibres/cm^3. Even with controlled (wet) removal there is significant potential for release of fibres of around 140 times the OEL for the removal of sprays. The high concentrations indicated for the two processes are quite well in accordance with results reported from other Member States.

Slovakia. The current OEL in Slovakia is 0.1 fibres/cm^3. Stevulova et al. (2020) has characterised demolition waste of an old three-story industrial building in Slovakia and measured the release of fibrous dust particles by the demolition. More than 200 air samples from seven sampling sites were tested to determine the asbestos fibre number. Asbestos fibres were determined by PCM (for diameters exceeding 3.0 µm) and scanning electron microscope (for fibres with a diameter in the range of the range of 0.2 to 3.0 µm. The demolition waste consisted of asbestos-cement. Indoor concentrations were measured before, during and after the removal using stationary samplers. Before the removal of the materials, the mean concentrations (apparently AM) within the buildings were in the range of 0.0001 - 0.0007 fibres/cm^3. During removal, the mean concentration increased to be in the range of 0.0001 - 0.0021 fibres/cm^3. Two days after removal mean concentrations were in the range of 0.0001- 0.0003 fibres/cm^3.

Spain. No exposure concentrations are reported for Spain. According to the ministry of employment (MTMSS; 2018) in 2017 4,551 exposure data were notified; of these the OEL of 0.1 fibres/cm^3 was exceeded in 43 of the situations i.e. the P99 was 0.1 fibres/cm^3. It is not indicated if RPE was taken into account in the estimation of exposure situations, but it is most likely.

USA. In a recent study from the USA, Perez et al. (2018) present a meta-analysis of measurement data concerning work with asbestos-containing floor tiles from 22 studies representing 804 personal measurements, 57 bystander measurements and 295 area samples. Arithmetic means for 8-hour TWA was found to be 0.020 fibres/cm^3 for personnel samples and 0.010 fibres/cm^3 for bystanders. Very few measurements exceeded 0.1 fibres/cm^3 and these were mainly associated with non-recommended 'aggressive' work practice using a course-grit sander for 20 minutes. The authors noted that asbestos is normally bound rather firmly in floor tiles. Analytical methods applied in the studies reviewed were PCM (phase contrast microscopy) and TEM (transmission electron microscopy).

Conclusion

Based on the available data the following parameters are brought forward for the calculations of burden of disease. The data where RPE is taken into account has its offspring in the weighted AM and P95 values of the dataset of Eypert-Blaison et al. (2018). The dataset is based in measurements in France at a time when the OEL was at the same level as the EU OEL and take the actual use of RPE into account. For the dataset where RPE is not taken into account the data from the SIREP database, Polish data and the French database is combined to the most likely distribution. Please note that the distributions are average for all Member States, of which three has lower limit values than the EU OEL.

Available data including stakeholder questionnaire responses indicates that RPE is used for virtually all exposure situations and the RPE used will depend on the concentrations of fibre in the air in the workplace in order to bring the adjusted exposure concentrations below the OEL. The high variation in air concentration between the different activities is thus adjusted so the variation in actual exposure when RPE is taken into account is smaller. Inadequate use of RPE may result in a lower actual protection factor than the APF, but no data are available to assess to what extent the actual protection factors are lower than the APF. As detailed training is required for working with asbestos subject to notification it is assessed that for these activities the awareness of proper use of RPE and other PPE is likely relatively high.

Table 4.16 Exposure concentration parameters used for calculations of burden of disease and modelling use of RPE; in fibres/cm^3 (exposure situations subject to notification)

RPE	Mean, AM	Median, P50	P75	P95	Source
RPE not taken into account	0.300	0.100	0.277	1.200	Model estimates on the basis of available data
RPE taken into account	0.028	0.024	0.034	0.057	Estimated on the basis of available data

Source: study team's calculation

4.3.1.2 Building and construction - Exposure situations covered by Article 3 (3) of the AWD and 'incidental' exposure

As described in section 4.2.1.2, provided that worker exposure is sporadic and of low intensity, and if it is clear from the results of the risk assessment that the exposure limit for asbestos will not be exceeded in the air of the working area, articles 4, 18 and 19 of the AWD may be waived where the work involves certain activities.

As mentioned before, it is here considered that the wording 'the air of the working area' means that the 8-hour TWA should not be exceeded even not adjusted for the use of RPE. However, the available data indicates that for some of the activities considered non-notifiable as well as some 'incidental exposure' situations, the workplace concentrations may in fact be above the OEL (and RPE is worn for much of the non-notifiable activities).

Besides providing input for the benefit assessment, below description is also aimed at clarifying to what extent lowering the OEL would change the status of the activities as to the Article 3 (3) waiver.

The actual determination of sporadic and low-intensity exposure may differ by Member State, but it is relevant to note that the data from national databases may only be representative for the work processes with higher concentrations included in the previous section.

As an example, the guidelines from the Health and Safety Agency in Ireland provides the following non-exhaustive list of considered 'low-risk activities', i.e. activities which may be waived to the need for the contractor to: 1) notify to the Authority of the intent to remove the ACM, 2) make available an assessment of the health of employees, and 3) maintain the medical records relating to health assessment of employees (HSA, 2013).

Table 4.17 Non exhaustive list of 'low-risk activities'

Non-friable ACM activities
• Removing less than 10 m^2 of non-degraded asbestos cement panels or roof sheets to access services behind them
• Removing non-degraded asbestos cement downpipes, gutters, bargeboards, ridge tiles or flue pipes/cowls without deterioration
• Repairing small section of damaged asbestos cement
• Removing asbestos cement or reinforced plastic product e.g. tank, duct, water cistern
• Painting non-degraded asbestos cement sheets
• Removing metal cladding lined with asbestos-containing bitumen
• Removing asbestos-containing bituminous products
• Removing an asbestos-containing ‘arc shield’ from electrical switchgear
• Removing a single asbestos-containing gas or electric heater
• Replacing an asbestos-containing fuse box or single fuse assembly
• Removing asbestos-containing mastic, sealant, beading, filler, putty or fixing
Permitted friable ACM short duration activities
• Removing and replacement of a compressed asbestos gasket from a pipe flange
• Removing and replacement of an asbestos rope seal to a boiler
• Removing an asbestos fire blanket
• Removing asbestos friction linings
• Removing flexible asbestos duct connectors (gaiters)
Activities involving deliberate disturbance of non-friable ACMs
• Drilling holes in asbestos cement and other highly bonded materials
• Cleaning debris from guttering on an asbestos cement roof
• Removing small amounts of asbestos cement remnants, e.g. debris from broken sheet
• Drilling and boring through textured coatings
• Inserting and removing screws through textured coatings
• Removing textured coating from a small area, e.g. 1 m^2
• Cleaning up debris following collapse of a ceiling or wall covered with textured coating
• Removing small amounts of asbestos-containing floor tiles and mastic

Source: HSA (2013)

The interpretation may be different in other Member States. As flat and corrugated asbestos-cement roofing is the major remaining ACM, a significant number of activities in this category could include removal of asbestos cement roofing. As shown in the table above, in Ireland removing less than 10 m^2 of non-degraded asbestos cement panels or roof sheets is considered low risk. In Denmark, according to the guidelines from the Danish Construction Association (Dansk Byggeri, 2019), dismantling of flat and corrugated asbestos-cement roofing sheets outdoors are considered non-dusty outdoor activities where notification to the authorities and medical surveillance are not required, irrespective of the removed area. Demolition of asbestos-cement roofing is considered dusty outdoor activities and are subject to notification.

'Incidental' exposure would be situations where the workers are not aware of contact with asbestos-containing materials. This could be due to ignorance (not making a proper survey of the materials before starting the work) or it could be due to situations where the ACM is located behind other materials and not easily recognisable. As reviewed below, even workers who are aware of ACMs may be exposed incidentally from time to time and the 'incidental' exposure may account for a significant part of the total exposure.

As the activities are in general not notified, limited information on exposure level is available. Many of the activities listed above, are similar to activities for which exposure concentrations are reported in the previous section and would exceed the OEL if undertaken for 8 hours. But if the activity lasts for short time, the calculated 8-h TWA would today be below the OEL. However, these workers are not exposed to these concentrations every day over their entire working life. It has been assumed that they are exposed to these concentrations half of their working time.

In France activities involving intervention (i.e. where the material is not removed or encapsulated but otherwise disturbed) are reported to the SCOLA database separately under sub-section 4. These activities likely include many of the activities which in other Member States may not be subject to notification. As shown in Table 4.11, the concentrations for sub-section 4 are lower than for sub-section 3. It is not indicated if the use of RPE is less frequent for sub-section 4 as compared to sub-section 3, but for the total of the two sub-sections, in 4% of cases the respiratory protection was absent or inadequate. For the stakeholder consultation, several experts have indicated that in general more efficient RPE is used for exposure situations subject to notification.

According to stakeholder input from the German Employer's Liability Insurance Association for the Construction Industry, BG BAU, the traditional asbestos products (asbestos cement for roofing and frontage, fire dampers, certain technical gaskets, etc.) were easy to recognise for specialists. But some types of asbestos products are very difficult/not possible to recognise. This included plasters, fillers, tile adhesives, mastics, coating materials, etc. Exposure to these materials have only recently become an issue in Germany. DGUV has recently initiated a measurement campaign expected to run until 2023. The aim of the campaign is to assess exposures from the crafts activities on asbestos-containing plasters, fillers, tile adhesives, mastics, coating materials, etc. It must be expected that 'Incidental' exposure would be common to these materials as workers would not be aware of the asbestos content.

A discussion paper on asbestos-containing plasters, fillers and tile adhesives in building from the Association of German Engineers (VDI) includes a review of available workplace concentration data from various tasks involving these materials. The table below provides an overview of the measurement results excluding some older results from 1979. The results show that, for all of the tasks, the workplace concentration (without taking RPE into account), at least for some of the samples, exceed the lowest of the OEL options of 0.001 fibres/cm^3. For many of the tasks the workplace concentrations also exceed 0.01 fibres/cm^3. According to the report, empirical values from 2010 to 2015 of a targeted search for asbestos-containing plasters, fillers and tile adhesives demonstrated that these materials to a varying degree could be detected in around 25% of the buildings examined.

Table 4.18 Workplace concentrations when working with asbestos-containing plasters, fillers and tile adhesives in buildings

Task	Sampling type	n	Workplace concentration fibres/cm^3	Source (as indicated in VDI, 2015)
Sampling of asbestos-containing fillers	Personal	n.d.	0.0035	A. Berg, unpublished lecture, Forum Asbest Haus der Technik, 2009
Removal of wallpaper from concrete walls with asbestos-containing fillers	Personal	6	LOQ to 0.0071	
Sanding plastered masonry walls with asbestos-containing fillers	Personal	n.d.	up to 1.56	
Milling of plastered masonry walls with asbestos-containing fillers	Personal	10	LOQ to 0.048	
Removal of asbestos-containing fillers on in-situ concrete with high pressure water jet technology	Personal	8	LOQ to 0.003	
Removal of the best-containing filler on in-situ concrete with a chisel hammer	Personal	n.d.	About 0.018	
Drilling holes in wall with asbestos-containing spatula without suction	n.d.	n.d.	About 0.010	Dr. K.-H. Schäffner, unpublished lecture, Forum Asbest Haus der Technik, 2009
Production of individual drill holes in tiles with tile adhesives containing asbestos	Personal	n.d.	About 0.036	
Chopping off individual tiles with tile adhesives containing asbestos	Personal	n.d.	About 0.077	
Sanding off asbestos-containing tile adhesives	Personal	n.d.	About 1.0	
Dismantling of plasterboard panels that were filled with asbestos-containing filler (moistening, separating with a knife, levering off, packing the plasterboard panels)	Stationary and personal	7 1 1	0.0014 0.0012 0.0049	Competenza GmbH 2015
Removal of asbestos-containing plaster residues by blasting with solid abrasive	Personal	n.d.	about 0.1 to1.2	SVB Sachverständigenbüro Dr. Sedat / AB – Dr. A. Berg GmbH 2015
Drilling 8 holes under suction with a commercially available vacuum cleaner attachment	Personal	n.d.	< LOQ	Wartig Nord GmbH 2015
Sanding off small residues of asbestos-containing filler in voids in concrete surfaces, sanding process with suction similar to sanding the adhesive layers of flex plate	n.d.	n.d.	0.016	R. Contrino, Contrino Consulting 2015

n.d. No data.

Source: VDI (2015)

According to Burdett and Bard (2007) data suggest that there is a significant risk to plumbers, gasfitters, carpenters, electricians, ventilation engineers, cleaners and other types of workers who maintain buildings and may through their work disturb ACMs. Plumbers are one of the highest risk cohorts of workers with a proportional mortality ratio of 4.57, based on 1978–1995 UK mesothelioma figures (Burdet and Bard, 2007). Burdet and Bard (2007) studied asbestos exposure of industrial plumbers using personal passive samplers. The samples were analysed by TEM but recalculated into PCM equivalent numbers. In the first round of the study, 96 samplers were sent to plumbers who had indicated they were willing to participate; 50 samples were returned and the plumbers returning samplers were sent samplers for a second round. The results of the TEM analysis of the passive samplers showed that the percentage of workers exposed to >5 mm long asbestos fibres was 62% in first round and 58% in second round. For PCM equivalent asbestos fibres, the values were 46 and 29%, respectively. The three samples with the highest numbers of fibres were followed up and were associated with plumbers working in areas which had supposedly been stripped of asbestos just prior to their starting work, suggesting that poor removal, clean-up and clearance practice presents a significant part of the risk to plumbers. The average exposure to regulated PCM equivalent fibres was 0.009 fibres/cm^3 for amphibole asbestos and 0.049 fibres/cm^3 for chrysotile. P95 values are not reported, but maximum values were reported to be between 1.0 and 2.0 fibres/cm^3. The concentrations represent a weighted average of 5 working days (i.e. average 8-h TWA for 5 working days). It is not reported if RPE was used but the risk estimates provided does not take any RPE into account. Approximately 20% of workers reported on the sample log that they had worked with asbestos. However, some 60% of the samples had >5 µm long asbestos structures found by transmission electron microscopy (TEM) analysis suggesting that the plumbers were aware of about only one-third of their contacts with asbestos materials throughout the week. The data thus shows that 'incidental' exposure of this group of workers were widespread.

Bard and Burdett (2007) as a follow up to the above-mentioned sample programme issued a questionnaire designed to gather information on the plumber's age, employment status, current and past perception of the frequency which they work with asbestos and knowledge of the precautions that should be taken to limit exposure and risk. The results from the questionnaire found that over half of the plumbers replying thought that they disturb asbestos only once a year and 90% of them thought they would work with asbestos for less than 10 hours per year. Their expectations and awareness of work with asbestos were therefore far lower than found during the 5-days period of monitoring in above mentioned study. The response to an open question on the precautions to be taken, found that 61% of plumbers would avoid disturbance and 59% would use RPE if they did disturb asbestos. The authors concluded that the awareness of the methods and the need to reduce the risk by control of emissions at source was very low and suggested that raising further awareness and training was needed. The data indicates that the plumbers are to a large extent exposed by 'incidental' exposure, where they are not aware of the exposure.

Health and Safety Executive in the UK (HSE, 2007) undertook a survey among 60 individuals working in construction and/or maintenance work and examined barriers to behaviour change amongst this group in relation to working with asbestos. The results were reported qualitatively only. Most workers felt that they ‘only occasionally’ came into contact with asbestos, although some stated that they worked with the material on an almost daily basis. Workers discussed a range of ways to identify asbestos, most of which involve at least some risk to health. Actions to get it professionally tested if the material contained asbestos tended to be referred to only by workers on larger sites, or employees of larger companies. Other strategies were to use the senses to identify ACM by colour, texture, taste or smell or drill it, scrape it or touch it to reveal what type of fibres lay beneath the surface of a material. Both methods are highly uncertain and the latter also result in exposure of the worker. Many individuals, however, were clearly without any strategies for identifying asbestos, and were totally reliant on co-workers.

Measured concentration by roofing work for sub-section 4 in the French SCOLA database is shown in Table C1.2 in Appendix C. For the disassembly, where the sheets are not cut or manipulated in other ways, the P95 varies from 0.060 to 0.585 fibres/cm^3 and the AM from 0.02 - 0.24 fibres/cm^3. Please note that samples are analysed according to NFX 43-050 and the concentrations will be higher than if analysed by PCM using the WHO method.

The German experience is summarised in DGUV (2013) as discussed in the previous section. The concentration for the corrugated sheets is quite well in accordance with the French data while the concentrations when removing asbestos-cement facade panels is significantly lower (the coated sheets cannot be compared). Data from Poland shown in Table 4.15 shows GM values in the range of 0.04-0.20 fibres/cm^3; well in accordance with the French data.

Compared to this, much lower concentrations are reported from the Netherlands. Data shown in Table C1.1 in Appendix C indicate exposure levels by dissembling asbestos cement with moderate/much damage with an AM of 0.003 fibres/cm^3 and a P90 at 0.0006 fibres/cm^3 (Spaan et al., 2019). With little damage the AM is 0.004 fibres/cm^3 and the P90 at 0.00097 fibres/cm^3. With no control measures, the P90 was 0.0026 fibres/cm^3.

Conclusion

Limited data on actual 8-h TWA concentrations by 'low-risk' activities and 'incidental' exposure are available. It is characteristic for 'incidental' exposure that no RPE is likely to be used as the worker is not aware of the risk of asbestos exposure. Furthermore, data from the UK showed that 40% of investigated plumbers were not using RPE when they disturbed asbestos. This could indicate that even the concentration in the work environment and the frequency of exposures are lower than for activities subject to notification, the actual exposure concentrations when the absence of RPE is taken into account could be relatively high. In order to be in compliance with the article 3(3) waiver, the P95 exposure concentration (without adjusting for RPE) should be below the current OEL of 0.1 fibres/cm^3. In many situations the workers would wear RPE with an APF of 10 or better, but investigations from the UK indicate that often no RPE is worn. Based on the available data, the exposure concentration parameters for this group, when RPE is taken into account, are estimated to be slightly below the concentrations for the activities subject to notification (although this conclusion is associated with a high degree of uncertainty).

Table 4.19 Exposure concentration parameters used for calculations of burden of disease and modelling use of RPE; in fibres/cm^3 (exposure situations covered by Article 3(3) and incidental exposure)

RPE	Mean, AM	Median, P50	P75	P95	Source
RPE not taken into account	0.050	0.045	0.062	0.100	Model estimates on the basis of available data
RPE taken into account	0.02	0.018	0.025	0.040	Estimated on the basis of available data

Source: study team's calculation

4.3.1.3 Building and construction - 'Passive' exposure

Workers in buildings with ACMs may be exposed to dust containing asbestos fibres which may be released to indoor air due to the possible disturbance of asbestos-containing building materials such as insulation, fireproofing material, dry wall, and ceiling and floor tile (ATSDR, 2001).

Asbestos concentrations measured in homes, schools, and other buildings that contain asbestos have been reviewed by the US Agency for Toxic Substances and Disease Registry (ATSDR, 2001). According to the review, the concentrations ranged from about 0.00003 to

0.006 fibres/cm^3) and measured indoor air values ranged widely, depending on the amount, type, and friability of ACMs used in the building. Asbestos levels were apt to be higher in some areas of a building (e.g., boiler room) than in others and these areas may not be accessible to most people using the building. In a survey performed by USEPA (1988 as cited by ATSDR, 2002), levels of asbestos measured by TEM in 94 public buildings that contained asbestos ranged from not detected (ND) to 0.2 fibres/cm^3 with an AM concentration of 0.006 fibres/cm^3 (Spengler et al. 1989 as cited by ATSDR, 2002). Analysis of data based on air samples from 198 buildings with ACMs indicated mean asbestos levels ranging from 0.000004 to 0.00024 fibres/cm^3 measured by TEM (HEI 1991 as cited by ATSDR, 2002). Corn (1994 as cited by ATSDR, 2002) reported the mean, P90, and maximum asbestos levels in 231 buildings, including schools, universities, and public, commercial, and residential buildings as 0.0001, 0.0005 and 2.06 fibres/cm^3, respectively, measured by PCM while outdoor levels were 0.00006 fibres/cm^3. The ATSDR (2002) reviews a number of other studies with results in the same ranges.

Some newer studies are reviewed below.

Vernez et al. (2019) has estimated yearly doses of asbestos to teachers, pupils and the janitor in a public school in Switzerland. Amosite fibers (about 1% in mass) were found in four out of 14 samples of the insulation boards lining the ceiling in the classrooms and corridors of the main building (the part built in 1972). The asbestos-containing boards were located in the oldest part of the main building, which included about half of the 29 classrooms and covered slightly less than 50% of the total ceiling surface. According to the authors, the ceiling boards are considered as friable materials and are susceptible to release asbestos fibres when disturbed. Concentrations of up to 0.005 fibres/cm^3 of amosite asbestos fibres were observed in one classroom while concentrations of 0.0001–0.0007 fibres/cm^3 were also observed in neighbouring rooms (n = 4) at the same period. The average yearly concentrations found were 0.00005–0.00032 fibres/cm^3. The analytical method was SEM in accordance with VDI 3492:2013. Sixteen air measurements performed during the regular use of the building and in simulated use (with slamming of doors, closure of blinds, etc.). All 16 measurements were negative, suggesting a background concentration significantly lower than the Limit of Detection (LOD), of 0.000095 and 0.00019 fibres/cm^3, corresponding to an 8 h and 4 h sampling period respectively. The study calculated the annual dose for teachers, pupils and the janitor using an 'average' and 'pessimistic' scenario taking into account the general concentration, events where the boards were hit, lamp replacement, board replacement, etc. For the teachers, the largest contribution was from the general concentration levels in the rooms of 0.000075 fibres/cm^3 and from incidents where the boards were hit, where the concentration was estimated at 0.001 fibres/cm^3. For the janitor higher contributions were from board and lamp replacement, but the exposure of the janitor does not fall within the category of 'passive exposure'; however the data illustrates that board replacement or breaking may lead to exposure concentrations up to 0.050 fibres/cm^3 for the janitor, but in the specific model with an event duration of less than 1 hour.

Obminski (2020) has reviewed and measured concentrations of asbestos fibres in the air of buildings in Poland with friable ACMs. The measurements were done by PCM with a method similar to NIOSH 7400. The calculated detection limit was 0.0003 fibres/cm^3. The number of samples and buildings are not reported. The results are summarised as follows:

- In brick buildings (sturdy, stiff construction) with mechanical ventilation with asbestos robes on the conjunction of air ducts, the concentration of asbestos fibres was around 0.0003 fibres/cm^3 with max concentrations of 0.0008 fibres/cm^3;
- Building with non-sturdy construction with panels PW3/A (insulation panels with asbestos-cement at both sides) had concentrations in the range of 0.0005 - 0.0008 fibres/cm^3;
- Buildings of un-sturdy, steel construction containing friable asbestos-cement panels was in the range of 0.0006 - 0.0012 fibres/cm^3;

- Buildings of un-sturdy construction with friable insulating panels (so-called "Sokalit" panels) had concentrations in the range of <0.0003 - 0.0024 fibres/cm^3;
- Materials in good technical state regardless of their cohesion (also in case of buildings with un-sturdy construction) could cause lower concentrations, most often around < 0.0003 - 0.0005 fibres/cm^3. In case of bad technical condition of the materials in sturdy constructions (brick buildings) the concentration typically reached around 0.0008 fibres/cm^3.
- In sturdy buildings with elevations made of non-friable asbestos-cement products the concentration of cement dust was typically in the range of 0 - 0.0003 fibres/cm^3. They rarely reached 0.0004 fibres/cm^3.

It should be noted as discussed in section 4.9.2.1, at low concentrations the background level of non-asbestos fibre may be high compared to the number of asbestos fibre and higher levels are measured by PCM as compared with the more asbestos-specific SEM/EDXA analysis.

Campopiano et al. (2004) provides a summary of environmental investigations carried out from 1992 to 2002 by the National Institute for Occupational Prevention and Safety on airborne asbestos fibre concentrations in 59 Italian primary and secondary schools. The ACMs were mainly asbestos-cement floors, roofs, ceilings, and wall whereas vinyl-asbestos tiles were used in fewer of the buildings. All air samplings were collected on membrane filters and analysed by PCM and SEM/EDXA. The detection limit of the method was 0.0004 fibres/cm^3 on the basis of 1 mm^2 of analysed filter area and a sample air volume of 3000 L. All the asbestos fibres found during SEM/EDXA analysis were chrysotile fibres and no airborne amphibole fibre was detected. Of the total airborne asbestos fibre measurements undertaken from 1992 to 2002, 85% were below 0.0004 fibres/cm^3, 14% were in the range of 0.0004-0.002 fibres/cm^3 and 3% were above 0.002 fibres/cm^3. At the time of the reporting, the Italian regulation for indoor air quality states the limit value of 0.002 fibres/cm^3.

Burdett et al. (2016) investigated the concentrations of airborne asbestos that can be released into classrooms of schools in the UK that have amosite-containing asbestos insulation board (AIB) in the ceiling plenum or other spaces, particularly where there is forced recirculation of air as part of a warm air heating system. Fibres were analysed by PCM and TEM. For the TEM analysis only the fibre of the size measured by the PCM analysis were counted. The PCM fibre concentrations were all below the LOQ (Limit of Quantification) but analytical TEM showed that few of the fibres counted in the background samples were asbestos. The background TEM air concentrations for individual samples from all three schools with warm air heating systems for asbestos fibres were at or below the analytical sensitivity of the analysis of 0.0001 fibres/cm^3. A more vigorous disturbance in one of the schools, by directly striking the asbestos-containing panels on heater cupboards and under the windows ~100 times in each classroom over a 2-hour sampling period, released airborne PCM equivalent amosite fibres with short-term concentrations of up to 0.0043 fibres/cm^3 with a pooled average of 0.0019 fibres/cm^3 for the four classrooms giving measurable releases. The level of disturbance used was considered to replicate a peak exposure event from disturbances which did not damage the panels.

In a study from the USA, Lee and Van Orden (2008) reported a total of 3978 indoor samples from 752 buildings, analysed by TEM. The buildings that were surveyed were the subject of litigation related to suits alleging the general building occupants were exposed to a potential health hazard as a result the presence of ACMs. The average concentration of all airborne asbestos structures was 10 structures/L and the average concentration of airborne asbestos ≥ 5 µm long was 0.00012 fibres/cm^3. For all samples, 99.9% of the samples were <0.01 fibres/cm^3 for fibres longer than 5 µm; no building averaged above 0.004 fibres/cm^3 for fibres longer than 5 µm. Background outdoor concentrations have been reported at 0.0003 fibres/cm^3. There was an increased concentration in asbestos-containing buildings under normal occupation compared to their immediate outdoor environment by a factor of

4 for public and commercial buildings and a factor of 5 for schools (Lee and Van Orden, 2008).

Stevulova et al. (2020) found seven buildings in Slovakia with asbestos-cement, before the removal of the materials, had mean concentrations (apparently AM) in the range of 0.0001 - 0.0007 fibres/cm^3.

Goldberg and Luce (2009) notes in a review of the health impact of non-occupational exposure to asbestos, that some information is available about the custodial, cleaning, and renovation staffs of buildings containing asbestos. Some of these cases involve personnel who only touch ACMs very occasionally, if ever, while others do so more frequently. The authors quote that mean fibre concentrations in the atmosphere have been reported at 11.9 fibres/cm^3 (brushing asbestos-flocked surfaces*),* 1.6 fibres/cm^3 to 4.0 fibres/cm^3 for dusting operations, and 15.5 fibres/cm^3 for cleaning books in a library where asbestos debris resulted from the decay of flocked surfaces. It is not noted for how many hours and how often the workers were exposed to these levels. The authors conclude there is only weak epidemiologic evidence about the health effects associated with passive exposure in buildings containing asbestos.

Pira et al. (2018) notes that in buildings with friable asbestos, concentrations vary irregularly; usually less than 0.001 fibres/cm^3 are found, but in some cases exposure reaches 10 fibres/cm^3.

A Dutch impact assessment of various exposure scenarios used for the scenario of living in a house with ACMs, an GM of 0.0005 fibres/cm^3 and a P90 of 0.0015 fibres/cm^3 (Schinkel et al., 2019).

Passive exposure may also take place outdoors in areas with high ambient asbestos concentrations. Krówczynska and Wilk (2019) report on ambient air measurements undertaken in Poland from 2004 to 2013. In 2004, concentrations of over 5 fibre/L were recorded in seven counties, and, for the period 2005–2013, in one county. The highest average asbestos fibre concentrations in the air were recorded in 2004 in one county at 0.0083 fibres/cm^3. In about half of the counties concentrations above 0.001 fibres/cm^3 were reported. The paper does not provide data on personal measurements, but for people working outdoors, the results indicate that the 8-h TWA exposure concentrations could be above 0.001 fibres/cm^3. These concentrations are relatively high as compared to concentrations reported elsewhere. WHO (2000) assumes for the calculations of lifetime burden that the average lifetime exposure concentrations for urban population with high exposure (5% of population) would be 0.0002 fibres/cm^3.

Conclusion

The available data indicates that in buildings with indoor use of asbestos-cement materials, under normal conditions where the materials are not disturbed, the concentrations are in general below the lowest of the assessed OEL option of 0.001 fibres/cm^3. Significantly higher concentrations may be reached if the materials are disturbed and, even though the events are short in duration, this has been estimated to contribute significantly to the total exposure of teachers in schools with ACMs. Based on the available data, it cannot be excluded, that lowering the OEL to 0.001 fibres/cm^3 would mean that some workers in buildings with ACMs would be exposed at levels above the OEL. Because of the low levels, the contribution from passive exposure will be small to the total burden of disease.

In order to have an indication of the possible contribution to the total burden, the parameters indicated below are used as exposure concentrations for workers occupationally exposed in buildings with ACMs. The number of workers exposed in buildings is not known, however, in order to obtain a first estimate, a total of 500,000 in the EU27 is assumed.

Table 4.20 Exposure concentration parameters used for calculations of burden of disease and modelling use of RPE; in fibres/cm^3 (building and construction: passive exposure)

RPE	Mean, AM	Median, P50	P75	P95	Source
RPE not taken into account	0.0005	0.0002	0.0005	0.002	Model estimates on the basis of available data
RPE taken into account	0.001	0.0009	0.0013	0.002	Estimated on the basis of available data

Source: study team's calculation

4.3.2 Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other

Very scarce information on exposure concentrations by maintenance or removal of asbestos from articles have been identified. Use of older data on exposure concentrations may overestimate the exposure levels and number exposed as many of the articles have likely reached the end of their service life or the asbestos-containing parts, such as brakes, have been replaced.

Data from Germany (see Table 4.37) indicates that in 2017 still some 3,000 workers in Germany within the transport industry were exposed to asbestos, while the total number of workers still working in the sectors which had been exposed during their entire work life was 23,000. A split by subsectors or actual exposure concentrations are not available.

Ships

Asbestos has been widely used in ships and workers in shipyards have historically been exposed to significantly high asbestos fibre concentrations e.g. when spray asbestos has been applied to ships. None of the reported concentrations reported from databases concern current exposure to asbestos by maintenance, refurbishment or demolition of ships.

According to Regulation (EU) No 1257/2013 on ship recycling, ships flying the flag of a Member State need an 'inventory certificate' supplemented by an inventory of hazardous materials, including asbestos. The inventory of hazardous materials shall be properly maintained and updated throughout the operational life of the ship. The Regulation does not require that the ACMs are removed from the ship. Transfer the flag of a ship to an EU Member States is considered import of an article and an asbestos-free certificate is required (as e.g. specified in the Danish legislation [16]). The HSA in Ireland notes for the stakeholder consultations that the difficulty with ships is, especially for ships that travel around the world, if a ship needs parts, they can easily purchase parts that still contain asbestos because they're coming out of countries where asbestos is not banned or well regulated.

Some companies in the EU are specialised in asbestos abatement in ships, decontamination of ships after fire and disposal of asbestos waste from ships. e.g. Ramid in Poland [17] and Berger Maritiem in the Netherlands [18]. In addition, it has been indicated by shipyards and one of the companies specialised in removal of asbestos in ships that some more general asbestos removal companies are also involved in removal of asbestos from ships.

[16] BEK nr 9104 af 01/01/2006, available at: https://www.retsinformation.dk/eli/retsinfo/2006/9104

[17] https://asbestosremovalship.com/asbestos/decontamination-ships/ and http://www.azbest.co

[18] http://www.bergermaritiem.nl/asbestos_inventory

Published data on exposure concentrations and exposed workforce have not been identified.

In order to in investigate the possible extent, targeted stakeholder consultation has been undertaken in Poland. In Poland contact has been established with industry associations, the trade union 'Solidarność' section on Shipbuilding Industry, four shipyards, a shipping company, and a company specialised in removing asbestos from ships. According to the shipyards and the trade union, all work with asbestos is outsourced to specialised companies. One shipyard report that they come into contact with asbestos once or twice a year, and in such cases, they use the services of specialized companies. In these cases they completely close the vessels until the asbestos is removed. Another shipyard reports that they call a specialist company, if they receive information from the shipowner that there is asbestos on board. This has not happened in the last few years. According to the specialised company, however, some asbestos work is still undertaken by the shipyards personnel and often material samples are not undertaken before the ACMs have been removed. This has not been confirmed by other stakeholders. According to an answer from on specialised company in Poland, lowering the OEL to 0.01 or 0.001 fibres/cm^3 would not have any impact on the business of the company as the exposure level when the use of RPE is taken into account is still below these levels. It has not been possible to obtain information on the number of workers in the specialised companies.

In Denmark, specific guidelines on asbestos in ships have, as mentioned, been issued by the Industry's Work Environment Council, Denmark (I-bar 2010), but no information on current exposures with rebuilding of ships has been available from contacted stakeholders.

The HSA in Ireland as part of the stakeholder consultation stated that they have had no notifications in recent years. According to HSA asbestos in vessels tends to be in the form of gaskets, rather than pipe insulation and other high-risk ACMs.

Aircraft

Data from the Finnish ASA exposure database (ASA, 2014) indicates that 136 workers in Finland within the group of 'Aircraft installers and repairers' were potentially exposed to asbestos. After 'Other construction workers' was the largest group registered in Finland. Data on exposure concentrations for this group are not available by the newer data from FIOH (2021) indicated exposure levels for a group of 'Repairers of machinery and motors' in which the aircraft installers and repairers may be included. Of this group, a few percent were exposed at levels of more than 0.05 fibres/cm^3, about 20% were exposed at 0.01-0.05 fibres/cm^3 and the remaining at levels < 0.01 fibres/cm^3. Statistical parameters are not reported, but the median is below 0.01 fibres/cm^3.

Blake et al. (2009) studied asbestos exposure that results from the installation and maintenance of an aircraft fitted with asbestos-containing brake pads. Personal air samples did not detect any measurable amount of asbestos fibres during the brake changing or subsequent clean-up procedures. Analysis of personal samples (n=9) using PCM indicated airborne fibre concentrations at or below 0.003 fibres/cm^3 as 8-h TWA and less than 0.069 fibres/cm^3 averaged over 28-30 min sampling periods. Airborne chrysotile fibres were detected by two area air samples with fibre concentrations remaining at or below 0.0013 fibres/cm^3 over an 8-h TWA.

Blake et al. (2011) investigated the level of airborne asbestos fibre exposure experienced by mechanics who work with fire sleeve protected hoses in aircraft. Duplicate testing was performed inside a small, enclosed workroom during the fabrication of hose assemblies. Analysis of personal samples (n=9) using PCM indicated task duration airborne fibre concentrations ranging from 0.017 to 0.063 fibres/cm^3 for sampling durations of 167-198 min, and 0.022-0.140 fibres/cm^3 for 30 min samples. Airborne chrysotile fibres were detected for four of these nine personal samples, and the resulting asbestos adjusted airborne fibre concentrations ranged from 0.014 to 0.025 fibres/cm^3.

Trains

Asbestos has historically been extensively used in trains and many railway workers has been occupationally exposed to significant concentrations of asbestos. As an example, today more than 13,500 employees or retirees of the French railway company SNCF, are subject to special medical monitoring because of their past exposure to asbestos[19].

No data on current exposure concentrations by maintenance or refurbishment of trains has been identified, but available data indicates that some asbestos may still be present in some trains. Compared to cars and trucks trains generally are in operation for more years and available data indicates that exposure to asbestos in trains may still be an issue even though some train companies in Member States have removed asbestos from the trains may years ago. The following information indicates that some asbestos may still be found in many trains even though asbestos was not detected by the reported measurements.

In a recent case from France, in 2019 it was estimated by the trade union that 400 employees in more than 20 workshops have in recent years been exposed to remaining asbestos in freight trains even it was expected that asbestos had been removed from all SNCF trains since 1997 [20]. Exposure concentrations are not reported.

According to the annual report from the Madrid Metro (2020), the company continues to work on the identification, control and removal of materials containing asbestos and to promote specific measures aimed at monitoring and protecting the health of its employees. At the end of March 2018, Madrid Metro implemented an Asbestos Removal Plan, agreed with the main trade unions, to resolve the situation caused by the asbestos problem. The plan concerned both the rolling stock, infrastructure and facilities. Concerning the rolling stock, the plan includes removal of elements with asbestos in plates, gaskets and valves (valve elements), elements in brake shoes and exhaust pipe joints and small parts in power supplies, inverter, stopcocks, solenoid valves, etc. The plan is to remove asbestos in rolling stock in 2018 to 2019 with a total budget of € 5 million whereas the removal of asbestos in infrastructure and facilities runs until 2025. Health monitoring includes 1,075 active workers. In 2019, 39 new workers were included in the monitored group. The target population include workers in the following departments: Central Workshops, Short Cycle Maintenance, Escalators, Warehouses, Material Reception Laboratory, Waste Management, Multipurpose Officers, Works, and Signals and Energy. In total, 2,728 measurements were taken on rolling stock in 2019; of these 334 positive. In total 35 personal measurements were taken in 2019; no asbestos fibres were detected by the measurements (LOQ not reported).

According to a newspaper article from 2020 [21], the Belgian railways NMBS lists 1,152 vehicles contaminated with asbestos, according to a reply from Belgian Transport Minister. The 1,152 vehicles consisting of 720 wagons, 193 locomotives and 239 motorized vehicles containing asbestos. That is almost half of the NMBS fleet. These are mainly vehicles built in the 1980s that are still in circulation but are expected to be withdrawn from Belgium by 2023.

The Belgian railway company Infrabel estimates that two-thirds of its fleet of 2,162 wagons contains small concentrations of asbestos fibres as indicated in a newspaper article from 2020 [22]. According to a spokesperson for the company, the company carry out air measurements during maintenance activities with the wagons but never measured asbestos.

The UK Office of Rail and Road carried in 2018 a survey to assess compliance with the UK Asbestos Exemption Certificate No. 1 of 2014 for placing on to the market asbestos-

[19] https://www.geoamiante.fr/actualite-des-cheminots-attaquent-la-sncf-pour-exposition-amiante.php

[20] https://www.francetvinfo.fr/sante/affaires/scandale-de-l-amiante/des-salaries-de-la-sncf-denoncent-la-presence-d-amiante-sur-des-wagons-de-fret_3560829.html

[21] https://www.vrt.be/vrtnws/de/2020/03/10/asbest-in-waggons-und-lokomotiven-der-belgischen-bahn-nmbs/

[22] https://www.tijd.be/tijd/algemeen/nmbs-vindt-asbest-in-meer-dan-duizend-spoorvoertuigen/10213445.html

containing railway vehicles or components (ORR, 2018). The placing on the market of equipment with asbestos is only allowed for equipment placed on the market before 2005. Eight responders informed on the amount of asbestos-containing vehicles put onto the market. The total number was approximately 3,000 vehicles with the majority reported by passenger rolling stock leasing companies. When asked to tell when they expected to have completely removed asbestos-containing components and vehicles two of three rolling stock leasing companies duty holders stated that this depended on the remaining lifespan of vehicles, with one making an estimate for complete asbestos removal across its entire fleet within the next 20 years (stated in 2018). The third company gave a more detailed spread of fleet-by-fleet vehicle redundancy from 2019 to 2032. The answers clearly indicate that occupational exposure to asbestos by maintenance, refurbishment and dismantling of trains may still be relevant, and the asbestos will remain in trains for many years to come.

In Denmark it was planned to remove all asbestos in trains of the Danish Railways (DSB) by 2006, but the work was not completed until 2009.

In Italy, in the mid-1950s, insulation began on new rolling stock with sprayed asbestos. At the beginning of the 1960s it was decided to extend this type of insulation to all circulating carriages, so much so that their total number amounted to approximately 8,000 carriages. (Silvestri et al., undated; provided for stakeholder consultation). Furthermore, presence of asbestos has been reported in parts of the electrical systems of the locomotives / electromotors. The first preventive measures were taken in the early 1980s and completed at the end of that decade. In the 1990s, the carriages with crumbly asbestos insulated boxes were set aside and the remediation program was completed in the early 2000s.

The HSA in Ireland stated within the stakeholder consultation that no works on trains have been notified.

Vehicles

As indicated in the German national profile for asbestos (BaUA, 2020), it is estimated that asbestos in vehicles in Germany almost no longer occurs. Some veteran cars may have been produced during the time when asbestos was used, but asbestos-containing brake pads have not been available for many years and it is unlikely even vintage cars would contain asbestos today.

The data from the French SUMER database (see The Ministry of Employment in France indicates that in 2017 certified companies employed 35,000 workers while in total 2 million workers were carrying out operations on ACMs (Lesterpt and Leray, 2017). For the stakeholder consultation EFBWW has indicated that in France there are about 1.5 million employees in the construction industry; potentially all those who do rehabilitation work can be exposed to asbestos (Personal communication with Ann Cocquyt, EFBWW). On this basis, the interviewee estimates that the number of workers doing rehabilitation work and potentially exposed would be in the range of 500,000 to 800,000 employees.

Table 4.38) showed that in 2010 nearly 30,000 auto repair workers were exposed to asbestos in France. The newest data reported from the SCOLA database, however, includes only a few notifications from the auto repair sector, indicating that exposure within this sector hardly takes place today. Exposure concentrations from the sector is not specifically reported.

Asbestos-containing brake pads and clutches containing asbestos are still allowed in many countries worldwide (e.g. the USA), the risk of illegal import of such parts from countries outside the EU may be high. As mentioned before, illegal import and use of illegally imported parts would likely not be affected by changing the OEL for asbestos.

Although it cannot be excluded that some workers may be exposed to asbestos e.g. by removing old brake pads and other parts from vintage cars or from imported cars with illegal asbestos-containing parts, it is assessed that the impact of changing the OEL for asbestos for this sector would be negligible compared to the impact on other exposure groups.

Summary

The available data suggests that asbestos may still be found in some ships, aircraft and trains, but the extent is not known. The available data indicates that exposure concentrations are below the current OEL, but data is not currently available from activities on trains and ships. In train and ships, spray asbestos and other materials are known to lead to relatively high exposure to asbestos by maintenance and removal, and it must be expected that works on trains and ships would include high-exposure situations.

For the calculation it is assumed that the exposure concentrations are similar to those in building and construction subject to notification.

Table 4.21 Exposure concentration parameters used for calculations of burden of disease and modelling use of RPE; in fibres/cm^3 (exposure to asbestos in articles: trains, vehicles, vessels, aircraft, etc.)

RPE	Mean, AM	Median, P50	P75	P95	Source
RPE not taken into account	0.200	0.080	0.243	1.200	Model estimates on the basis of available data
RPE taken into account	0.028	0.024	0.034	0.057	Estimated on the basis of available data

Source: study team's calculation

4.3.3 Exposure from waste management

As mentioned in section 4.2.5.3, asbestos-containing waste must be disposed of as hazardous waste. Exposure may take place by collection of the waste (e.g. waste collection points), handling of the waste before transport, transport to the collection point and disposal facility and by handling at disposal facility. The actual handling and exposure situations will be different for the different waste types and depend on to what extent the waste is properly packed before handed over to the waste collection points and disposal facilities.

Limited data are available. According to the stakeholder response from Hazardous Waste Europe (HWE), as far as asbestos is concerned, the only service represented by HWE is the landfilling in landfills for hazardous waste. The operators of the member companies are never in contact with ACMs, only with the packages containing these materials. The handling of these packages (truck unloading, placement in the landfill) is performed outdoors. The operators have collective means of protection, handling vehicles/machinery are equipped with absolute filters and are under pressure, a minimum distance with the packages is ensured. For tasks where manual handling is needed, operators are equipped with adapted breathing protections. Moreover, they benefit from specific and regulated training.

According to data from Italy (Scarcelli et al. 2020), the number of exposed workers in the category collection of non-hazardous waste in Italy was 4,300 while in total about 1,300 were exposed by collection and treatment of hazardous waste. The exposure concentrations for by sewage and refuse disposal, sanitation for the period 2014 - 2016 are shown in the table below. P95 values are not provided but the AM is reported at 81.5 and 45.9 for two job tasks, respectively. The use of RPE is not reported.

Table 4.22 Descriptive statistics of asbestos exposure by sewage and refuse disposal, sanitation, similar activities (SIREP, 1996–2016). Data in fibres/cm^3.

Economic activity sector (NACE Rev 1 code) / job task	2014–2016	
	GM (GSD)	AM (SD)
Sewage and refuse disposal, sanitation, similar activities (90.00)	0.046 (0.0065)	0.082 (0.0037)
Job task: Asbestos-containing materials disposal workers	0.012 (0.0084)	0.0046 (0.0049)

* GSD: geometric standard deviation. SD: Standard deviation. The paper indicates standard deviation and geometric standard deviation as well for each period. These statistical parameters are further considered by the use of the results in the current study.

Source: (Scarselli et al. 2020)

The dataset from France with data from 2009-2010 described in section 4.3.1. provides data for 'Landfill for asbestos wastes big bag unloading and dismantling before inerting' with an AM and median of 0.006 fibres/cm^3, and a maximum of 0.009 fibres/cm^3. Measurements done by TEM. It is reported that RPE was not used (Eypert-Blaison et al., 2018).

A survey of asbestos in waste recycling centres (waste collection points) in Denmark found based on 22 samples from 6 stations exposure concentrations up to 0.21 fibres/cm^3 measured by SEM (RenoSam, 2008). The AM for 9 measurements above the detection limit was 0.033 fibres/cm^3. The highest concentration at 0.21 fibres/cm^3 were found by sweeping around containers for asbestos-cement products. It is not reported if RPE is used, but filter mask P2 (protection factor of 10) is prescribed for the operations.

According to a UK industry guidance for managing and working with asbestos in soil and construction and demolition materials there is monitoring evidence available within the ground investigation and remediation industry to suggest that significant visible quantities of bound ACMs will need to be present to give rise to exposures above 0.00001 fibres/cm^3. (CL:AIRE, 2016). Furthermore, it is indicated that whilst it is relatively easy to release asbestos fibres when working with building materials and/or debris consisting of asbestos insulation, asbestos coating and other ACMs, in most circumstances similar materials in the ground are unlikely to give rise to equivalent airborne fibre releases and, consequently, the potential risk to human health from exposure to and inhalation of asbestos fibres will be significantly lower.

Table 4.23 Exposure concentration parameters used for calculations of burden of disease and modelling use of RPE; in fibres/cm^3 (waste management)

RPE	Mean, AM	Median, P50	P75	P95	Source
RPE not taken into account	0.080	0.065	0.043	0.024	Model estimates on the basis of available data
RPE taken into account	0.012	0.0105	0.0147	0.024	Estimated on the basis of available data

Source: study team's calculation

4.3.4 Mining and quarrying

Information on exposure in mining and quarrying is available from Finnish and German data bases as well as a few studies.

About half of approximately 100 exposed workers in mining and quarrying in Finland were exposed at a level of 10-50 % of the Finnish OEL (corresponding to 0.01-0.05 fibres/cm^3) and the other half were exposed at levels below 10% of the level (corresponding to <0.01 fibres/cm^3 (FIOH, 2020a, see Figure 4.1). Statistical parameters are not provided, but as read from the figure, the median value (P50) is close to 0.01 fibres/cm^3. The actual mining and quarrying activities are not reported. The use of RPE by the various processes are not reported, but the Finnish guidelines for management of asbestos in the mining sector indicate that RPE must always be used when working in an asbestos area (Kähkönen et al., 2019). The guidelines do not include data on actual exposure concentrations in the sector.

Exposure data on asbestos fibre exposure (amphibole asbestos) during activities with potentially asbestos-containing mineral raw materials in selected work areas from the German MEGA database are summarised in Table 4.28 (Kolmsee et al., 2010). The data in the table concerning manufacture of asphalt and traffic areas is discussed in the next section.

According to Kolmsee et al. (2010), the use of potentially asbestos-containing mineral raw materials is not only restricted to a few companies in the mining and quarrying industry but extends to wide areas of further processing of mineral raw materials in building construction and civil engineering. Also, earthworks and rock works, e.g. in tunnel construction, are concerned.

Exposure measurements in quarries, at asphalt mixing plants, for milling of asphalt in traffic areas, in tunnel construction as well as when working with talcum powder and soapstone were carried out by the German employer's liability insurance association as part of their prevention program. No detailed information on sampling strategy and selection of sampling sites was provided. However, asbestos was not detected in all samples. Therefore, it can be anticipated that the exposure data describe typical exposure situations in the listed work areas with potentially asbestos-containing mineral materials, rather than 'high exposures' from working situations where high exposure levels are a known issue.

Exposure data from activities with talcum powders are not included in the table below but referred to in Kolmsee et al. 2010. Measurements at workplaces show that activities with asbestos-containing talcum powder (asbestos ≤ 0.1% by mass), asbestos fibre loads in the order of about 0.010 fibres/cm^3 occurred. Asbestos fibres were only found in five out of 68 samples.

The data for quarries are shown in the table below, while data for asphalt work and milling of asphalt are described in the next section.

The P50 reported in the dataset is well in accordance with the P50 reported from Finland.

According to BaUA (2000), the BG for the raw materials and chemical industry in Germany estimated that the German acceptance level of 0.01 fibres/cm^3 during mining and treatment is violated in 10 out of 2,000 active quarries in Germany so safety measures have to be applied. It is not indicated how many quarries have concentrations above 0.001 fibres/cm^3.

Table 4.24 Exposure data on asbestos fibre exposure (amphibole asbestos) during activities in quarries (Data period: 2000 to 2009, data from MEGA database).

Work area	No of measurements, n	No of companies	No of values below the detection limit	Concentration in fibres/cm³				
				Min	Max	P50	P90	P95
Quarries								
Extraction (drilling, digging with an excavator, wheel loader)	14	9	4	0.0048	0.0727	0.0074	0.0415	0.0611
Loading, conveying, transport (excavators, wheel loaders, dumpers)	30	10	13	0.0015	0.1262	0.0083	0.0276	0.0464
Preparation (control station, breaking, sieving, grinding)	22	8	3	0.0034	1.5303	0.0259	0.2318	0.2479
Loading (weighing room, silo passage)	9	4	2	0.0047	0.0442	-	-	-

Source: Kolmsee et al., 2010

Cattaneo et al. (2012) investigated air contaminated with asbestos fibres released from serpentinites in occupational settings (quarries and processing factories), in the environment close to working facilities, and at urban sites in the Valmalenco area in Italy. The only natural occurrence of asbestos found was chrysotile. Airborne asbestos fibre concentrations were measured using SEM and analysis was performed in accordance with ISO 14966. The highest concentrations were generated by the processing of the stones with a mean value (AM) of 0.097 fibres/cm^3 and a P95 at 0.352 fibres/cm^3 while the corresponding values for extraction were 0.027 and 0.044 fibres/cm^3, respectively. Ambient concentrations in the area were mainly below 0.001 fibres/cm^3 with a P95 at 0.0012 fibres/cm^3. The use of RPE by the various processes are not reported.

Table 4.25 Chrysotile fibre concentrations obtained by personal and stationary sampling in working and living environments at serpentine quarries and stone processing facilities. All data in fibres/cm³.

Environment	*n*	AM (SD)	P50	P95	Range
Extraction	40	0.0027 (0.118)	0.023	0.439	0.004–0.753
Processing	43	0.0097 (0.333)	0.047	3.520	0.004–1.852
Ambient	22	0.0005 (0.0011)	0.003	0.012	0.00005–0.00053

Source: Cattaneo et al. (2012)

Cattaneo et al. (2012) furthermore reviewed studies from Europa, USA and Japan. According to the authors, the consensus conclusion of these studies is that asbestos concentrations are higher in areas near ophiolitic rock quarries and roads paved with crushed asbestos-containing serpentinites, while fibre concentrations in urban centres near active quarries remain generally very low. In Italy, a previous study (Falcone et al., 2006 as cited by Cattaneo et al., 2012) on asbestos fibre dispersion in the workplace during serpentinite extraction and processing showed that slab cutting and dry finishing activities produced the highest occupational exposures to amphibole fibres.

Cavallo and Rimoldi (2013) have reported that concentrations from the serpentine mining in the Valmalenco area are in the same range as reported by Cattaneo et al. (2012). About 30 enterprises in the valley perform quarrying and processing of the serpentinite, with more than 180 workers involved (Cavallo and Rimoldi, 2013).

Cavariani (2016) report on the presence of amphibole asbestos fibres, characterized as tremolite, in mineral powders coming from the milling of feldspar rocks extracted from a mining site in Italy. A static monitoring to measure airborne asbestos fibres, carried out in the proximity of the grinding, mixing and bagging plants found concentrations of airborne tremolite fibres around 0.1 fibres/cm^3. Actual 8-h occupational exposure data are not reported. Feldspar is produced in many Member Stats; major producers are Italy and Germany[23]. No data on asbestos in feldspar or occupational exposure in mining of feldspar has been identified.

The data from the Italian SIREP database presented in section 4.3.1.2 and 4.4.1 does not include data on exposure concentrations or number of workers from the mining sector. An explanation may be that the studies by Scarcelli et al. (2016; 2020) included only sectors and occupations having more than 50 measurements reported to SIREP.

For the stakeholder consultation, France has pointed at some current discussions regarding mineral cleavage fragments in quarry materials which also concern asbestos. According to Anses (2015) cleavage fragments are mineral particles naturally present in rocks used, among others, in public works (road mixes). Some can, by their chemical composition and their dimensions, be similar to asbestos fibres. Anses (2017) in an assessment of 'elongated mineral particles' (EMP) notes that a few measurements of dust (environmental and / or personal), reveal the presence of actinolite in rare quarries and chrysotile has been detected in a single quarry. The "raw" actinolite concentrations, without taking into account the expanded uncertainty, vary at one site from 0 to 0.0025 fibres/cm^3 and from 0 to 0.053 fibres/cm^3 in another site. An individual measurement revealed an actinolite / chrysotile concentration greater than 169 fibres/ L. According to stakeholder consultation response, at the moment a survey of EMP (among these asbestos fibre) is being undertaken by the French Organisation for Prevention of Occupational Hazards in the Construction Industry (OPPBTP).

According to stakeholder input from the Industrial Minerals Association – Europe (IMA-Europe) the association have consulted with its Members about the revision of the EU OEL for asbestos. IMA-Europe is an umbrella organisation which brings together a number of European associations specific to individual minerals including the associations on feldspar and talc. According to the responses from the members, on extremely rare occasions there can be a natural presence of asbestos in the minerals extracted from the ground, but it is a geological curiosity, and the OELs which are currently set in EU and in the Member States do not cause any issue for the Members. According to the response, members of the associations have no issue with complying with the low OEL adopted in the Netherlands at 0.002 fibres/cm^3. In its stakeholder response, IMA-Europe express concern about the possibilities of compliance monitoring as, according to the organisation, 0.01 fibre cm^3 is beyond the limits of technologically feasibility in real-world settings.

Conclusion

Investigations of mining and quarrying activities have so far focused on areas with asbestos-containing minerals where exposure concentrations may exceed the current EU OEL of 0.1 fibres/cm^3. Less attention has been drawn to mining and quarrying activities where the exposure concentrations are well below the current OEL. For the stakeholder consultation 10

[23] http://www.euromines.org/mining-europe/production-mineral#Feldspar

out of 15 Member States answer that asbestos in soil or bedrocks is not an issue in the country.

However, if the OEL is lowered to one of the lowest OEL options, potentially many more mining and quarrying activities may lead to exposure concentrations exceeding the OEL but data is not available to indicate the extent.

On the basis of available data, it is estimated that in areas with asbestos-containing raw material the concentrations without considering the use of RPE could be as follows: AM: 0.040 fibres/cm^3; P95: 0.160 fibres/cm^3. Assuming the use of RPE with a protection factor of 10, the parameters used for the further benefits calculations are shown in the table below.

Table 4.26 Exposure concentration parameters used for calculations of burden of disease and modelling use of RPE; in fibres/cm^3 (mining and quarrying)

RPE	Mean, AM	Median, P50	P75	P95	Source
RPE not taken into account	0.040	0.010	0.031	0.160	Model estimates on the basis of available data
RPE taken into account	0.005	0.0045	0.0062	0.010	Estimated on the basis of available data

Source: study team's calculation

4.3.5 Tunnel excavation

Occupational exposure to asbestos may occur by tunnel excavation through asbestos-containing rocks. No data on exposed workforce by tunnel excavation are available from national databases.

Asbestos exposure during tunnel activities have been reported in several studies from Italy and information from Austria has been obtained as part of the stakeholder consultation. In order to control both occupational exposure and releases of asbestos to the surroundings, asbestos concentrations are continuously monitored by tunnel excavation through asbestos-containing rocks.

According to Gaggaro et al. (2017) tunnelling across formations with naturally occurring asbestos can release fibres into the environment, exposing workers, and the population. Data of 1,571 samples of airborne dust, collected between 2014 and 2016 inside the Terzo Valico tunnel in Italy and analysed by SEM/EDXA are discussed in the paper. It is noted that PCM was not applicable for the analysis. During excavation under normal working conditions, asbestos concentrations were below 0.002 fibres/cm^3 in 97.4% of the 668 analysed samples (from 12 different tunnels). Highest concentrations were found by tunnelling excavation across a serpentinite lens. In this rock 84% of 128 analysed samples (from the zone closer to the front rock) were above 0.002 fibres/cm^3. The authors note, that thanks to safety measures implemented and tunnel compartmentation in zones, the asbestos fibre concentration did not exceed the Italian OEL of 0.1 fibres/cm^3. In case the concentration was above 0.1 fibres/cm^3, workers were supplied with suitable personal protection equipment in order to reduce the asbestos exposure.

Baietto et al. (2020) notes that the presence of naturally occurring asbestos is one of the greatest dangers during excavations and tunnelling. As part of the consultancy provided in the works of the "Terzo valico dei Giovi" which includes the excavation of numerous tunnels in areas potentially affected by rocks containing asbestos, a case study of the tunnel called "Castagnola" is provided. The “Castagnola” tunnel area is characterized by greenish - reddish rocks metabasalt covered by recent grey shales in the upper part of the area. The concentration of asbestos in the excavated rocks were constantly higher than 1,000 mg/kg.

Airborne asbestoses were continuously monitored by SEM/EDXA analysis. In total 356 airborne samples in the work environment were analysed in the first phase of the work and 1525 in the second phase. Statistical parameters for the analytical results are not reported, but some data from the second phase are represented graphically by day (progress in the tunnel). Concentrations in the 'contaminated zone' varied between 0.001 and 0.048 fibres/cm^3 with the majority of measurements between 0.001 and 0.030 fibres/cm^3 (apparently average for a workshift). The limit value used for the work was 0.002 fibres/cm^3. It is not reported if RPE is used, but as mentioned above has been reported for similar tunnelling work in Italy (Gaggaro et al., 2016).

Lunardi et al. (2017) report on asbestos monitoring during railway tunnel excavation in Italy. Approx. 700 samples analysed with SEM showed concentrations in the most contaminated A zone of up to 0.12 fibres/cm^3. With respect to RPE, ground staff operating mainly in A and B Zones were issued with TMP3 full-face Air Purifying Respirator (APR) equipped with P3 EN143/02 filters, with a nominal protection factor of 400.

Labagnara et al. (2016) describe good practices for risk assessment and management by Tunnelling in Rock Formations Potentially Containing Asbestos. The information is included in section 4.5; the article does not provide actual exposure levels.

Chromy et al. (2006) discuss measures to prevent exposure to asbestos in tunnel construction in Germany but provide no data on exposure concentrations. The German technical rule TRGS 517 specifies that after tunnelling through the asbestos-containing layers of rock, a clean-up of contaminated work equipment and other construction site equipment must be performed. The cleaning must be performed to achieve an asbestos fibre concentration of less than 0.01 fibres/cm^3.

According to stakeholder consultation responses from Austria, naturally occurring asbestos in rocks is also an issue in tunnel excavation in Austria, and the potential for presence of asbestos-containing rocks is a part of the tender specifications for new tunnel projects.

Asbestos may also be an issue by tunnel excavation for trains, and excavation though asbestos-containing rocks has been a major issue for the Turin-Lyon high-speed rail[24].

Conclusion

The exposure parameters brought forward for the analysis is shown in the table below.

Table 4.27 Exposure concentration parameters used for calculations of burden of disease and modelling use of RPE; in fibres/cm^3 (tunnel excavation)

RPE	Mean, AM	Median, P50	P75	P95	Source
RPE not taken into account	0.020	0.006	0.017	0.080	Model estimates on the basis of available data
RPE taken into account	0.002	0.0018	0.0025	0.004	Estimated on the basis of available data

Source: study team's calculation

4.3.6 Road construction and maintenance

Data from the German MEGA database on exposure to asbestos fibre by manufacture of asphalt and cold asphalt milling of traffic areas are shown in the table below (Kolmsee et al. (2010). The basis for the data is described in the previous section. It is not indicated

[24] https://www.railway-technology.com/features/featureturin-lyon-high-speed-rail-project-controversy-at-the-heart-of-europe-4896951/

whether the milled asphalt has intentionally had asbestos added or the asbestos is naturally occurring asbestos in the raw materials. For the manufacture of asphalt, the asbestos originates from the mineral part of the raw materials.

The German TRGS 517 specifies methods to determine if the road paving contain asbestos and requirements regarding asbestos management by road milling incl. requirements regarding machinery and use of PPE and specifies that reclaimed asphalt with intentionally added chrysotile must not be reused.

Table 4.28. Exposure data on asbestos fibre exposure (amphibole asbestos) during activities with potentially asbestos-containing mineral raw materials in selected work areas (Data period: 2000 to 2009, data from MEGA database).

Work area	Number of measurements, n	No of companies	No of values below the detection limit	Concentration in fibres/cm^3				
				Min	Max	P50	P90	P95
Manufacture of asphalt								
Material feeding, dosing (wheel loaders, dozers)	32	12	8	0.005	0.056	0.012	0.026	0.040
Control station, system monitoring (control station, control walker, mixing tower)	22	11	11	0.005	0.065	0.008	0.046	0.061
Loading, weighing, shipping	11	8	5	0.005	0.093	0.009	0.073	0.084
Asphalt laboratory	24	12	6	0.005	0.071	0.011	0.038	0.057
Recycling of asphalt	Out of 21 exposure measurements from 12 companies with a detection limit of up to 0.024 fibres/cm^3, only one measurement with asbestos detection (0.019 fibres/cm^3)							
Cold milling of traffic areas								
Machine operator on the ground *	249	34	129	<0.0038	0.383	-	0.071	0.116

* Restriction of the sampling time to ≥ 0.5 h. The 50% value is not shown because the number of samples contains too many results below the detection limit. If only data with a sampling time of ≥ 1 h are taken into account, the percentile values shown do not change significantly. The 50% value in this case would be around 12,000 F/m³.

Source: Kolmsee et al. (2010)

Until the mid-1990s, chrysotile-type asbestos was in France and Germany (and possibly also other Member States) intentionally added to certain road surfaces to ensure better durability of the topcoat. Roadway repair or redevelopment work can destroy the coating matrix, emit asbestos fibres and, consequently, expose workers. Romero-Hariot et al. (2015) presents data on the analysis of 302 measurements (173 personal and 129 stationary) from 53 road maintenance sites in France. Analysis was done by TEM according to NF X 43-050. Overall statistical parameters for the entire dataset are not provided and cannot be calculated on the basis of presented data. Data from personal samples for those occupations with sufficient number of measurements for calculating statistical parameters are shown in the table below. Milling, chiselling and sawing operations have the highest dust levels, values which can reach respectively 0.039 fibres/cm^3 for an operator on the ground when milling, 0.968 fibres/cm^3 when chiselling and 0.096 fibres/cm^3 when sawing (data not shown in the table). P95 values were in the range of 0.003 to 0.094 fibres/cm^3 depending on activity. Workers used RPE. Based on the study the authors provide recommendations for technical RMMs and PPE.

Table 4.29 Exposure to asbestos by maintenance of asbestos-containing road paving. Personal samples for those occupation with sufficient number for calculating statistical parameters (based on Romero-Hariot et al., 2015). In fibres/cm^3 Not adjusted for the use of RPE

Process	Occupation	n	median	min	max	P95
Milling	Milling machine driver	16	0.0035	0.0035	0.0014	0.0690
	Excavator operator	3	-	-	0.0013	0.0133
	Truck driver	7	-	-	0.0015	0.0040
	Sweeper operator	7	-	-	0.0015	0.0064
	Adjuster	3	-	-	0.0015	0.0327
	Ground worker: operator in charge of watering, cleaning, waste management (tarpaulin, packaging, strapping of big bags, etc.)	22	0.00393	0.0039	0.0008	0.0394
Shovelling, decrusting, deconstruc-tion	Excavator operator	1	-	-	0.0015	0.0015
	Ground worker: operator in charge of watering, cleaning, waste management (tarpaulin, packaging, strapping of big bags, etc.)	2	-	-	0.0026	0.0037
Chiselling	Electric jackhammer-perforator	5	-	-	0.0015	0.9680*
Coring	Core collector	12	0.0015	0.0015	0.0005	0.0031
	Sample transfer	2	-	-	0.0015	0.0015
Sawing			0	0.0000	0.0000	0.0000
Sawing	Opening of the trench	3	-	-	0.0015	0.0956
Depaving	Excavator operator	2	-	-	0.0015	0.0015
	Ground worker: operator in charge of watering, cleaning, waste management (tarpaulin, packaging, strapping of big bags, etc.)	2	-	-	0.0015	0.0015
Thermo-pickling	Machine operator	1	-	-	0.0018	0.0018
Coating de-signer	Pothole repair	2	-	-	0.0015	0.0015

Process	Occupation	n	median	min	max	P95
Re-grouping of data	Ground worker: operator in charge of watering, cleaning, waste management (tarpaulin, packaging, strapping of big bags, etc.)	28	0.00273	0.0027	0.0008	0.0394
	Closed cabin operator	20	0.0015	0.0015	0.0013	0.0133
	Machine or tool without cabin (ex-cluding operator on the ground worker)	42	0.00164	0.0016	0.0005	0.9680

In France it is today required to take samples for asbestos before new road maintenance activities are started.

Data on asbestos in road paving has not been available from other Member States.

Conclusion

The available studies indicate that exposure concentrations (P95) would typically be below the existing EU OEL of 0.1 fibres/cm^3. The available information indicates that attention has been paid to asbestos in tunnelling work. As regards to other construction activities, attention has been paid in some Member States but it is not clear to what extent as the exposure concentrations were typically below the OEL. In their responses to the stakeholder consultation, 10 out of 15 Member States indicate that asbestos in soil or bedrocks is not an issue in the country. If the OEL is lowered to one of the OEL options, potentially many more construction activities may lead to exposure concentrations exceeding the OEL, but data are not available to indicate the extent.

The exposure concentration parameters brought forward for the estimation of current burden of disease and estimation of RMMs are summarised in the table below.

Table 4.30 Exposure concentration parameters used for calculations of burden of disease and modelling use of RPE; in fibres/cm^3 (road construction and maintenance)

RPE	Mean, AM	Median, P50	P75	P95	Source
RPE not taken into account	0.013	0.005	0.013	0.050	Model estimates on the basis of available data
RPE taken into account	0.004	0.0035	0.0049	0.008	Estimated on the basis of available data

Source: study team's calculation

4.3.7 Sampling and analysis

Scarselli et al. (2020) estimate the number of workers in Italy within the sector 'Technical testing and analysis of products at 3,682, but do not provide data on exposure concentrations. Sampling and analysis is listed in Article 3 (3) of the AWD for which notification can be waived if exposure concentrations are below the OEL.

Data from four companies has been obtained as part of the stakeholder consultation: Three large testing companies in France and a small industry laboratory in Spain. In total the number of employees in the companies are 1,317 of which 1,099 (83%) may be exposed to asbestos either by sampling or analysis.

Only one company (France 1) provide more statistical parameters for the sampling activities whereas another company (France 3) only report max values which indicates that the concentrations may be as high as 6.0 fibres/cm^3. One laboratory in France (France 2) and one in Spain report on concentrations by analysis of the sample. According to the answer from France 2, the concentrations are below the LOQ (LOQ not reported) whereas the laboratory from Spain report on AM values in the range of 0.01-0.04 fibres/cm^3 and max values at 0.02-0.08 fibres/cm^3. All companies report that RPE with a APF of 10 is used.

Data are not available from other sources, but it is assumed that the data obtained by the stakeholder consultation would be representative for similar sampling and analysis in other Member States.

Table 4.31 Stakeholder responses from companies undertaking sampling and analysis. All concentrations in fibres/cm^3.

Company	No of exp. workers	Activity	n	AM	Min	Median	P95	Max	Applied RPE	APF	Adjusted AM	Adjusted P95
France 1	165	Intervention on the outskirts of asbestos removal sites	82,240	0.083	0	0.065	0.465	0.485	Half mask with P3 filter	10	0.0083	0.0465
		Intervention in asbestos removal site	25,241	0.021	0	0.014	0.11	0.115	same	10	0.0021	0.011
		Asbestos emission control of materials in place in a building	2,094	0	0	0	0	0	same	10	0	0
		Intervention after fire	996	0	0	0	0	0	same	10	0	0
France 2	620	Materials samples analysis	65	0	0	0	0	0	same	10	0	0
		Air samples analysis	65	0	0	0	0	0	same	10	0	0
France 3	300	Taking samples of materials that may contain asbestos	n.d.	n.d.	0	n.d.	n.d.	0.1	same	10	n.d.	0.01 *
		Inspection of asbestos removal / encapsulation work	n.d.	n.d.	0	n.d.	n.d.	6.0	same	10	n.d.	0.60 *

Company	No of exp. workers	Activity	n	AM	Min	Median	P95	Max	Applied RPE	APF	Adjusted AM	Adjusted P95
Spain 1	5	Reception of samples	6	0.03	0.02	0.02	n.d.	0.05	Filtering half mask EN 149	10	0.004	0.005 *
		Preparation of samples	6	0.04	0.01	0.01	n.d.	0.08	same	10	0.001	0.008 *
		Identification	6	0.01	0.01	0.01	n.d.	0.02	same	10	0.002	0.002 *
		Cleaning workplace	6	0.02	0.01	0.01	n.d.	0.03	same	10	0	0.003 *

* Using max value as a proxy for P95. **All analyses from France are by the use of TEM.

Source: Consultation exercise for this study.

Conclusion

The available data indicates that the exposure concentrations by sampling would typically be higher than by analysis. During sampling, the responsible person has to enter the site where they could be exposed. RPE with an APF of 10 is typically used.

The exposure concentration parameters brought forward for the estimation of current burden of disease and estimation of RMMs are summarised in the table below.

Table 4.32 Exposure concentration parameters used for calculations of burden of disease and modelling use of RPE; in fibres/cm^3 (sampling and analysis)

RPE	Mean, AM	Median, P50	P75	P95	Source
RPE not taken into account	0.060	0.008	0.032	0.240	Model estimates on the basis of data from stakeholder consultation
RPE taken into account	0.012	0.011	0.015	0.030	Same

Source: study team's calculation

4.3.8 Summary

The parameters used for the calculation of the baseline burden of disease and later used for the assessment of the cost savings due to avoided ill health resulting from potential lower OELs are summarised in the table below. The number of workers exposed used for the calculations of burden of disease is shown in the table as well. The exposed workforce is described further in the next section and reference is made to section 4.4.2 for details and ranges for estimated workforce by sector.

It should be noted that the exposure concentrations represent an average of all Member States, and that France, Germany and the Netherlands (representing 37% of the total population) are considered to have lower concentrations than the remaining Member States as a consequence of lower current OELs.

Table 4.33 Exposure concentration parameters used for calculations of burden of disease; in fibres/cm^3. Use of RPE taken into account. (based on summaries of previous sub-sections)

#	Exposure group	Mean, AM	Median, P50	P95	Estimated exposed workforce *
1	Building and construction - exposure situations subject to notification	0.028	0.024	0.057	400,000
2	Building and construction - exposure situations subject to Article 3(3) waiver	0.02	0.018	0.040	4,500,000
3	Building and construction - passive exposure in buildings	0.001	0.0009	0.002	600,000
4	Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	0.028	0.024	0.057	15,000
5	Waste management	0.012	0.0105	0.024	125,000

#	Exposure group	Mean, AM	Median, P50	P95	Estimated exposed workforce *
6	Mining and quarrying - naturally occurring asbestos	0.005	0.0045	0.010	12,500
7	Tunnel excavation	0.002	0.0018	0.004	3,000
8	Road construction and maintenance	0.004	0.0035	0.008	30,000
9	Sampling and analysis	0.012	0.011	0.030	17,500

* Workforce used for calculations. See section 4.4.2 for details and ranges for estimated workforce by sector.

** Exposure only occurs occasionally, and the total number of cases may be overestimated by assuming that all workers are exposed at the estimated exposure levels. However, the comparison with recognised cases indicates that the estimates calculated on this basis would not overestimate the actual number of cases.

*** The number of workers is highly uncertain. The number is based on little evidence, but not further justified as the estimations indicate that the contribution to the total burden of disease is small.

Exposure concentrations without taking RPE into account are summarised in the table below.

Table 4.34 Exposure concentration parameters used for estimation of RPE used; in fibres/cm^3. Workplace concentrations without RPE taken into account. (based on summaries of previous sub-sections)

#	Exposure group	Mean, AM	Median, P50	P95
1	Building and construction - exposure situations subject to notification	0.300	0.1	1.2
2	Building and construction - exposure situations subject to Article 3(3) waiver	0.050	0.045	0.10
3	Building and construction - passive exposure in buildings	0.0005	0.0002	0.002
4	Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	0.200	0.08	1.2
5	Waste management	0.080	0.065	0.024
6	Mining and quarrying - naturally occurring asbestos	0.040	0.01	0.160
7	Tunnel excavation	0.020	0.006	0.080
8	Road construction and maintenance	0.013	0.005	0.050
9	Sampling and analysis	0.060	0.008	0.240

4.3.8.1 Trends in exposure concentrations

Data on asbestos exposure concentrations in Italy do not indicate a general trend in the exposure concentrations from 1996-1998 to 2014-2018 (Scarcelli et al., 2020). For the main sector 'Other construction work involving special trades', the AM decreased from 0.636 fibres/cm^3 in 1996-1998 to 0.086 fibres/cm^3 in 2014-2018 as shown in Table 4.8 (a deceasing trend in the full dataset was also observed from the GM, but the GM for 1996-1998 was very low). For other sectors, the concentrations even increased during the period. The concentrations are without taking RPE into account and it is from the data not possible to assess whether the breathing concentrations further decreased as consequence of the use of more efficient RPE.

Kauppinen et al. (2013) assessed the prevalence of exposure to chemical agents and exposure concentrations and its change in Finland during 1950–2020. The data includes all exposure situations of which many for asbestos are historic. The average exposure level for asbestos has decreased over the years from 0.67 fibres/cm^3 in 1950, 0.49 fibres/cm^3 in 1970 to 0.04 fibres/cm^3 in 2008. The authors predict that in 2020, the average exposure level for asbestos will be 0.03 fibres/cm^3 in Finland. The average levels in 2008 were approximately 5% of the level in 1950. Data on trends in workforce are shown in the table to keep the date together, but further discussed in section 4.4.3.

Combining the trend in the workforce and in exposure concentrations, Kauppinen et al. (2013) calculate the trend in the so-called NOIE (national occupational inhalation exposure) values. The NOIE values are intended to be indicators of ‘national dose’, which may predict the agent-specific burden of work-related diseases in Finland (i.e. the future burden of the total exposure the year concerned). The NOIE value in 2008 was at only 0.2% of the value in 1970 when the NOIE was at its highest, and the 2020 value was predicted to be at 0.03% of the 1970 value.

Table 4.35 Trend in exposure concentrations, exposed workforce and national occupational inhalation exposure (NOIE) in Finland during 1950–2020

	Exposure concentration (fibres/cm^3)					**Levels as compared to 1990 (%)**				
	1950	1970	1990	2008	2020	1950	1970	1990	2008	2020
Exposure to asbestos	670	490	60	40	30	1,137	841	100	60	43
	Prevalence of exposure (% of total workforce)					**Prevalence as compared to 1990 (%)**				
Exposure to asbestos (any concentration)	3.0	5.2	1.1	0.2	<0.1	276	483	100	15	4
High exposure to asbestos (>0.15 fibres/cm^3)	2.5	4.1	0.3	<0.1	<0.1	793	1,301	100	10	2
						NOIE compared to 1990				
NOIE						2,671	3,683	100	9	2

Source: Kauppinen et al. (2013)

The marked decrease in exposure concentration in the past is also reported in other studies.

According to Baur (2018) exposure concentrations declined in the following decades, with the 90% percentile of asbestos fibre concentrations in German companies from 100 fibres/cm^3 in the early 1950s to 40 fibres/cm^3 in the early 1960s, to 10 fibres/cm^3 in the 1970s and to 3 fibres/cm^3 in the early 1980s. Peters et al. (2016) report that the geometric mean (GM) of airborne asbestos for low exposed jobs has decreased from 0.0061 fibres/cm^3 in 1980 to 0.004 fibres/cm^3 in 2000 and for high exposed jobs from 0.074 fibres/cm^3 in 1980 to 0.005 fibres/cm^3 in 2000.

Past and future trends in exposure concentrations for those exposure situations relevant today are summarised in section 4.14 and 4.15, respectively.

4.4 Exposed workforce

4.4.1 Published data from databases and the literature

Data on exposed workforce are available from national databases in a number of Member States. The data in general include exposed workforce from activities subject to notification.

Italy. Data on number of exposed workers in Italy by economic activity compiled from the SIREP database (Scarselli et al., 2020) are shown in the table below. The table includes sectors where more than 3 companies have been registered in SIREP and where more than 1% of the total workforce of the sector is registered in SIREP. The data are based on the SIREP 1996-2016 dataset, but the estimate of the number of workers exposed represents the estimated exposed workforce in 2020. Overall, 46,422 workers (86% male) were estimated potentially at risk of exposure to asbestos in the selected industrial sectors. The sectors with most exposed workers were 'other construction installation (NACE code: 43.29)' with 15,541 potentially exposed workers and 'roofing activities' (NACE code 43.91) with 12,013 potentially exposed workers. The number of exposed workers can be grouped into the following groups:

- Building and construction activities: 32,403 (70 % of all)
- Waste collection and treatment: 10,337 (22 % of all)
- Testing and analysis: 3,682 (8% of all)

Table 4.36 Estimates of potentially exposed workers to asbestos in the sectors of economic activity selected

Sector of economic activity (NACE Rev 2 code)	No. of firms[a]	% of firms[b]	No. of workers[c]	% of workers[d]	% of exposed[e]	90% CI[f]	No. of exposed[g]	% of men[h]
Water collection, treatment and supply (36.00)	13	0.7	4845	16.5	4.7	2.4 – 7.0	1,373	79
Collection of non-hazardous waste (38.11)	28	0.8	3851	4.6	5.1	2.6 – 7.7	4,300	74
Collection of hazardous waste (38.12)	8	2.3	188	7.2	21.8	11.2 – 32.4	566	88
Treatment and disposal of hazardous waste (38.22)	16	7.0	253	8.0	24.9	15.9 – 33.9	787	84
Recovery of sorted materials (38.32)	12	1.0	291	2.9	16.2	7.3 – 25.0	1,640	87
Remediation activities and other waste management services (39)	94	14.9	1911	39.7	34.7	31.7 – 37.7	1,671	67
Demolition (43.11)	8	0.5	413	6.3	30.0	23.3 – 36.8	1,978	92
Other construction installation (43.29)	30	0.2	832	1.4	26.9	22.0 – 31.8	15,541	94

Sector of economic activity (NACE Rev 2 code)	No. of firms[a]	% of firms[b]	No. of workers[c]	% of workers[d]	% of exposed[e]	90% CI[f]	No. of exposed[g]	% of men[h]
Roofing activities (43.91)	122	1.4	1357	5.0	44.0	40.7 – 47.3	12,013	89
Other specialized construction activities n.e.c. (43.99)	19	0.2	1356	4.2	9.0	4.7 – 13.3	2,871	84
Technical testing and analysis of products (71.20)	10	0.3	188	1.2	23.9	13.5 – 34.4	3,682	62

a: Number of firms in SIREP.

b: Percentage of total number of firms in in Italy registered in SIREP

c: Number of workers reported by firms (exposed + non-exposed) in SIREP.

d: Percentage of total number of exposed workers in in Italy represented in SIREP registered in Italy in SIREP

e: Percentage of exposed workers with respect to non-exposed workers reported by firms in SIREP.

f: 90% confidence interval (CI) of the percentage of exposed.

g: Total number of estimated exposed workers in Italy.

h: Percentage of exposed workers which are male.

n.e.c., not elsewhere classified.

Source: Scarselli et al., 2020

Germany. The national asbestos profile for Germany from 2020 (BAuA, 2020) includes an estimate of workers in Germany exposed to asbestos in 2017. The estimates are based on data from the central registration and medical care agency (GVS – Gesundheitsvorsorge) and the Statutory Social Accident Insurance.

According to the German law on preventive medical examination, employers are responsible for organising medical examinations when evidence of exposure to asbestos has been found and the limit value of the asbestos fibre concentration is exceeded. If the limit value is not exceeded, voluntary examinations have to be offered (BAuA, 2014). According to the GVS data, the total number of workers 31/12/2017 who were registered for medical examinations because of asbestos exposure was 114,431 (compared to 88,979 in a national profile from 2014 (BAuA, 2014)). The total number of workers (working in 2017) that have been ever exposed was 646,582 (the estimate for 2014 was 564,920 (BAuA, 2014). There is no official number available that includes every worker that has been exposed to asbestos over time. According to a previous asbestos profile (BAuA, 2014), based on the GVS figure and the experience from research studies on asbestos exposure and related health impacts it has been estimated that up to 2.5 million workers were exposed to asbestos in the past in Germany.

The GVS database does not offer a direct breakdown of the industries where each exposed person works. In order to estimate the number by sectors, BAuA (2020) combine the GVS data with data from German social accident insurance. The insurance is roughly organised according to the main industry sectors represented by accident insurance schemes (BGs). Data are shown in the table below. Besides the 2017 estimate, the table indicates the estimated number of workers (still working in 2017) within each sector which has ever been exposed to asbestos over the years. The table shows that 89% (101,617) of the potentially exposed workers in 2017 worked within the building trade. For the total of workers exposed at any time (but still working), the building trade accounted for 25% only. It is not indicated in the dataset how many of the workers within the building sector worked specifically on demolition or renovation of asbestos-containing buildings. The second largest group, woodworking and metalworking industry which covers a broad range of metal and wood making products had a share of 3.7%. The third largest fraction of exposed workers worked in the transport sector (2.6% of total). It is not indicated what is the exposure situation in the transport sector, it may cover transport of asbestos-containing waste materials or work on transportation equipment containing asbestos.

The number of currently registered enterprises involved in working tasks with ACMs in Germany in 2017 were 20,455. Yet, despite the registration and licensing provisions, it is not always known in many actual worksites that various construction materials such as plasters, glues, fillers, paints etc. can contain asbestos. BAuA (2020) estimates that in Germany around 750,000 workers, representing numerous construction-related occupations, may be exposed to various levels of asbestos during renovation works in buildings with ACMs. The difference between this number and the approximate 100,000 workers in the construction sector indicated in the table below may represent activities not subject to notification i.e. about 650,000 workers could be included in the group of workers potentially, and occasionally exposed.

Table 4.37 Workers exposed according to the data from Statutory Social Accident Insurance in Germany

Accident insurance scheme (BG) within industrial and public sector	Includes former BGs *	Number of workers ever exposed (still working 31/12/2017)	Number exposed 31/12/2017	Percentage of total exposed in 2017
Raw materials and chemical industry	The former BGs for mining, chemical industry, leather industry, papermaking, quarry and sugar	124,320	1,991	1.7%
Woodworking and metalworking industries	The former BGs for metallurgical plants and rolling mills, mechanical engineering, woodworking, metalworking	118,514	4,279	3.7%
Energy, textile, electrical and media products sectors	The former BGs for precision and electrical engineering, textiles and clothing, printing and paper processing, gas, district heating and water management	110,981	1,299	1.1%
Foodstuffs and catering industry	The former BGs for foodstuffs and catering industry, and meat trade	7,627	2	0.0%
Trade and distribution industry	The former BGs for retail sale, wholesale and distribution	22,026	856	0.7%
Administrative sector and other.	The former BG for the administrative sector, ceramics and glass, tram and railway	37,236	476	0.4%

Accident insurance scheme (BG) within industrial and public sector	Includes former BGs *	Number of workers ever exposed (still working 31/12/2017)	Number exposed 31/12/2017	Percentage of total exposed in 2017
Transport industry	The former BG for vehicle operators, maritime	22,953	3,003	2.6%
Health and welfare services		7,180	53	0.0%
Building trade		160,454	101,617	88.9%
Agricultural and forestry sector		14,681	363	0.3%
Public sector		20,610	363	0.3%
Total		646,582	114,431	100%

** Between 2000 and 2011 several institutions for statutory accident insurance merged. In this column the institutions for statutory accident insurance that merged are shown.*

Source: (based on BAuA, 2020)

France. The Medical Monitoring Survey of Professional Risks (Surveillance médicale des expositions aux risques professionnels, SUMER, provide extrapolations from a sample of workers who self-declare exposure in a survey administered by company medical officers during the workers' regular compulsory medical examination (Eurofound, 2013). The sample size for asbestos is not indicated.

The data are reported in aggregated sector categories where the percent of exposed workforce is below 4.8% for all categories. Actual exposure concentrations by sector is not provided. The majority of workers were employed in micro and small sized companies with approximately 25,000 employees in each of the groups of companies with 1-9 employees and 10-49 employees (in total 96% of workers were employed in SME companies).

The main sectors in terms of number of workers were construction and motor vehicle repair, each represent by more than one sub-group in the table below.

It should be noted that the SUMER estimates are based on self-declaration and encompass a large number of workers that are exposed to low concentrations for short periods of time. In the dataset, the majority of workers (65.5%) are exposed for less than 2 hours per week, and of the total, only 4.5 % of the exposed workforce was exposed at levels above the French OEL of 0.1 fibres/cm^3 at the time the report was published. The respondents were considered exposed as soon as the agent was present at the workplace, regardless of the duration and intensity of exposure. As a result, workers in the SUMER dataset should be considered as 'potentially exposed' rather than exposed to specific concentrations.

Workers in the construction sector (both skilled and unskilled workers) account for about 67% of all exposed workers. Notably, the second large group was repair of automobiles and motorcycles (incl. trade) which accounted for 29% of the total. This is likely to be historical. For the period 2012-2019 only 0.1% of notification (from a total of 12 companies) of asbestos exposure in France as reported to the Scolamiante database was from the repair of motor vehicles and motorcycles sector (INRS, 2020)

According to the website of ANSES, in 2007, the French National Research and Safety Institute (INRS) estimated that 1 to 2 million workers were potentially exposed to asbestos during repair and maintenance operations, including 900,000 in the building sector (ANSES, 2021). The main professions at risk of inhalation of asbestos dust are: Workers in asbestos removal companies; building and public works employees; building and public works (construction sector) personnel involved in demolitions or refurbishments; light work building professionals, repair and maintenance staff (plumbers, electricians, heating installers, painters, etc.); workers in waste treatment activities; and workers on asbestos-bearing sites. It should be noted that at that time (2007) the number of workers potentially exposed to asbestos in articles were significantly higher than today.

The Ministry of Employment in France indicates that in 2017 certified companies employed 35,000 workers while in total 2 million workers were carrying out operations on ACMs (Lesterpt and Leray, 2017). For the stakeholder consultation EFBWW has indicated that in France there are about 1.5 million employees in the construction industry; potentially all those who do rehabilitation work can be exposed to asbestos (Personal communication with Ann Cocquyt, EFBWW). On this basis, the interviewee estimates that the number of workers doing rehabilitation work and potentially exposed would be in the range of 500,000 to 800,000 employees.

Table 4.38 Workers exposed to asbestos in the SUMER survey, 2010

Total no. of workers (% of the workforce)	**81,340 (0.4%)**	
Duration of exposure (hours per week)	No indication: 9,000 (11.0%) <2h 54,200 (65.5%) 2-10h 10,600 (13.1%) 10-20h none >20h 4.600 5.6%)	
Extent of exposure *Low exposure: less than 50% of OEL. High exposure: >50% of OEL, Very high exposure: may exceed OEL. The OEL used is not indicated. The French OEL has since 2. July 2015 been 0.01 fibres/cm^3.*	Not declared: 17,900 (22%) Very low: 45,300 (55.6%) Low: 13,500 (16.5%) High: 3,800 (4.7%) Very high: none	
Sector	**Number of exposed**	**Percent of work-force in the sector**
Production and distribution of electricity, gas, steam and air conditioning	4,100	2.1%
Construction	31,300	2.1%
Trade ; repair of automobiles and motorcycles	15,900	0.5%
Skilled auto repair workers	12,900	5.8%
Skilled construction workers	13,100	3.8%
Skilled workers in the structural work of the building	7,300	3.2%
Skilled maintenance workers	10,000	2.9%
Unskilled workers in the building work, public works, concrete work and mining	5,900	2.1%

Source: Vinck and Emmi (2015)

Finland. According to the Finnish Institute of Occupational Health (FIOH, 2021), asbestos demolition work is strictly regulated and subject to authorisation and may only be carried out by companies in the register of asbestos demolition work permits. In 2018, the register was estimated to have 320-350 companies with 3,100-3,300 employees (FIOH, 2021). The FIOH notes that additional demolition workers and people in the vicinity of demolition sites may continue to be exposed to asbestos fibres if the work is not carried out as required by law. In addition to the demolition and construction, exposure to asbestos in Finland may also continue in the mining industry and in some maintenance work.

The number of workers and the exposure concentrations has according to estimates based on the FIOHs FINJEM exposure information system decreased, but in 2013-2015, still more than 1,200 workers in Finland have been exposed to asbestos as shown in the figure below. The concentrations are shown in comparison to the Finnish limit value of 0.1 fibres/cm^3.

During the period 2004 to 2015, the most asbestos exposed sectors and jobs were building and construction sector (assistant workers in house buildings, other construction workers, unskilled/assistant workers in other construction work, etc. (see Figure 4.1). The second largest group was repairers of machinery and motors. Other occupations exposed to asbestos during this period are electricians, electronics and telecommunications installers, painters (paints and varnishes), miners, shotfirers/chargers, bricklayers, plasterers and tile setters, etc. The exposure levels are mainly less than 10% of the limit value. According to ECHA (2021), during the period 2004 to 2015 the occupational limit value for asbestos, 0.1 fibres/cm^3 was exceeded in Finland very rarely in situations other than inside the enclosed environment where asbestos removal work took place. In these situations, airborne concentrations could reach levels over 10 fibres/cm^3. Also, from the outlet air of these enclosed spaces and sometimes even inside respiratory protective equipment high exposures were measured. The use of RPE is not reported.

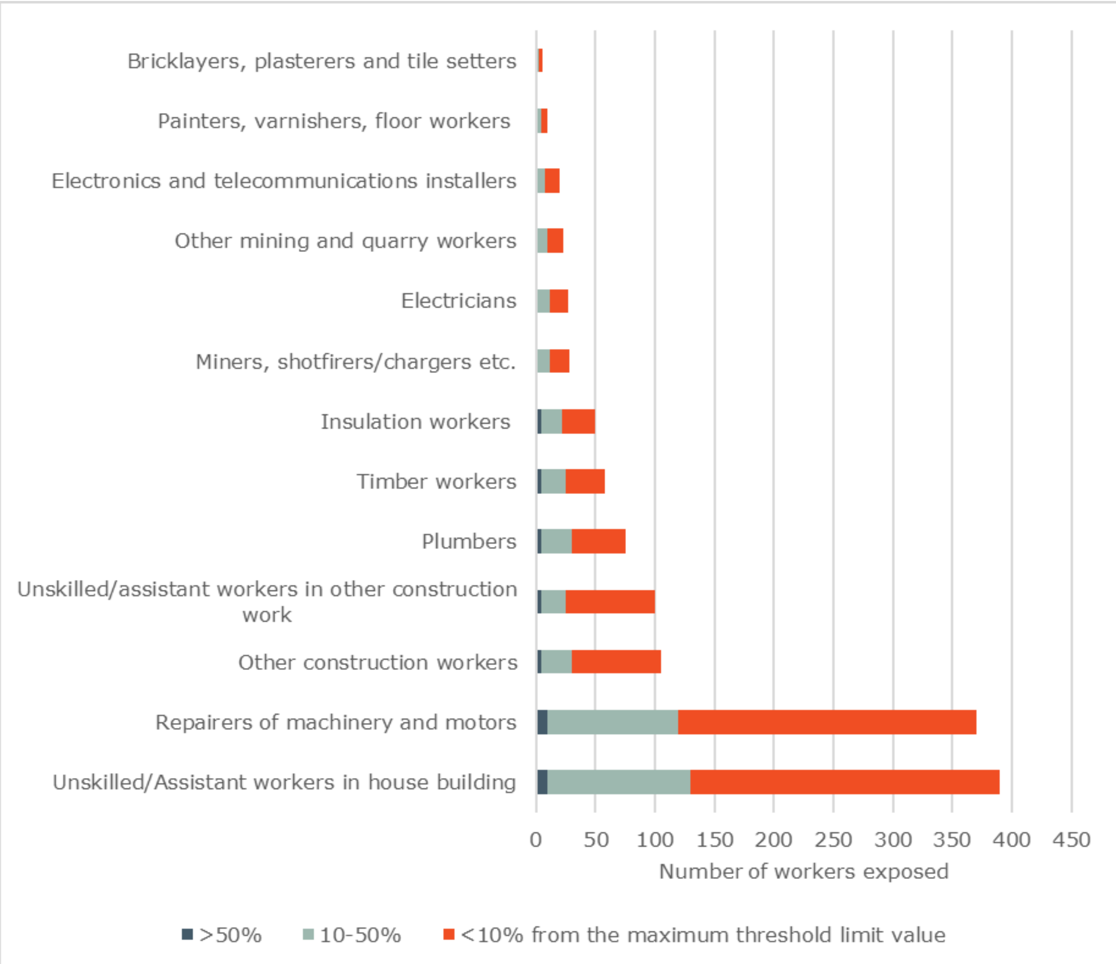

Figure 4.1 Exposure to asbestos classified by profession during years 2013-2015. The threshold value (OEL) used in all calculations is 0.1 fibres/cm^3 (Exposure

database FINJEM of the Finnish Institute of Occupational Health, version 2016, translated from FIOH 2020a).

Number of workers exposed to asbestos in Finland as reported to the ASA database in 2014 is shown below. The grouping of workers is somewhat different from the figure above. Combining the data indicates that the exposed repairers of machinery and motors would be approximately the same as the 133 reported 'aircraft installers and repairers' which is the second largest registered occupation with asbestos exposure in Finland in 2014. No data on this occupation is available from other Member States.

Table 4.39 Number of employees exposed to asbestos by sector

Occupation	Men	Woman	Total
Other construction workers	300	1	301
Aircraft installers and repairers	133	3	136
Construction experts	58	8	66
Plumbers	56	2	58
Motor vehicle installers and repairers	40	0	40
Agricultural and industrial machinery installers and repairers	39	0	39
Officers	35	0	35
Other electricians	34	1	35
Laboratory technicians and others	14	20	34
Non-commissioned officers	32	0	32
Other occupations	493	33	526
Total	1,234	68	1,302

Source: translated from ASA (2014)

Spain. The Spanish Ministry for Health regularly evaluates a programme (PIVISTEA) for the surveillance of workers exposed to asbestos. According to the latest evaluation (SANIDAD, 2018), 17,645 workers are currently exposed and under health surveillance and in addition, 30,387 workers exposed in the past are included in the programme. Of the currently exposed, 98.4% are men. The report presents number of workers by economic sector for both current and past exposure. The main activities, concerning past exposure, were shipbuilding and manufacture of vehicles. The information by economic sector is shown in the table below. Data are only available for 5 Autonomous Regions. The total number of workers included in the table is 3,018 which represent 18% of the total number of currently exposed workers in Spain included in the PIVISTEA.

Building and waste management/decontamination represent in total 78% of exposed workers and 87% of the companies. Repair of motor vehicles represent 1%. For other sectors such as administrative activities and public administration it is difficult to assess the actual activities with exposure but likely it includes building owner's own staff e.g. for maintenance activities.

*Table 4.40 Number of companies that currently work with asbestos and their workers by sex included in PIVISTEA by economic activity of the company in 5 regions in Spain in 2016 **

Sector	No of companies	Number of workers			
		Male	In percent of total	Female	In percent of total
Manufacturing industry	1	111	3.6	0	0
Supply of electricity, gas, steam and air conditioning	1	4	0.1	0	0
Water supply, sanitation activities, waste management and decontamination	72	955	31.1	10	28.6
Building	180	1431	46.6	10	28.6
Wholesale and Retail; repair of motor vehicles and motorcycles	7	30	1.0	1	2.9
Transport and storage	2	24	0.8	0	0
Professional, scientific and technical activities	7	88	2.9	7	20.0
Administrative activities and auxiliary services	4	29	0.9	1	2.9
Public Administration and Defense; Mandatory Social Security	6	345	11.2	4	11.4
Other services	8	42	1.4	2	5.7
Activities of households as employers of domestic staff; household activities as producers of goods and services for their own use	3	14	0.5	0	0
Total	**291**	**3,073**		**35**	

*Data for the following regions: Aragón, Castilla-La Mancha, Extremadura, Comunidad de Madrid y Comunidad Foral de Navarra.

Poland. Vencovsky et al. (2017) quote the Central Register in Poland for a total number of 1,400 workers exposed to asbestos which is remarkably low compared to other Member States. No other data on exposed workforce in Poland are available.

Bulgaria. A national asbestos profile for Bulgaria (Vangelova et al., 2015), indicates that the actual number of workers exposed is not directly available, but is estimated at 27,000. Employers declarations according to Ordinance No 3/ 2010 (State Gazette No.19, 2010) show that 1,188 workers have been occupationally exposed to asbestos in 2012, but their number could according to the authors be higher (Vangelova et al., 2015).

United Kingdom. As part of an assessment of Health and Safety Executive (HSE, 2017) 30 companies in the construction sector were contacted regarding non-notified asbestos work. About half of the companies reported that they did work with asbestos on occasion and did undertake regulatory duties as a result. On this basis the HSE (2017) concluded that the number of businesses in the UK that occasionally undertake some asbestos work was around 480,000 and it estimated that there are 2.2 million workers in the construction sector who could come across asbestos in their work.

CAREX Europe. According to CAREX Europe, the total workforce exposed to asbestos in EU15 in 1990-1993 was approximately 1.2 million. The data are quite old and extrapolated from a few Member States incl. Finland. As newer data are available from Finland and a number of other Members States representing more than 60% of the EU27 population, the CAREX Europe data are not further considered here.

CAREX Canada. According to CAREX Canada [25] approximately 152,000 Canadians are currently occupationally exposed to asbestos. Prohibition of asbestos and products containing asbestos in Canada came into force as late as 2018. Therefore, the data are not considered applicable for estimation of potential occupational exposure in the EU Member States.

4.4.2 Summary of exposed workforce

The available data on the total exposed workers in various Member States are shown in the table below. For comparison, the data are extrapolated to EU27 on a per capita basis. Below the table, total number of exposed workers by exposure situation is described.

Table 4.41 Published data on total workforce exposed to asbestos

Country	Year(s)	Coverage of national data (source)	Number of exposed workers (rounded) in the Member States	Extrapolated number of exposed workers in the EU27
Italy	2019	Extrapolated from numbers reported to the Italian SIREP database. Includes only sectors where more than 3 companies have been registered in SIREP and where more than 1% of the total workforce of the sector is registered in SIREP (Scarselli, 2020)	46,000	248,000
Germany	2017	Workers covered by the German asbestos registry (BAuA, 2020)	114,000	615,000
		All potentially exposed workers (based on number of workers in the relevant sectors in building and construction - includes the majority of above number) (BaUU, 2020)	647,000	3,500,000
France	2010	Extrapolated from self-declarations of exposure to the French SUMER database (Vinck and Emmi, 2015)	81,000	602,000
	2017	Estimated number of workers carrying out operations on ACMs - potentially exposed (Lesterpt and Leray, 2017)	2,000,000	14,000,000
	2020	Estimated number of workers who do rehabilitation work and can be exposed to	500,000 - 800,000	3,700,000 - 5,900,000

[25] Asbestos - CAREX Canada

Country	Year(s)	Coverage of national data (source)	Number of exposed workers (rounded) in the Member States	Extrapolated number of exposed workers in the EU27
		asbestos - potentially exposed (EFBWW, stakeholder consultation).		
	2007	Total estimated number in France (INRS as quoted by ANSES)	1,000,000 - 2,000,000 (of these 900,000 in the building sector)	7,000,000 - 14,000,000
Finland	2013-2015	Workers registered in the Finnish asbestos registry (FIOH, 2020)	1,200	97,000
Spain	2016	Workers registered in the PIVISTEA database (SANIDAD, 2018)	17,645	167,000
Poland **	2013	Not reported (Quoted by Vencovsky et al. (2017) with reference to Central Register in Poland)	1,400	17,000
Romania **	2006	Not reported (Quoted by Vencovsky et al. (2017) with reference to Ministerului Sănătăţii şi Familiei in Romania	7,300	169,000
Bulgaria	2012	Registered exposed (Vangelova et al., 2015)	1,188	76,000
		Estimated potentially exposed (Vangelova et al., 2015)	27,000	1,700,000

The largest numbers of potentially exposed workers can be extrapolated from estimates of total exposed workforce in France, from which a total of 7,000,000 to 14,000,000 potentially exposed workers in EU27 can be estimated.

The available data suggest that a major part of the exposed and potentially exposed workers are within the 'Specialised construction activities' sector. According to data from Eurostat (see section 4.12 there are 2 million companies with 5 million workers in this sector in the EU27. Of these 5 million workers the actual number of workers exposed at a significant level may be much smaller, but no data are available.

Workforce exposed by exposure situation

The estimated exposed workforce by exposure situation is summarised in Table 4.42. The basis for the estimates are as follows:

Building and construction - exposure situations subject to notification. The per capita number of workers covered by the national asbestos registry varies by Member State with relatively many in Germany as compared to other Member States. Lowest per capita numbers are from Poland and Bulgaria. The total for Member States with data is about 245,000. Not all of these are within building and construction. On basis of the available data it is estimated that in the range of 300,000 - 500,000 workers in building and construction are exposed by exposure situations subject to notification.

Building and construction - exposure situations subject to Article 3(3) waiver and 'incidental' exposure. Potentially several million workers may be may occasionally be exposed to asbestos in exposure situations not subject to notification. The total number of employed workers in the relevant sectors in the EU27 (see Table 4.54) is 7.8 million. It is worth noting that self-employed workers that come into contact with asbestos at building and construction sites are expected to comply with the OELs under the Council Directive 92/57/EEC on temporary and mobile construction sites[26].

In addition to the 7.8 million employees, about 2.5 million self-employed are working are working in the sector, this would increase the number of workers to 10.3 million. This would be the upper limit if all workers in these occupations were exposed. Considering the extrapolation of total number of workers potentially to be exposed in Germany, France and the UK mentioned above and assuming that only a part of the workers potentially exposed will actually be exposed, the total number of actually exposed in EU27 (and not included in above category) each year is estimated at 3.5 - 5.5 million workers. These workers will only be exposed occasionally. However, a study from the UK using passive samplers shows that the workers are more frequently exposed that expected by themselves. As no or less efficient RPE is often used for workers within this category, the exposure concentrations when RPE is taken into account, for this category may not be much lower than the exposure concentrations by activities subject to notification as discussed in section 4.3.1.2.

Passive exposure. The number of workers potentially exposed at very low levels by passive exposure in buildings may be up to several millions. No data indicating how many workers are working in buildings with friable ACMs which can release asbestos fibres to the indoor environment have been identified. Examples of asbestos released to the indoor environment in schools are common in the media at least in Denmark and Germany, but asbestos in other buildings has less public attention. A review from 2019 by the thinktank-ResPublica in the UK estimate that 94% of hospitals and 80% of schools in the UK have asbestos indoors, but do not indicate the extent of asbestos in the buildings (Morrin et al., 2019). The review estimates the total number of buildings with asbestos in the UK at 1.5 million. Based on the available data, it cannot be excluded, that lowering the OEL to 0.001 fibres/cm^3 would mean that some workers in buildings with ACMs would be exposed at levels above the OEL. In order to have a first idea it is assumed that 200,000 - 1,000,000 workers are exposed at those levels estimated in section 4.3.1.

Exposure to asbestos in articles. Limited information is available on number of workers exposed to asbestos in articles. The activities would typically be subject to notification and some of the activities would be undertaken by specialised companies. Examples are 133 aircraft installers and repairers notified in Finland in 2014 and a case from France, 2019 where it was estimated that 400 employees in more than 20 workshops were exposed to asbestos even though it was expected that asbestos had been removed from all SNCF trains since 1997 [27]. The activities may be included in a group such as 'Repair and installation of machinery and equipment' where the French SCOLA database include notifications from 123 companies (INRS, 2019). In Madrid Metro, health monitoring includes 1,075 active workers, but asbestos should be removed from rolling stock by the end of 2019 i.e. the workers are after 2019 exposed to asbestos in buildings and infrastructure. Whereas asbestos is reported to have been removed from rolling stocks of several national train companies, asbestos may still be present in private railway companies. Data from the UK and Belgium shows that asbestos is still present in the rolling stock of many railway companies and likely this is also the case in other countries. Large numbers of vehicle mechanics were in the past exposed to asbestos in brakes and other parts, but it is estimated that it will only very seldom happen that vehicle brakes contain asbestos. The presence of several companies specialised in removal of asbestos in ships indicates that a number of workers may also be involved in asbestos removal activities in ships. Some 'incidental' exposure may

[26] Council Directive 92/57/EEC of 24 June 1992 on the implementation of minimum safety and health requirements at temporary or mobile construction sites (eighth individual Directive within the meaning of Article 16 (1) of Directive 89/391/EEC), available at: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A31992L0057

[27] https://www.francetvinfo.fr/sante/affaires/scandale-de-l-amiante/des-salaries-de-la-sncf-denoncent-la-presence-d-amiante-sur-des-wagons-de-fret_3560829.html

also take place by maintenance and renovation involving ACMs which has not been identified. No data on other exposure to asbestos in shipyards has been identified. On the basis of limited information, it is roughly estimated that the number of workers actually involved in activities with asbestos in articles including 'incidental' exposure is likely in the range of 5,000 - 25,000 even the number of potentially exposed may be significantly higher.

Waste management. The data for waste management varies considerably between Member States. The Italian SIREP database includes data for 10,337 workers in this sector (22% of all registered); the majority was in the non-hazardous waste sector. Contrary to this, the Finnish and the German data does not specifically indicate number of workers involved in waste management. In the German data, some activities within transport industry may involve transport of waste, and in Finland waste management may be included in the group of other activities. The French SCOLA database includes notifications from 149 companies within this sector accounting for 3% of all notifications (INRS, 2020). A survey from Denmark from 2008 demonstrated exposure of workers on Danish recycling stations (waste collection points for both hazardous and non-hazardous waste) e.g. by sweeping around containers with asbestos-containing waste. The number of recycling stations in Denmark is 364 with several thousand employees. For the stakeholder consultation Hazardous Waste Europe, representing the hazardous treatment installations, has indicated that for the activities represented by the sector, workers would not be exposed to asbestos as they only handle asbestos-containing waste in closed packaging. Exposure may typically take place when the waste is packed e.g. in waste collection points (also for non-hazardous waste), but it seems to be common to require that all asbestos-containing waste should be delivered in suitable containment (e.g. bagging or wrapping) and placed in a secure skip or container on-site. Potential exposure of the workers in waste collection points may happen by cleaning procedures e.g. when waste is disposed in improper containment. The number of workers that occasionally may be exposed to asbestos by waste collection, transport and final disposal may be high. An extrapolation of the data from the SIREP database in Italy would suggest a total of about 78,000 in the EU27. Many situations in the waste sector where workers are occasionally exposed at shorter time would not be registered and e.g. not included in the SIREP database. The total number of employees in the waste sector in the EU is approximately 1,000,000; of these 46,000 in the hazardous waste sector (see Table 4.54). No data are available on the potential number of workers involved in land reclamation. Even though the number of potentially exposed may be higher, the number of workers exposed at levels comparable to these concentrations used for the calculation of burden of disease is estimated at 50,000 - 200,000.

Mining and quarrying - naturally occurring asbestos. Limited data are available. According to stakeholder response from the Industrial Minerals Association – Europe (IMA-Europe), natural presence of asbestos in the minerals extracted from the ground is extremely rare and a geological curiosity. Euromines has not provided data for the stakeholder consultation. In Finland, the reported number of exposed workers in the sector is about 50. Half of these are exposed at levels above 0.01 fibres/cm^3. Cavallo and Rimoldi (2013) have reported on asbestos exposure concentrations from the serpentine mining in the Valmalenco area in Italy. About 30 enterprises in the valley perform quarrying and processing of the serpentinite, with more than 1,810 workers involved (Cavallo and Rimoldi, 2013). This illustrates that even though the occurrence is rare, the total number may be significant. Mining industry is not among the sectors reported from the Italian SIREP database discussed above. In Germany the number of exposed workers in 'Raw materials and chemical industry' is recorded at 1,991, but it is not indicated how many of these are within the mining and quarrying sector. According to BaUA (2000), the BG for the raw materials and chemical industry in Germany estimated that the German acceptance level of 0.01 fibres/cm^3 during mining and treatment is violated in 10 out of 2,000 active quarries in Germany so safety measures have to be applied. The number of miners is not reported and it is not indicated how many quarries have concentrations above 0.001 fibres/cm^3. The French Scolamiante database includes notifications from 29 companies within the mining sector accounting for

0.3% of all notifications, but it is not clear if the exposure is from naturally occurring asbestos or from maintenance of buildings and equipment (INRS, 2020). From Italy one study point at asbestos exposure in the mining of feldspar, but it has not been reported elsewhere. Feldspar is widely mined in the EU and if exposure to low levels of asbestos take place, the number of workers relevant for the assessment of the lowest OEL at 0.001 fibres/cm^3 could potentially be high. On the basis of the available data the number of workers exposed at levels comparable to the exposure levels reported is estimated at 5,000-30,000.

Tunnel excavation No data are available on the number of workers exposed to asbestos in tunnel excavation. The reported exposure levels are low so the sector is considered not to contribute significantly to the total burden of disease. However, if the OEL is lowered to 0.001 fibres/cm^3, the number of workers exposed at levels relevant for the assessment could potentially be high. Tunnel excavation in asbestos-containing rocks and use of asbestos-containing rocks for various construction works is demonstrated to lead to exposure to asbestos, but no data are available to determine how common it is. For tunnel excavation, exposure has been reported from Italy, Austria and Germany. The total number of workers is roughly estimated to be in the range of 500 - 5,000.

Road construction - naturally occurring asbestos and asbestos in pavement from past intentional use. For road construction no data are available for an estimate. An investigation from 2015 included 173 personal samples at 53 road maintenance sites in France with intentionally added asbestos. It is not known to what extent raw materials across the EU contain asbestos at low levels. As the exposure concentrations are well below the current OELs in most Member States, these activities would not be subject to notification and data are not available from national databases. The number of workers in the EU27 within the sector 'Construction of roads and motorways' is 630,759. If only a few percent of these may be exposed to asbestos, the number of exposed workers could be in the range of 10,000 - 50,000.

Sampling and analysis. Air monitoring and control is among the processes subject to the Article 3(3) waiver of the AWD, and consequently numbers of workers are not recorded in national databases. The number estimated on the basis of the Italian SIREP database is 3,682 however numbers are not available from other Member States. In France, the number of accredited organisations for dust-level control and analysis is 256 (Lesterpt and Leray, 2017) but the number of workers involved in sampling of asbestos samples is not reported. On the basis of the data from Italy, the total number involved in sampling and analysis is estimated at 10,000 - 25,000.

Table 4.42 Estimated total workforce exposed to asbestos by exposure situation

#	Exposure group	Estimated exposed workforce	Remark
1	Building and construction - exposure situations subject to notification	300,000 - 500,000	
2	Building and construction - exposure situations subject to Article 3(3) waiver, 'incidental' exposure	3,500,000 - 5,500,000	Exposure duration is probably lower than for other exposure groups, but no data are available to take this into account.
3	Building and construction - passive exposure in buildings	200,000 - 1,000,000 Potentially millions	The contribution from passive exposure is estimated to be insignificant for the total burden of disease and passive exposure in consequently excluded from the benefit assessment.

#	Exposure group	Estimated exposed workforce	Remark
4	Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	5,000 - 25,000	Based on very limited data.
5	Waste management	50,000 - 200,000	The number of workers estimated to be exposed at reported exposure levels.
6	Mining and quarrying - naturally occurring asbestos	5,000-20,000	Based on very limited data. The number of workers estimated to be exposed at reported exposure levels.
7	Tunnel excavation	500-5,000	Based on very limited data. The number of workers estimated to be exposed at reported exposure levels.
8	Road construction and maintenance	10,000 - 50,000	Based on very limited data.
9	Sampling and analysis	10,000 - 25,000	
	Total (rounded)	4,100,000 - 7,300,000	Excl. potentially more at levels close to 0.001 fibres/cm^3

Source: study team's calculation

4.4.3 Trends in exposed workforce

As consequence of the phasing out of asbestos, the number of workers exposed to asbestos has been reduced markedly.

In Finland, Kauppinen et al. (2013) assessed the prevalence of exposure to chemical agents (as percent of the employed workforce) and its change during 1950–2020 (see data in Table 4.35). When at its highest in 1970, 5.2% of the total workforce was exposed to asbestos and 2.5% of the total workforce was exposed at levels >0.15 fibres/cm^3. The study estimates that in 2020 <0.1% of total workforce in Finland will be exposed to asbestos corresponding to about 1% of the number in 1970 and 4% of the numbers in 1990.

The trend for the period 2004 to 2015 in workforce and exposure concentrations in Finland is shown in the figure below (FIOH 2020a). A shown in the figure no marked decrease in number of exposed workers is seen between 2007-2009 and 2013-2015.

Figure 4.2. Trend in exposure to asbestos during 2004-2015. The threshold value (OEL) used in all calculations is 0.1 fibres/cm^3 (Exposure database FINJEM of the Finnish Institute of Occupational Health, version 2016, FIOH 2020a).

The asbestos profile for Germany provides data on the number of registered workers that are currently exposed to asbestos and the number of companies with current work with ACMs (BAuA, 2020). For both the workers and number of companies, an increasing trend has been observed during the period 2009 to 2017.

These data are quite well in accordance with data on increasing quantities of asbestos-containing waste reported from Denmark and Germany in section 4.2.4.

Table 4.43 Employees who are registered at GVS for occupational health care because of current exposure to asbestos, as well as companies that currently work with ACMs

Date	No of registered workers with current exposure	No of companies currently working with asbestos
31.12.2009	73,434	17,725
31.12.2010	75,206	17,013
31.12.2011	77,318	17,230
31.12.2012	88,979	17,337
31.12.2013	79,524	17,975
31.12.2014	83,424	18,453
31.12.2015	86,067	17,579
31.12.2016	87,673	18,238
31.12.2017	114,431	20,455

Source: BAuA, (2020)

It should be noted that the trends represent activities subject to notification only. No data are available to indicate the trend for activities not subject to notification and 'incidental' exposure. As for the 'incidental' exposure, a decreasing trend would be expected as consequence of a decrease in the total amount of asbestos in buildings, infrastructure, installations and articles.

Past and future trends in workforce for those exposure situations relevant today are summarised in section 4.14 and 4.15, respectively.

4.5 Current risk management measures

Risk management measures (RMMs) are described in two sections: This section describes the current RMMs applied across the EU today whereas in section 4.8 best practice is addressed. The information is used later in the assessment of the potential compliance cost of introducing new OELs. Some of the RMMs prescribed by the AWD are independent of the actual OEL and the description focuses on the measures where a significant impact of introduction of a lower OEL is expected.

The section lists the risk management measures defined in the AWD with an analysis of which RMMs may be impacted by the introduction of a new OEL.

This is followed by a list of examples of existing guidelines from EU and national bodies.

The guidelines can broadly be divided into two groups:

- mandatory legal interpretation of the legislation and published by competent authorities, mandatory legal interpretation of the legislation and published by competent authorities, and
- guidelines published by competent authorities or other stakeholders providing information on how to identify ACMs and provide guidance on what is ‘accepted best practice’.

No surveys of actual RMMs applied in Member States or across the EU have been identified and the description of current RMMs will therefore be based on current guidelines. Stakeholder responses from companies provide information on RMMs currently used, but virtually all responses are from France and cannot be considered representative of the general situation in EU Member States. Data on RPE use from the questionnaires are summarised in section 4.5.4.

Whereas the exposure should be reduced to a minimum and the OEL represent the minimum requirement, it is considered that in particular the mandatory guidelines will represent current minimum practice in the Member States. Also, other guidelines are considered to some extent to reflect the OEL in force e.g. as regards description of sporadic and low-intensity exposure. The exposure levels vary considerably between different exposure situation and this is reflected in the different RMMs applied. The RMMs described for the high-exposure situations below may, in the case that the OEL is lowered by a factor or 10 or 100, require application in medium-exposure situations, and for the high-exposure situations additional RMMs may be required. The description of best practice in section 4.8 will thus have a particular focus on the RMMs applied for high-exposure situations.

In practice RPE is used during most activities - such as demolition, asbestos removal work, repairing and maintenance - in combination with technical RMMs - in order to limiting asbestos in air concentrations to a minimum. Introduction of lower OELs may require that RPE with a higher protection factor is applied and the maintenance of the equipment is improved. The description of RPE is included in this section only, as the described RPE ranges from the lowest protection factor to the highest protection currently used in exposure situations with very high exposure.

Many of the RMMs applied have the aims of reducing the contamination of the surroundings and other part of the building where asbestos removal takes place. The RMMs consequently also have health benefits for a broader population e.g. bystanders and people living or working in other parts of the building, in adjacent buildings or working around the building.

At renovation and demolition sites, workers may be exposed to multiple hazardous substances in building materials. A screening of hazardous substances before initiation of the work would typically include tests for asbestos, PCB (polychlorinated biphenyls), chlorinated paraffins, heavy metals (lead, cadmium, mercury, hexavalent chromium) and PAH (polyaromatic hydrocarbons). Many of the applied RMMs (in particular the organisational measures) would to some extent reduce exposure to all the substances. However, the typical situation is not that the specific asbestos removal activities would also lead to exposure to the other hazardous substances, as the ACMs would typically not contain heavy metals or other hazardous substances. An exception may be asbestos-containing bitumen which would also contain PAHs. Exposure to lead and lead compounds by renovation and demolition would typically be by removal of paint (decorative and anticorrosive) and by handling of lead metal. These activities would typically not lead to exposure to asbestos. Even the technical measures to reduce dust may be the same (e.g. wetting and use of LEV), asbestos and paint removal are typically not undertaken simultaneously, and the application of technical RMMs and RPE for reducing lead exposure would have no influence on the need for RMMs for reducing asbestos exposure. It cannot be excluded that persons responsible for sampling for compliance control at a demolition or renovation site may take samples in different rooms where exposure to asbestos and lead, respectively may take place, and the RPE applied may be governed by the substance with the highest concentrations compared to the OEL. For the total costs assessment, the impact of this is, however, considered insignificant.

In waste operations many of the applied RMMs (in particular the organisational measures) would to some extent reduce exposure to all hazardous substances. Waste containing lead would typically be separated from waste containing asbestos and it is considered that additional measures taken to reduce the exposure to lead would have no significant impact on the exposure to asbestos, and *visa versa*.

4.5.1 Risk management measures defined in the AWD

The Asbestos at Work Directive puts in place a number of risk management measures which are summarised in Table 4.44. The table indicates where lowering the OEL could have an impact on the RMMs needed to be in compliance with the directive.

Measures for which lowering the OEL may have a significant impact can be summarised as follows:

- **Monitoring of asbestos**. Need for more measurements of asbestos in the air and use of other, more expensive analytical methods. Building up capacity for sampling and analysis.
- **Surveillance, registering and notification.** Possible need for surveillance, registering and notification for processes where worker exposure is sporadic and of low intensity (some requirements may be waived if it is clear from the results of the risk assessment that the OEL will not be exceeded in the air of the working area).
- **Technical measures.** Need for further technical measures in order to e.g. not produce dust, avoid the releases of dust, and clean equipment and premises.
- **Personal protection equipment.** Need for more efficient RPE and other PPE. Possibly further use of RPE for processes where worker exposure is sporadic and of low intensity.
- **Training.** Further training may be needed on safe work practices, use of respiratory equipment and decontamination procedures.
- **Decontamination by completion of work** (requirements are not specified in the AWD, but decontamination levels are specified in some national guidelines).

For some of the measures particular actions may be needed for a transition period after the introduction of a lower OEL. This may e.g. concern the need for further training and the need for further measurements. It is common that monitoring is not done regularly when certain procedures are followed for which the previous monitoring has shown that the OEL is not exceeded when these procedures are followed. As an example, in Denmark it is not common to monitor for asbestos in the workplace but to follow the industry guidelines for proper asbestos management. Asbestos measurements in the air are taken only for quality control of the decontamination level (Aldrich et al., 2020).

After introduction of a lower OEL there will be an extensive need for measurements in order to assess which technical measures and RPE is needed in order to be incompliance with the new OELs. This would also involve the updating of guidelines.

Table 4.44 Asbestos at Work Directive – defined risk management measures and potential impact of lowering the OEL

Key requirements	Relevant articles	Description	Potential impact of lowering the OEL
Conducting a risk assessment	3(2)	In the case of any activity likely to involve a risk of exposure to dust arising from asbestos or materials containing asbestos, this risk must be assessed in such a way as to determine the nature and degree of workers' exposure to dust arising from asbestos or materials containing asbestos.	No significant impact.
	3(3)	Provided that worker exposure is sporadic and of low intensity, and if it is clear from the results of the risk assessment referred to in paragraph 2 that the exposure limit for asbestos will not be exceeded in the air of the working area, Articles 4, 18 and 19 may be waived where the work involves: (a) short, non-continuous maintenance activities in which only non-friable materials are handled; (b) removal without deterioration of non-degraded materials in which the asbestos fibres are firmly linked in a matrix; (c) encapsulation or sealing of ACMs which are in good condition; (d) air monitoring and control, and the collection of samples to ascertain whether a specific material contains asbestos.	Lowering the OEL may have the result that the exposure limits is exceeded for more activities with sporadic exposure at low intensity. This could have the effect that Articles 4, 18 and 19 should be applied for more activities.
Regular measurement of asbestos fibre	7 (1)	Employers must regularly measure asbestos fibres in the air and ensure they are maintained below limit values specified in Article 8.	Need for more analysis in order to ensure that concentrations are below the OEL.
	7(4,5)	Sampling must be carried out by suitably qualified personnel and the samples taken must be analysed in laboratories equipped for fibre counting. The fibre counting must be carried out, wherever possible, by phase-contrast microscope (PCM) in accordance with the method recommended in 1997 by the WHO, or any other method giving equivalent results.	Need for changing the required analysis method - need for use of more costly analysis methods. Laboratories and companies providing sampling services may need to build up capacity.
Information for workers	4(4)	Workers (and/or their representatives) must have access to the documents which are the subject of the notification (referred to Article 4(2)).	Lowering the OEL may increase the number of activities for which employers must inform

Key requirements	Relevant articles	Description	Potential impact of lowering the OEL
			the responsible authority cf. comment to Article 3 (3).
	17	1. In the case of all activities referred to in Article 3(1), appropriate measures must be taken to ensure that workers and their representatives receive adequate information concerning: (a) the potential risks to health from exposure to dust arising from asbestos or materials containing asbestos; (b) the existence of statutory limit values and the need for the atmosphere to be monitored; (c) hygiene requirements, including the need to refrain from smoking; (d) the precautions to be taken as regards the wearing and use of protective equipment and clothing; (e) special precautions designed to minimise exposure to asbestos. 2. In addition to the measures referred to in paragraph 1, and subject to Article 3(3), appropriate measures shall be taken to ensure that: (a) workers and/or their representatives in the undertaking or establishment have access to the results of asbestos-in-air concentration measurements and can be given explanations of the significance of those results; (b) if the results exceed the limit value laid down in Article 8, the workers concerned and their representatives in the undertaking or establishment are informed as quickly as possible of the fact and the reasons for it and the workers and/or their representatives in the undertaking or establishment are consulted on the measures to be taken or, in an emergency, are informed of the measures which have been taken.	No significant impact.
Training of workers	14	Employers must provide appropriate training for all workers who are, or are likely to be, exposed to dust from asbestos or materials containing asbestos. Such training must be provided at regular intervals and at no cost to the workers and must cover: (a) the properties of asbestos and its effects on health, including the synergistic effect of smoking; (b) the types of products or materials likely to contain asbestos; (c) the operations that could result in asbestos exposure and the importance of preventive controls to minimise exposure; medical examination requirements. (d) safe work practices, controls and protective equipment; (e) the appropriate role, choice, selection, limitations and proper use of respiratory equipment; (f) emergency procedures;	Further training may be needed on safe work practices, use of respiratory equipment and decontamination procedures.

Key requirements	Relevant articles	Description	Potential impact of lowering the OEL
		(g) decontamination procedures; (h) waste disposal; (i) medical surveillance requirements.	
Health surveillance	18	The AWD sets very detailed and comprehensive requirements on health surveillance of workers.	Lowering the OEL may increase the number of workers under health surveillance cf. comment to Article 3 (3). The methods for health surveillance are not affected by the introduction of a lower OEL.
Consultation of workers	3(5), 7(3), 12	Workers and/or their representatives must be consulted about the risk assessment (Article 3(5)) and about the measures used to ensure workers' protection while they are engaged in activities where it is foreseeable that the limit value set out in Article 8 will be exceeded (Article 12). Workers and/or their representatives must also be consulted before sampling is undertaken (Article 7(3)).	No significant impact.
Notification system	4	Employers must inform the responsible authority of any planned activities where employees are, or may be, exposed to dust from asbestos or materials containing asbestos before the work starts.	Lowering the OEL may increase the number of activities for which employers must inform the responsible authority cf. comment to Article 3 (3).
Measures to reduce exposure	6	For all activities referred to in Article 3(1), the exposure of workers to dust arising from asbestos or materials containing asbestos at the place of work must be reduced to a minimum and in any case below the limit value laid down in Article 8, in particular through the following measures: (a) the number of workers exposed or likely to be exposed to dust arising from asbestos or materials containing asbestos must be limited to the lowest possible figure; (b) work processes must be designed so as not to produce asbestos dust or, if that proves impossible, to avoid the release of asbestos dust into the air; (c) all premises and equipment involved in the treatment of asbestos must be capable of being regularly and effectively cleaned and maintained; (d) asbestos or dust-generating ACM must be stored and transported in suitable sealed packing; (e) waste must be collected and removed from the place of work as soon as possible in suitable sealed packing with labels indicating that it contains asbestos; this measure shall not apply to mining activities; such waste shall then be dealt with in accordance with Council Directive 91/689/EEC of 12 December 1991 on hazardous waste (1).	Need for further measures not to produce dust and avoid the releases of dust (b), and clean equipment and premises (c) For other listed measures no, significant impact is foreseen

Key requirements	Relevant articles	Description	Potential impact of lowering the OEL
Maximum exposure limit	8	Employers must ensure that no employees are exposed to an airborne concentration of asbestos in excess of 0.1 fibres per cm^3 as an 8-hour time-weighted average Time Weighted Average (TWA).	Se comments under Article 7
Cessation of work	10 (1,2)	Where the OEL is exceeded, the reasons for the limit being exceeded must be identified and appropriate measures to remedy the situation must be taken as soon as possible. Work may not be continued in the affected area until adequate measures have been taken for the protection of the workers concerned.	Cessation of work may be needed more often
Identifying ACM	11	Employers must take all appropriate measures, including by obtaining information from the building's owners, to identify ACMs prior to the commencement of works.	No significant impact
Use of Personal Protective Equipment	12	Employers must identify measures to ensure that employees are protected during any activities where it is foreseen that limits may be exceeded in particular the following (a) workers shall be issued with suitable respiratory and other personal protective equipment, which must be worn; (b) warning signs shall be put up indicating that it is foreseeable that the limit value laid down in Article 8 will be exceeded; and (c) the spread of dust arising from asbestos or materials containing asbestos outside the premises or site of action shall be prevented.	Need for more efficient RPE and other PPE Need for preventing spread of dust from more types of activities
	10 (3)	Where exposure cannot be reduced by other means and where compliance with the limit value makes necessary the wearing of individual protective breathing equipment, this may not be permanent and shall be kept to the strict minimum necessary for each worker. During periods of work which require the use of such equipment, provision shall be made for breaks appropriate to the physical and climatological conditions and, where relevant, in consultation with the workers and/or their representatives within the undertaking or establishment, in accordance with national laws and practice.	Possible need for more often use of RPE
Plan of work	13	Prior to commencing work, employers must prepare a plan of work	No significant impact.
Access to risk areas and hygiene and individual protection measures	16	Employers must clearly have demarcated and provide warning signs to areas where activities involving asbestos are taking place, ensuring they are not accessible to workers other than those who are required to enter them, and smoking should be prohibited. Areas must be set aside where workers can eat and drink without risking contamination by asbestos dust and they workers are provided with appropriate working or protective clothing which should remain on-site (it can be	No significant impact. Need for further PPE addressed under Article 12.

Key requirements	Relevant articles	Description	Potential impact of lowering the OEL
		laundered by specialist establishments after transport in closed containers). Separate storage places must be provided for working or protective clothing and for street clothes. Protective equipment must be placed in a well-defined place and checked and cleaned after each use, and appropriate measures taken to repair or replace defective equipment before further use. Workers must be provided with appropriate and adequate washing and toilet facilities, including showers in the case of dusty operations.	

Source of information: Study team's interpretation of wording of the Asbestos at Work Directive.

Whereas monitoring of asbestos is addressed in section 4.9, the following section focuses on the type of risk management measures that may be affected by the introduction of a lower OEL, first technical measures for dust prevention, the use of PPE and training.

The extension of a number of measures such as preparation of risk assessment, identification of ACM, plan of work, access to risk areas, consultation of workers, etc. will not be significantly affected by the introduction of new OELs even the content of the activities may be slightly changed to reflect the new OELs. Consequently, as the objective of the description in this section is to provide background for the costs assessment in Chapter 6, these measures will not be described on their own, but only in the context of introduction of other new measures as consequence of lowering the OEL.

4.5.2 Existing guidelines

A number of guidelines have been published by the EU Commission, national authorities or research institutions and industry stakeholders. Examples of guidelines are listed in the table below on the basis of responses to the stakeholder consultation and literature search. The list is not exhaustive, most Member States would have guidelines at different levels.

The guidelines describe best practice at the time they were issued, but may not describe the best practice and most efficient risk management measures which may be required for compliance with an OEL 10-100 times lower than the OEL in force at the time the guidelines were issued. We assess that as a consequence of lowering the OEL, many of the guidelines may need an update.

As mentioned in the introduction to this chapter the guidelines can be grouped into two groups. Exemplified with France, the Ministry of labour has issued instructions specifying which RMMs would be required in order to meet the legislation while the French National Research and Safety Institute (INRS) has published guidelines describing in detail all steps in managing ACMs with more specific information on the different RMMs.

As part of the stakeholder consultation contact has been established to Dutch experts in order to understand to what extent guidelines are available and has been updated to reflect the lowering of the Dutch OEL to 0.002 fibres/cm^3. There are no common guidelines, but guidelines were developed on how to assess that a specific working method is safe. Parties can decide to develop a safe working method to be applied at nationwide level, which would result in having to apply a less strict safety regime. These safe working methods often include the application of some type of control measures (like a wetting agent). For such safe working methods to be generally available these have to be evaluated and approved by a specific committee that has been installed by the Ministry of Social Affairs and Employability. Currently a limited number of such safe working methods are now generally available in the Netherlands (Spaan, personal communication 2021). It has been beyond the scope of this study to review these safe working methods as they currently cover a limited number of processes only.

Table 4.45 Examples of guidelines for management of asbestos in the workplace

Title	Published by (year)
EU level	
A practical guide on best practice to prevent or minimise asbestos risks in work that involves (or may involve) asbestos: for the employer, the workers and the labour inspector.	Issued by the Senior Labour Inspectors Committee (SLIC) for use in the 2006 asbestos campaign undertaken throughout Europe and published by the European Commission (undated)
Practical guidelines for the information and training of workers involved with asbestos removal or maintenance work.	European Commission (2012)
National authorities or Occupational Health and Safety institutes	
Asbestos-containing materials (ACMs) in workplaces. Practical guidelines on ACM management and abatement	Health and Safety Authority, Ireland (HSA, 2013)
Asbestos risk management guidelines for mines	Finnish Institute of Occupational Health (Kähkönen et al., 2019)
Tätigkeiten mit potenziell asbesthaltigen mineralischen Rohstoffen und daraus hergestellten Gemischen und Erzeugnisse. TRGS 517. [mandatory]	Federal Institute for Occupational Safety and Health, Germany (BAuA, 2015)
Technische Regeln für Gefahrstoffe Asbest: Abbruch-, Sanierungs- oder Instandhaltungsarbeiten. TRGS 519. [mandatory]	Federal Institute for Occupational Safety and Health, Germany (BAuA, 2019)
Instruction DGT/CT2 no 2015/238 du 16 octobre 2015 concernant l'application du décret du 29 juin 2015 relatif aux risques d'exposition à l'amiante [mandatory]	Ministère du Travail, de L'emploi, de la Formation Professionnelle et du Dialogue Social, France MTEFR (2015).
Exposition à l'amiante dans les travaux d'entretien et de maintenance. Guide de prévention.	Institut National de Recherche et de Securité, France (INRS, 2019a)
Situations de travail exposant à l'amiante	Institut National de Recherche et de Securité, France (INRS, 2007)
Para la evaluación y prevención de los riesgos relacionados con la exposición al amianto	Instituto Nacional de Seguridad e Higiene en el Trabajo (INSHT, 2006)
Asbestos. Health and Safety at Workplaces. [mandatory]	Occupational Health and Safety Authority, Malta (OSHA, 2016)
Varno delo zazbestom. [Safe work with asbestos] [mandatory]	Ministrstvo za delo, druûino in socialne zadeve, Urad RS za varnost in zdravje pri delu, Slovenia (Vrečko, 2002)
Arbetsmiljöverkets föreskrifter om asbest och allmänna råd om tillämpningen av föreskrifterna [The Swedish Work Environment Authority's regulations on asbestos and general advice on the application of the regulations] [mandatory]	Arbetsmilöverket, Sweden (Arbetsmiljöverket, 2019)

Title	Published by (year)
Asbest. Regler for ethvert arbejde med asbest og herunder reparation, vedligeholdelse og fjernelse af asbestholdige materialer. [Mandatory]	Arbejdstilsynet, Denmark
Ασφάλεια και Υγεία στην Εργασία. Διεθνείς Συμβάσεις [Occupational Safety and Health. Asbestos]	Website of Department of Labour Inspection, Cyprus[28]
Inventaire d'amiante et programme de gestion	Service Public Federal Emploi, Travail et Concertation Sociale, Belgium (SPF Emploi, 2020)
Препоръки за опазване здравето на работещите при експозиция на азбест [Recommendations for protecting the health of workers by exposure to asbestos]	Website of Ministry of Health, National Center of Public Health and Analyses, Bulgaria [29]
Industry stakeholders	
Information modules Asbestos (a list of information modules) Available in Bulgarian, Croatian, Czech, English, French, German, Hungarian, Italian, Latvian Lithuanian, Polish, Romanian, Slovenian, Spanish, and Turkish	European Construction Industry Federation (FIEC) and European Federation of Building and Woodworkers (EFBWW or FETBB), available at the websites of EFBWW and FIEC [30]
EFBWW Trade Union Guide on using Asbestos Registries	European Federation of Building and Woodworkers (EFBWW, 2018)
Guía sobre amianto. Visión general y proceso de descontaminación (desamiantado)	AEDED - Asociación española de demolición, descontaminación, corte y perforación. Prepared in cooperation with the European Demolition Association (EDA) and a number of national associations (AEDED, 2020)
Asbest. Den grønne asbestvejledning og beskrivelse for udførelse af asbestsanering [Asbestos. The green asbestos guide and description for performing asbestos remediation]	Danish Construction Association (Dansk Byggeri, 2019)
Vejledning om asbest i skibe [Guidelines on asbestos in ships]	The Industry's Work Environment Council, Denmark (I-bar 2010)
Asbesthuset [The asbestos house. interactive guideline] https://asbest-huset.dk/	Social partners within the building and construction sector, Denmark

4.5.3 Technical and organisational measures to prevent generation and spread of dust

It should be noted that the objective of application of technical and organisational measures to prevent generation and spread of dust is not only to reduce occupational exposure but also to reduce spread of asbestos to the surrounding and prevent contamination of other parts of the buildings and to ensure that the asbestos left in the building and surroundings after the ACMs are removed is as low as possible. Some of the measures thus may have only small effect on the direct exposure of workers.

The RMMs applied will depend on the actual work and airborne concentrations of asbestos from the activities.

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28 http://www.mlsi.gov.cy/mlsi/dli/dliup.nsf/All/2E24CA4412E799C9C2257DD6003AC247?OpenDocument&highlight=asbestos

29 https://ncpha.government.bg/uploads/pages/3001/Azbestos-Prot_Workers.pdf

30 https://www.fiec.eu/our-projects/completed-projetcs/information-modules-asbestos

The table below summarises the French decree of RMMs to be taken for works at three levels of asbestos air concentrations in order to meet the French OEL of 0.01 fibres/cm^3. The RMMs concern indoor environment only. The measures are divided into three groups:

- Surface protection and containment
- Employee decontamination facility
- Waste decontamination facility

For works outdoors the decree specifies for all works that, depending on the employer's risk assessment, RMMs should be adapted to avoid the dispersion of fibres outside the area and ensure a level of worker protection equivalent to that provided for the indoor environment (not further specified). Furthermore, employee and waste decontamination facilities should be available - provisions are identical to the provisions for the indoor environment.

Table 4.46 Table summarizing the French decree of April 8, 2013 relating RMMs to be implemented by companies in operations involving a risk of exposure to asbestos. For indoor environments

Level 1 **Concentration < OEL**	**Surface protection:** • Resistant and waterproof protection of surfaces and equipment that cannot be decontaminated by a clean film **Employee decontamination facility:** • Pre-decontamination area: suction, wetting by spraying the suit • Hygiene shower • Facility lighting + approach locker room + recovery area **Waste decontamination facility:** • Adapted to the nature of the work
Level 2 Concentration 1 - 60 times OEL	**Surface protection and containment:** • Isolation of the work area by physical separation airtight and watertight • Sealing of the work area (neutralization, blocking of ventilation devices, etc.) • If physical separation cannot be decontaminated: protection by clean film • Elements in the area that cannot be decontamination: protection by clean film • Viewing window in the confinement of the work area unless this is not possible • Creation of a fresh and permanent air flow from the outside to the inside of the area • THE (very high efficiency) extractors, with air discharge to the outside environment + emergency extractors (emergency electrical installation) • Homogeneous air renewal: at least 6 volumes / h • Depression ≥ - 10 Pa + vacuum controller **Employee decontamination facility**: • At least 3 compartments + 2 showers (renewal rate: 2x Shower volume / min) • Facility lighting + approach locker room + recovery area • Separate installation from the waste decontamination facility unless this is not possible **Waste decontamination facility:** • Illuminated, compartmentalized, air speed of 0.5m / s over the entire section
Level 3	**Surface protection and containment:** • Isolation of the work area by physical separation airtight and watertight

Concentration 60 - 250 times the OEL	• Sealing of the work area (neutralization, blocking of ventilation devices, etc.) • If physical separation cannot be decontaminated: 1 cleanliness film; if physical separation cannot be decontaminated: 2 cleaning films • Elements in the area cannot be decontaminated: protection by clean film • Viewing window in the confinement of the work area unless this is not possible • Creation of a fresh and permanent air flow from the outside to the inside of the area • THE (very high efficiency) extractors, with air discharge to the outside environment + emergency extractors (emergency electrical installation) • Homogeneous air renewal: at least 10 volumes / h • Depression ≥ - 10 Pa + vacuum controller **Employee decontamination facility:** • At least 3 compartments + 2 showers (renewal rate: 2 x shower volume / min) • Facility lighting + approach locker room + recovery area • Separate installation from the waste decontamination facility unless this is not possible **Waste decontamination facility:** Illuminated, compartmentalized, air speed of 0.5m / s over the entire section

Source: based on MTEFR (2015).

4.5.3.1 Specific for activities with sporadic exposure and of low intensity

This section concerns low-risk activities including activities with sporadic exposure and of low intensity. The RMMs listed for these activities should also be applied for the higher-risk activities where they should be supplemented with additional RMMs as further described in the following section.

For work involving sporadic and low-intensity exposure the EU guidelines (European Commission, 2012) state that the following minimum technical precautions should be taken:

- Thorough planning of the work;
- Covering up the surroundings of the work site if necessary;
- Keeping doors, windows, openings in the immediate working area closed;
- Working as much as possible with wetted material;
- Vacuum-cleaning dust with a suitable vacuum cleaner;
- Removing material without damaging it;
- Thorough cleansing of the work site before declaring it safe.

It is further specified, that only low-emission processes and equipment should be used. Cleaning of the asbestos cement sheets is only allowed if the surface will not be damaged. Grinding, brushing and high- or low-pressure cleaners are not permitted. One should not clean or coat roof coverings comprising uncoated asbestos products. The cleaning water must be collected and disposed of as wastewater.

In addition to the measures listed above, existing guidelines includes various measures for low risk activities. Several of the measures concern mainly reducing the spread of asbestos to the surroundings and would be independent on the actual OEL in force. Those measures that are most relevant as to the reduction of exposure of workers can be summarised as follows:

- Use hand-tools; power tools create dust.

- Use hand tools with local exhaust ventilation (LEV).
- Where there is no choice but to use power or pneumatic tools, set them at the lowest effective speed with additional control measures such as LEV.
- Minimise breakage of any ACM.
- Do not allow waste to accumulate – clear it up as you go - put asbestos waste into a suitable sealed container.
- Avoid working with ACMs overhead.
- Wash hands and face before eating, drinking or smoking and at the end of the day's work.
- For asbestos cement, avoid the need to attach items to it and avoid routing items such as wiring and pipes through it.

4.5.3.2 Work with higher risk ACMs

In addition to the measures specified in the previous section, working with higher risk ACMs as indicated in Table 4.46 requires additional measures.

The following table summarises some of the technical measures needed for higher risk ACMs. The methods are dependent on the type of asbestos and basically the RMMs applied in removal of asbestos from articles such as ships and trains are broadly the same as the RMMs applied for removing similar materials from buildings and industrial installations.

The description is mainly based on the Irish guidelines (HSA, 2013) and most parts of the description is direct citation.

Table 4.47 Technical RMMs needed for higher risk ACMs

Preventing the formation of dust	
Wet spray method	The wet spray method is the preferred asbestos removal method and should be used for the removal of asbestos from structures and plant. The wet spray method requires the use of a constant low-pressure water supply for wetting down asbestos and related items to suppress asbestos fibres. If no water supply is readily available, a portable pressurised vessel (for example, a pump-up garden sprayer) may be used. Other methods involve the use of airless sprayers or 'Gracos', which are suitable for larger ACM removal projects. The wet spray method involves applying a fine water spray to the asbestos in a manner that ensures that the entire surface of the asbestos is saturated and the run-off is minimised. The asbestos should be maintained in a wet condition throughout the removal. A wetting agent (surfactant), e.g. detergent, may be added to the water to facilitate more rapid wetting of the asbestos. Consideration should be given to applying a PVA emulsion, as it may be more effective than water (with a wetting agent) in minimising fibre release. Wherever reasonably practicable, a H-Type vacuum cleaner should be used in conjunction with the wet spray method. The H-Type vacuum cleaner should be used prior to spraying asbestos with water and for the collection of any dust spread over a large area. The asbestos should be wetted through to its full depth and the water spray should be directed at the site of the cut. The wetted material should be removed as the cut is progressed. Immediately after the asbestos is removed from its fixed or installed position, spray should be directed on the sides that have not been previously exposed..
Saturation and water injection method	Saturation and water injection method with total saturation should be used if the asbestos is so thick that the spray method will not suppress the asbestos significantly. This method involves injecting water or a water-based solution under low pressure (3.5 bar) directly into friable asbestos such as laggings, sprayed coatings and painted asbestos insulating board. It is a process that requires specific training in relation to the use of the equipment and the process.

Dry methods	Dry methods are not advisable, as there is a much greater potential for airborne asbestos fibres to be generated and can only be used if the wet methods are not suitable. The wrap and cut method is also used, in particular for pipework/vessels which are redundant. This method requires less contact time with asbestos. Glove bags can only be used without an enclosure where the assessment shows minimal risks to other people if the glove bag leaks or fails. This may be the case where the site is remote from other workers, e.g. runs of open-air pipework in a chemical works where the prevailing weather conditions could make building and maintaining an enclosure impractical. The shadow vacuum technique involves local exhaust ventilation using H-Type vacuum cleaners to capture any asbestos fibres released during work with ACMs. Such controls can be used during the removal of ceiling tiles by carefully vacuuming the top of the ceiling tile during removal. Similar techniques can be used whilst unscrewing asbestos insulation boards.
Preventing spread of dust	
Enclosures	Enclosures are a fundamental component in the control of the risks associated with the release of asbestos fibres during removal work, and are required for almost all notifiable asbestos removal work. Enclosures are generally formed using timber, polythene film, tape and spay-tac adhesive. Enclosures should be a reasonable size and should correspond to sketches in the contractor's plan of work. They should be designed to allow sufficient airflow through to avoid 'dead spots'. The enclosure should be maintained under negative pressure (e.g. 5 Pa), and the pressure should be as uniform as possible throughout the enclosure. Negative pressure units (NPU) with pressure monitoring facilities and supplementary air inlets should be located to achieve good air flow and to avoid dead spots. Air movement should be checked during the smoke test following construction of the enclosure. The negative air units should operate continuously (twenty-four hours a day) until all asbestos removal work and decontamination within the enclosure has been completed, a clearance certificate issued and the enclosure dismantled. If the units stop during removal work, the specialist contractor must ensure that all removal work ceases immediately until the problem is rectified and the required number of units are in operation. With the use of appropriate NPUs, there should be at least eight air changes per hour within the enclosure. Therefore, accurate ventilation calculations for enclosures are critical. This is achieved as follows: Each enclosure must have a viewing panel (minimum 600 mm x 300 mm) or bubble window, wherever possible, including a viewing panel on the inner stage of the three-stage airlock. The use of closed circuit television (CCTV) may be required to enable the work and workers to be inspected without needing to enter the enclosure, e.g. basement boiler rooms, roof spaces, complex enclosures etc. An exclusion 'buffer' zone around the enclosure should be created, as far as practicable, using red asbestos barrier tape. Depending on the location, additional barriers should be installed to stop unauthorised access. Airlocks and bag locks should be of an appropriate size for the controlled movement of personnel, waste and equipment in and out of the work area. An exclusion 'buffer' zone around the enclosure should be created, as far as practicable. Airlocks and bag locks should be of an appropriate size for the controlled movement of personnel, waste and equipment in and out of the work area. Enclosures may only be dismantled once all of the following are done:
Maintenance of plant and equipment	All equipment should be subject to regular visual inspection (at the start of every shift), monitoring and maintenance, all of which should be recorded.
Hygiene measures	Operatives must not eat, drink or smoke in an asbestos work area or in the washing and changing facilities. Any operative working with asbestos insulation, asbestos insulation board or coatings should be subjected to rigorous decontamination procedures. The provision of an appropriate hygiene unit, usually referred to as a decontamination unit, or DCU, is essential for notifiable asbestos work. A DCU is a three-stage unit with a shower between a 'clean end' and a 'dirty end'. The DCU should be fully cleanable, with adjustable heated shower and separate areas for clean clothing and for discarding contaminated disposable work

	clothing. The unit should display, in a prominent position in the clean end, a copy of the clearance certificate from the most recent asbestos removal job. Extract ventilation with a HEPA filter produces a flow of air (through grilles) from 'clean end' to 'dirty end' of the decontamination unit. Ideally, a DCU should be connected to the enclosure. Where transiting arrangements are in place (i.e. the DCU is not directly linked to the enclosure), additional procedures, PPE and preliminary decontamination is required at the enclosure before travelling to the DCU for full decontamination. There must be a bucket of clean water and sponge and a dedicated H-Type vacuum should be available in the airlock for primary decontamination. Arrangements should be made for the facilities to be cleaned at least at the end of each working day.

Source: HSA Ireland (2013)

Efficiency of applying good practice.

The practical guidelines for management of ACMs from the Health and Safety Authority in Ireland (HSA, 2013) list typical concentrations by different removal processes. The reduction rate in airborne concentrations range from a factor of four for the processes which lead to relatively low airborne concentrations to factors of 25 and 37 for works with friable asbestos materials that lead to high exposure concentrations. The HSA notes that for spray products, the average fibre levels during poorly controlled dry removal are about 360 fibres/cm^3, and for asbestos insulation boards, about 15 fibres/cm^3 which is some 3,600 and 150 times, respectively, the OEL in Ireland. Even with controlled (wet) removal there is, for removal of sprays, significant potential for release of fibres of around 140 times the exposure OEL and it will be necessary to supplement with the use of RPE with high protection factors.

Table 4.48 Assessment of average personal airborne concentration of regulated asbestos fibres during removal of ACMs

Product group	Controlled wet removal / good practice fibres/cm^3	Limited controls / dry removal, fibres/cm^3	Reduction rate applying good practice *
Spray and other insulation products	144	3,580	25
Asbestos insulating board (AIB) including millboards	4	150	37
Asbestos cement	0.1	0.8	8
Fillers and reinforcements in a flexible matrix (incl. textured coatings)	0.2	0.8	4
Jointing (gaskets) and packing	0.5	2.0	4
Flooring	0.1	0.5	5
Moulded plastics and battery cases	0.01	0.1	10

* Calculated as part of the current study.

Source: (HSA Ireland, 2013 quoting Health and Safety Laboratory, UK)

4.5.3.3 Use of wetting agents, dust stabilizers, local ventilation and containment

Wetting agents and dust stabilizers

According to the stakeholder consultation further use of wetting agents would be one of the main RMMs used in response to lowering the OEL; in particular for activities not subject to notification.

No data are available for assessing the prevalence of the use of wetting agents and dust stabilizers for activities not subject to notification, but data are available from France for the activities subject to notification.

The reporting from the SCOLA database (INRS, 2020; see description in section 4.3.1) summarise the use of wetting method across all activities i.e. it is not indicated to what extent the methods applied depend on the asbestos concentration in the workplace air. This information was not recorded for 7% of the notified works. No wet work measures were taken in 27% of the works (i.e. 29% of recorded works). Humidification of the material by "material spraying alone" is the most widely used technique (45% of those recorded). The remaining 26% of the recorded wetting methods consisted on 'misting or nebulization in the work area alone' (8% of reported) and 'humidification of the material by spraying the materials and misting or nebulization' (17% of reported). The 'core impregnation of the material alone' represents 1% of works. It is not indicated to what extent only water is used for the wetting or if the water is added some wetting agents.

The efficiency of use of moisturising methods varies by the material to be removed as illustrated in the table below. It should be noted that the table summarises reported data from various data sources and is not summarising the results of a controlled experiment where the same materials are removed with and without the use of moisturising.

Table 4.49 Efficiency of the use of moisturising methods, in fibres/cm^3 (based on data from Spaan et al., 2019)

Product group	Removal method / control measures *	N	AM	P90	AM % of no control	P90 % of no control
Window sill	B: No control measures	25	0.0003	0.0006	-	-
	B: Moisturising	8	0.0002	0.0002	45%	38%
Glue	B: No control measures	11	0.0002	0.0003	-	-
	B: Moisturising	8	0.0021	0.0066	976%	2129%
Asbestos cement	B: No control measures	9	0.0011	0.0026	-	-
	B: Moisturising	76	0.0008	0.0009	72%	34%
Asbestos chord	No control measures	6	0.0204	0.0630	-	-
	Moisturising	22	0.0024	0.0048	12%	8%
Gasket	B: No control measures	1	0.0003	0.0000	-	-
	B: Moisturising	12	0.0003	0.0005	94%	-
Board	B: No control measures	34	13.6890	37.1200	-	-

Product group	Removal method / control measures *	N	AM	P90	AM % of no control	P90 % of no control
	B: Moisturising	52	0.2950	0.2900	2%	1%
Stucco	B: No control measures	4	0.0014	0.0018	-	-
	B: Moisturising	3	0.0006	0.0000	45%	0%

Obmiński and Janeczek (2020) have evaluated the effectiveness of asbestos stabilizers during abrasion of asbestos-cement sheets. According to the authors, unlike water, asbestos stabilizers act as film-forming binders, fixing fibers even after evaporation of their volatile fraction. While there is a wide range of stabilizers on the market, they have different binding properties and, thus, their levels of effectiveness in binding asbestos fibers in AC sheets may vary significantly. The binding effectiveness of the stabilizers varied from 35% (bitumen-based) to >90% (polyurethane resin (PUR), acrylic paint, flexible coating). According to the authors, previous studies have shown that both the surface condition of asbestos-containing ceiling tiles and treatment with stabilizers are the major factors controlling the number of fibers released during wind tests; airborne asbestos fiber concentrations released from damaged ceiling tiles treated with stabilizers decreased by 69.5–84.5% as compared to untreated tiles. The greatest effectiveness in binding asbestos fibers is achieved by applying stabilizers that combine a hard coating (PUR), high degree of flexibility (flexible coating) and adhesiveness (acrylic dispersion paint).

According to Obmiński and Janeczek (2020), currently, the use of stabilizers is not mandatory in Poland and, as a result, ACM are usually not treated with stabilizers by removal. Information on the prevalence in the use of stabilizers is not available from other Member States.

Use of local ventilation

Data on the use of local ventilation is available from France where information on ventilation is summarised in the reporting from the SCOLA database (INRS, 2020). The information was not recorded for 9% of the works and no dust collection measure at the source was carried out in 50% of the works (55% of recorded works). The use of source suction with industrial vacuum cleaner was the most widely used source capture technique (45 % of recorded works).

Use of containment

Data on the use of containment is available from France where information on containment is summarised in the reporting from the SCOLA database (INRS, 2020). Information on containment was not recorded for 10% of the notified works and in 36% of works (40% of recorded works) no measures to isolate the area were taken. Confinement was used in 54% of the works (60% of recorded works). Dynamic confinement with a minimum negative pressure of -20 Pa was the most frequently encountered (20% of recorded works), dynamic confinement with a negative pressure at -10 Pa and replacement of air was used in 27% of the works whereas simple isolation and caulking was used in 13% of the works.

4.5.3.4 Naturally occurring asbestos

Mining and quarrying sector

The following is based on Finish guidelines for management of asbestos in the mining and quarrying sector (Kahkonen et al., 2019). The general prevention methods for reducing exposure are the same as for other work with asbestos except for one specific method for the sector: To avoid mining and quarrying in areas with high asbestos in the minerals. It is considered unlikely that lowering the OEL would have the impact that some current mining and quarrying activities would cease, as asbestos exposure can be reduced by use of RPEs with a higher protection factor, as RPE is used in any case. The main concern of the mining and quarrying sector if the OEL is lowered is the challenges in measuring asbestos at low levels in the dust from mining and quarrying activities.

Exposure of the users of mining machinery and vehicles can be reduced by increasing cabin sealing and improving the incoming air filtering in the cabin. When work is carried out in machines, the cabin doors and windows must be kept closed and eating, drinking and smoking in the cabin is prohibited. The incoming air filter of the cabin must also filter out fine dust. Mining machinery and vehicles used in an asbestos area must be washed before maintenance or use in locations other than asbestos areas.

The guidelines provide the following *'Examples of dust control and good practices for reducing exposure:*

Mining, loading, transportation, drilling:

- *Ventilation is appropriately scaled and sufficiently effective and exhaust air is directed into exhaust shafts.*
- *Rock being loaded and roads are watered, walls are washed with water.*
- *Only wet rock is loaded to prevent the formation of dust.*
- *The ore transportation line system is equipped with effective dust removal and enclosed.*
- *Water is sprayed at the unloading point and in the crushing plant during drilling, work is carried out in the cabin as far as possible. In quarries, the prevailing wind direction is taken into account when placing machinery and the goal is to be upwind when working outside the cabin.*

Sample handling:

- *The sawing of drill cores is carried out in separate premises with wet techniques.*
- *Powdery samples are handled in fume hoods that have their own exhausts. The functioning of fume hoods is tested regularly.*
- *If fume hoods alone are not sufficient to prevent exposure, respiratory protective equipment is used when working'*. (Kahkonen et al., 2019)

Tunnel excavation

No guidelines specifically addressing tunnel excavation and other construction activities have been identified. The studies presented in section 4.3.5 on exposure concentration also describe some of the main measures taken to minimise occupational exposure. Main technical measures were physical division of the tunnel with decontamination units and vacuum dedusting systems. Labagnara et al. (2016) describe OSH procedures in tunnel excavation in rock formations potentially containing asbestos. The study mainly concerns improved preliminary analysis, monitoring and PPE.

4.5.4 Respiratory protection equipment

In line with their mode of action, respiratory protective devices may be divided into respirators and breathing apparatus (European Commission, 2014). Breathing apparatus function irrespective of the ambient atmosphere while respirators remove pollutants from the ambient atmosphere depending on the type of filter contained. For activities involving asbestos only respirators are used in general (European Commission, 2014).

Protection class and performance of RPE is summarised in the table below on the basis of French guidelines. The protection factors applied to various RPE may vary between

Member States, but the factors shown in the table serves as a good indicator of the protection factors of the different equipment. The nominal protection factor (NPF) is calculated based on the total leakage inside the respiratory protection device set by the respiratory protection standards. It is measured in the laboratory. The assigned protection factor (APF) is the level of protection achieved in a work situation by 95% of operators trained to wear respiratory protection devices and correctly using, after checking, a well-maintained and well-adjusted device. The APF are the relevant factors to use in the assessment of the need for using RPE in response to introducing a new OEL.

The actual protection obtained will be highly dependent on the selection of the correct RPE, face-fit testing of the user, training, supervision and maintenance. Under improper conditions the actual protection factor may be lower than the assigned protection factor and workers may be exposed to higher levels than calculated in the risk assessment undertaken prior to the work. As consequence some workers may be exposed to levels above the OEL even the calculated exposures would indicate compliance. It has not been possible to identify any information which could illustrate to what extent the actual protection factors of applied RPE is lower than the APF.

Table 4.50 Protection class and performance of PPE for work with asbestos

Description	Class	Nominal Protection Factor, NPF	Assigned Protection Factor, APF
Filtering half-mask Half mask with filter Full face mask with filter	FFP3 P3 P3	50 48 1,000	10 10 30
Assisted ventilation filter device with half mask [power assisted masks]	TM2 P	200	20
Assisted ventilation filter device with hood or helmet	TH3 P	500	40
Assisted ventilation filter device with full facepiece	TM3 P	2,000	60 (100)*
Continuous flow air supply insulating device	4A/4B	2,000	250
Ventilated waterproof suit - ventilated-pressurized garment	from 1 to 5	from 2,000 to 50 000	from 2 000 to 50 000

* The guideline indicates that the APF are to be updated by INRS. In bracket is shown the APF indicated in the newest guidelines from INRS (2019). Assisted ventilation often designated 'power assisted'

Source: (MTEFR, 2015)

In the assessment of the need of using other RPE it is also of importance to take into account how many hours a day the workers are allowed to use the various RPE. As shown in the table below, some types of filters are allowed for short-term activities only.

In Spain, workers are allowed to use RPE for a maximum of 4 hours a day.

The German Technical Rule TRGS 519 (BAuA, 2019) indicates the following RPE may be regarded as suitable provided there is no reason to fear oxygen deficiency.

Table 4.51 RPE required in German Technical Rule TRGS 519 (adapted from BAuA, 2019). The RPE is required in order to comply with the German acceptance level of 0.01 fibres/cm^3.

Asbestos fibre concentration	RPE
0.01-0.1 fibres/cm^3	1. Particle-filtering half masks FFP2 for short-term activities of a maximum two hours per shift, 2. Half masks with P2 filter for long-term activities, 3. Mask with blower and TM1P particle filter or higher quality suitable and to be used
0.1 - 0.3 fibres/cm^3	Respirators with a P3 particle filter must be worn: 1. Particle-filtering half masks FFP3 for short-term activities of a maximum two hours per shift, 2. Half masks with P3 filters for long-term activities, 3. Mask with blower and TM2P particle filter or higher quality breathing apparatus. Due to the increased physical stress when using respiratory protective devices with P3 filters, the use of TM2P fan-assisted breathing apparatus recommended, if necessary with warming of the breathable air

Asbestos fibre concentration	RPE
> 0.3 fibres/cm^3	Full face masks with blower and particle filter TM3P or higher quality breathing apparatus to be used, if necessary with heating of the breathable air.
> 4 fibres/cm^3	(if e.g. dry removal of sprayed asbestos is unavoidable) Insulation devices

In addition to the RPE, other PPE will be required, including: Coveralls to prevent asbestos being spread from the workplace enclosure, smooth, easily cleanable footwear (without laces), disposable underclothing, socks and gloves, and other PPE as required, if shown necessary by the risk assessment (BAuA, 2019).

The efficiency of the RPE depends on the maintenance and correct use of the devices and the employer must ensure that (BAuA, 2019):

- Respiratory protective devices are properly stored, cleaned and maintained,
- the employees have been instructed accordingly and are trained in the use of the respiratory protective equipment.

Changing RPE to a higher level of protection in order to comply with a lower OEL, may require additional training of staff and is included in the assessed costs of additional training. However, the one-off costs for this training (as use of any RPE require training) is considered small as compared with the additional costs of equipment and maintenance.

Prevalence of the use of RPE

No detailed data are available on the prevalence of RPE used within the different exposure groups. Questionnaire responses from companies in France (representing 99% of stakeholder responses in terms of exposed workforce) shows that often various RPE is used by the companies for different activities. Of the 96 companies answering the questionnaire, 68 provided information on RPE used while one company informed that no RPE was used. The result are shown for all respondents in the table below. The majority of the activities are assumed to be subject to notification, but the questionnaire did not specifically ask for this. Each company may report on the use of several types of RPE, but 10 companies (14% of total) reported that they used Half mask + P2 or P3 filter only. The current OEL in France is 0.01 fibres/cm^3, and the prevalence may consequently be used as a rough indication of the distribution in other Member States for activities subject to notification if an OEL of 0.01 fibres/cm^3 is implemented. As mentioned in section 4.3.1., for all notifications to the French SCOLA databases, for only 4% of all notification it was reported that RPE was either not used or inadequate. Due to the low number of responses to the questionnaire, the data does not allow for an assessment of possible differences in the use of RPE between the different sectors.

Table 4.52 Prevalence in the use of RPE among French respondents to the questionnaire. The majority of activities are assumed to be activities subject to notification. Note that the current OEL in France is 0.01 fibres/cm^3. Each company may report on the use of several types of RPE so percentages add up to more than 100%.

RPE used	Number of companies	% of those reporting the use of RPE
Half mask + P2 or P3 filter	42	61%
Powered hoods/masks and breathing apparatus	46	67%
Constant flow breathing apparatus	41	59%
Self-contained breathing apparatus	12	17%
No RPE used	1	1.4%
Total number of companies with information on RPE	69	

Source: consultation exercise for this study

Mining and quarrying

According to the Finnish guidelines, Respiratory protective equipment must be used always (except for simple handling if the concentrations are below 1/10 of the OEL) when working in an asbestos area. According to the guidelines *'The minimum requirement for employees working in an asbestos area is a class FFP3 filtering half mask. This is recommended only for a very short-term use under low asbestos concentrations. A more recommended option is to use a half mask that is equipped with separate P3 particle filters. A half-face mask equipped with separate particle filters usually fits better than a filtering half mask. In longer-term work, it is recommended that a filter respirator equipped with a fan and a particle filter is used*.' (Kahkonen et al., 2019)

4.5.5 Training

As indicated in Table 4.44, the AWD requires employers to provide appropriate training and adequate information to employees who are (or are likely to be) exposed to dust from asbestos or materials containing asbestos covering:

- (a) the properties of asbestos and its effects on health, including the synergistic effect of smoking;
- (b) the types of products or materials likely to contain asbestos;
- (c) the operations that could result in asbestos exposure and the importance of preventive controls to minimise exposure; medical examination requirements.
- (d) safe work practices, controls and protective equipment;
- (e) the appropriate role, choice, selection, limitations and proper use of respiratory equipment;
- (f) emergency procedures;
- (g) decontamination procedures;
- (h) waste disposal;
- (i) medical surveillance requirements.

The training and information is required for all types of works with asbestos, including low risk work. The training must, according to the AWD, be provided at regular intervals, but the interval is not defined.

The level of training and instruction will typically be dependent on the type of works where higher risk work would require a more extensive training than lower risk work.

As an example, in Denmark workers involved in demolition and removal of ACMs inside/indoors in buildings, ships, trains, etc. are required to have undertaken a special education and obtained an 'asbestos certificate'.[31] For other types of works workers are required to be trained and instructed in accordance with the bullets listed above before the work with asbestos is started and should be repeated regularly. Training should be e.g. be repeated in case of a new type of activity or the circumstances are changed. Other Member States may have different requirements as to which types of works require the extensive training and certificate e.g. that it would apply to all works subject to notification (HSA, 2016).

For works undertaken by specialised companies and work subject to notification it is considered that introduction of new OELs would only require limited training beyond the current training of workers provided at regular intervals as new requirements could be included in training well before a new OEL is transposed into the national legislations and has entered into force.

For other types of work, more extensive training may be needed if a lower OEL is introduced; in particular if the work will no longer fall under the Article 3(3) waiver. This training may concern more extensive working procedures and use of RPE, decontamination procedures, and medical surveillance requirements.

4.5.6 Decontamination by completion

The measures taken for the control of the quality of the decontamination work may be affected by changing the OEL as lowering the OEL may also be reflected in the air concentration levels to be reached by the decontamination.

As stated in European Commission (2012) in the section on concluding work and disposal, in addition to a visual inspection, a measurement should be carried out in order to verify whether the admissible maximum value of fibre concentration is exceeded. Only if it is not the case the partitioning or enclosure can be removed. The AWD or the guidelines from the European Commission does not indicate a level to be achieved.

In most of the identified national guidelines, the level to be achieved is not defined in the national guidelines with a few exemptions. The Irish guidelines (HSA, 2013) state that after a visual inspection, clearance air monitoring with dust disturbance is then conducted inside the enclosure to check that airborne fibre levels are below the recommended limit of 0.01 fibres/cm^3 (corresponding to 1/10 of the OEL). For larger areas, 1 in 5 sample results may lie between 0.01 fibres/cm^3 and 0.015 fibres/cm^3). Once satisfactory results are achieved, the analyst will issue a site clearance certificate of reoccupation. The guidelines from the Danish Construction Association state that the concentration in the air should be below 0.1 fibres/cm^3 after the decontamination, but notes that this concentration is high compared to a guiding limit value from the WHO of 0.001 fibres/cm^3 (Dansk Byggeri, 2019).

The procedures are described as follows: 'On completion of work in confined spaces, partitions and enclosures, the removal area, the surrounding area and the partition or enclosure itself requires thorough vacuum cleaning. Smooth surfaces have to be wet-cleaned and areas with a rough structure, such as e.g. the brickwork support of a windowsill made from asbestos cement or wall ducts with removed seals or fills have to be sprayed with a residual fibre-binding agent. As a precondition, floor covers with a roughened surface, such as

[31] Asbestuddannelse og oplæring og instruktion i arbejde med asbest - Arbejdstilsynet (at.dk)

carpets or flagstones, have to be covered and masked with a thick enough sheet before starting work. Furthermore, the devices, machines, construction equipment and tools used in the work should be vacuumed and wet-cleaned before taking them out of the workplace. Electrically driven hand machines in particular but also tools that do not tolerate wet cleaning should be used for work on asbestos only and stored in a fibre-proof container until the next use'. (European Commission, 2012).

Lowering the OEL may result in lowering the concentrations to be achieved by the decontamination and may require more extensive cleaning procedures by the completion of the work. However, this is not directly a consequence of the changed OEL, but possible changes at national level by the implementation of the OEL. Possible costs of lowering the level to be achieved, as this is not directly a consequence of changing the OEL, will not be included in cost assessment.

4.5.7 RMMs considered for the cost assessment

Based on above description, the following RMMs are considered for the assessment of compliance costs for companies in Chapter 6:

- Various RPE (need for applying RPE with a higher protection factor).
- Installation of LEV by use of tools.
- Further use of vacuum cleaners.
- Further use of wetting agents and use of wetting agents of higher efficiency.
- Further training of staff.
- Further need for monitoring (addressed separately in section 4.9).

Furthermore, for activities currently not subject to notification the following RMMs are included in the costs assessment:

- Health surveillance.
- Registering and notification.

4.6 Alternatives

Encapsulation of the ACMs is an alternative to removal of the materials. In principle, if lowering the OEL would lead to significantly higher costs of removal and disposal of asbestos, this may push the choice between removal and encapsulation toward the encapsulation.

In the longer perspective, the encapsulated materials would anyhow have to be removed and for the assessment of benefits and costs in a 40-years perspective, encapsulation is not considered to make a significant difference. The possibility that introduction of a lower OEL may lead to more encapsulation in the short-time perspective is considered to be out of scope of the current quantitative assessment.

4.7 Voluntary industry initiatives

Voluntary industry initiatives identified by the stakeholder consultation and literature search concern mainly the development of guidelines for good practice for working with asbestos. Some examples are included in Table 4.45.

No industry initiatives which specifically concern voluntary occupational exposure limit values or specific targets for workers' protection have been identified.

At the EU level, a number of information modules on asbestos has been published jointly by the European Construction Industry Federation (FIEC) European Federation of Building and Woodworkers (EFBWW).

At the national level, many organisations have developed various guidelines; a few examples are listed in Table 4.45.

The EFBWW is currently running a 'Free Europe from Asbestos Campaign' [32].The campaign includes five different areas:

- Registration, Notification and Medical Surveillance. The EFBWW published in 2018 a Trade Union Guide on using Asbestos Registries (EFBWW, 2018). The EFBWW campaigns for all Member States to set up registries as an integral part of their asbestos removal strategies. A proposal for EU minimum standards for national asbestos registries is included in the EFBWW guide.
- Safe working conditions. As part of the work for safe working conditions, the above-mentioned modules have been developed jointly with FIEC. The EFBWW calls for specific requirements for the activities, their operation and protection of the environment.
- Better training for all workers. The EFBWW calls for new minimum standards for training of two groups of workers: 1) workers who specialise in asbestos removal and 2) workers who are irregularly and unintentionally exposed to asbestos. EFBWW has together with partners developed an e-learning course offer for asbestos awareness in construction companies that are not specialised in asbestos removal. The course is available in Polish, Lithuanian, Spanish and English[33].
- Recognition of asbestos-related diseases. EFBWW has commissioned a report which provides an overview of asbestos-related occupational diseases and the regulations and practices of monitoring and surveillance, recognition and compensation in 14 Central and East European (CEE) countries.
- Recognition procedures and compensation of asbestos-related diseases

The European Demolition Association (EDA) has participated in the development of a guide for working with asbestos published by the Spanish Demolition Association (AEDED, 2020).

The European Economic and Social Committee has published an 'own-initiative opinion' on working with asbestos in energy renovation available in all Member State languages[34].

In Germany, the social partners in the building and construction sector and employer's liability insurance associations for the sectors have recently agreed on measures to be used when building in existing structures (unpublished draft received as part of the stakeholder consultation).

4.8 Best practice

An assessment of which types of risk management measures that may be affected by the introduction of a lower OEL is provided in Section 4.5.1.

The extension of a number of measures such as preparation of risk assessment, identification of ACM, plan of work, access to risk areas, consultation of workers, etc. is unlikely to be significantly affected by the introduction of new OELs. Consequently, as the objective of the description in this section is to provide background for the cost assessment in Chapter 6 – examples of best practice are this selected with the view to inform the impact

[32] https://www.efbww.eu/campaigns/campaign-4/35-a

[33] https://www.efbww.eu/publications-and-downloads/reports-and-studies/abclean-asbestos-awareness-e-learning-course/290-a

[34] Working with asbestos in energy renovation (own-initiative opinion) | European Economic and Social Committee (europa.eu)

assessment in this study, i.e. with regard to their relevance to the potential introduction of other new measures as consequence of lowering the OEL.

Whereas monitoring of asbestos is addressed in section 4.9, the following section focuses on the type of risk management measures that may be affected by the introduction of a lower OEL, first of all technical and organisational measures and training. The use of PPE is addressed in section 4.5.4 and is not further described in this section.

The risk management measures described for work with higher risk ACMs are in accordance with the best practice described in the EU practical guide on best practice to prevent or minimise asbestos risks (European Commission, undated) even though the guide describes some of the measures in more detail.

It is considered that the described RMMs would overall be sufficient for meeting a lower OEL, but it may be necessary to further use some of the measures used at higher exposure levels for medium and lower exposure levels. As RPE is used in any case, for all exposure situations one option would be to change to RPE with higher protection which are more costly but not necessarily less comfortable to wear for the workers.

For situations with high exposure levels some new technologies may be further introduced:

- Use of remote-controlled robots are already used for removal of materials from surfaces, confined spaces, ceilings and building walls. In recent years some research projects have been funded in order to develop suitable robots. As an example, the Bots2Rec project developed a robotic system used for the automated removal of asbestos contamination. It consists of multiple mobile robotic units that perform the asbestos-removal-tasks autonomously. Each unit consists of a mobile platform and robotic arm with an abrasive tool. The combination of optical and radar sensor systems will allow the environmental perception and local monitoring of the asbestos-removal-tasks.[35]
- Better binding of dust with water or gel - more extensive use of these methods to reduce the likelihood of asbestos fibres to remaining suspended in workplace air.

A number of new technologies have been developed for treatment of asbestos-containing waste, but these are considered out of the scope of the current study.

4.9 Standard monitoring methods/tools

The current AWD specifies that fibre counting shall be carried out wherever possible by phase-contrast microscopy (PCM) in accordance with the method recommended in 1997 by the World Health Organization (WHO)[36] or any other method giving equivalent results.

For the purpose of measuring asbestos in the air, the Directive specifies that '*only fibres with a length of more than 5 µm, a breadth of less than 3 µm and a length/breadth ratio greater than 3:1 shall be taken into consideration*'. As the WHO method is not able to distinguish between asbestos and other fibres, in practice, any fibre of the specified dimensions is within the scope of Directive.

The Directive does not specify the strategy for monitoring compliance.

For the assessment of analytical methods below, it is assumed that the revision of the OEL concerns the concentration, and no changes to the definition of fibres are introduced.

Introduction of a lower OEL may require changes in the applied analytical methods and the detection limits of the available analytical methods may influence the monitorability of the

[35] https://robotnik.eu/bots2rec-robotic-system-used-for-the-automated-removal-of-asbestos-contamination/#

[36] https://www.who.int/occupational_health/publications/en/oehairbornefibre.pdf

OELs under consideration. The possible costs of monitoring using more sensitive analytical methods are further assessed in section 6.3.5.

Lowering the OEL, to the extent it requires the use of more sensitive analytical methods, may be considered to change the definition of the fibres within the scope.

The assessment of the availability of analytical methods and the feasibility of monitoring asbestos in the workplace includes the following elements:

- Strategy for monitoring compliance. Depending on the method used, detection limits of analytical methods well below the OEL may be required.
- Sensitivity of analytical methods.
- Sample conditions and interferences that influence the limit of detection of the analytical methods. For all methods, the presence of non-fibrous dust particles (in particular in high concentrations) complicates the counting and identification of fibres. These may necessitate lowering sampling volumes to avoid the loading of particles in the filter and the consequent increase of the method's limit of quantification unless a larger filter area is analysed.
- Background levels of asbestos fibres.

Air monitoring is generally used for two purposes with regard to work with ACM: Monitoring the exposure of workers and quality control after remediation measures. This section focuses on exposure of workers and includes a few remarks on the methods applicability for quality control.

4.9.1 Standard for monitoring compliance with OEL

Procedures for monitoring of contaminants in the workplace are typically established by national guidelines prepared by the national working environment authorities. These guidelines may make reference to European or national standards to be used for the monitoring.

As concerns the monitoring of substances in the workplace, guidelines may make reference to two European standards:

- EN 482:2012+A1:2015: Workplace exposure. General requirements for the performance of procedures for the measurement of chemical agents.
- EN 689:2018+AC:2019: Workplace exposure. Measurement of exposure by inhalation to chemical agents. Strategy for testing compliance with occupational exposure limit values

For the stakeholder consultation, Belgium, Bulgaria, Denmark, Spain, Slovenia and Finland (35% of answers) have indicated EN 689 is used for compliance control of the three substances of this study, some Member States use slightly different methods while others use the AM of the measurements.

The strategy described in EN 689:2018 gives the employer a procedure to overcome the problem of variability and to use a relatively small number of measurements to demonstrate with a high degree of confidence that workers are unlikely to be exposed to concentrations exceeding the OELs.

The compliance with an OEL is determined by either a screening or a test of compliance.

The **screening test** requires three to five exposure measurements on workers belonging to a SEG.

- a) If all results are below:
  - 1) 0.1 * OEL for a set of three exposure measurements or,
  - 2) 0.15 * OEL for a set of four exposure measurements or,

- 3) 0.2 * OEL for a set of five exposure measurements
- then it is considered that the OEL is respected: **Compliance**.

- b) If one of the results is greater than the OEL, it is considered that the OEL is not respected: **Non-compliance.** If the first measurement result is above the OEL, it is not necessary to perform any additional measurements.
- c) If all the results are below the OEL and a result above 0.1 * OEL (set of three results) or 0.15 * OEL (set of four results) or 0.2 * OEL (set of five results) it is not possible to conclude on compliance with the OEL. **No-decision.** In this situation additional exposure measurements shall be carried out in order to apply the test based on the calculation of the confidence interval of the probability of exceeding the OEL, as specified below.

Test of compliance with the OEL

The appraiser shall select a statistical test of whether the exposures of the SEG comply with the OEL. The test shall measure, with at least 70% confidence, whether less than 5% of exposures in the SEG exceed the OEL.

Required limit of quantification

In order to undertake the screening tests, ideally an analytical method with a limit of quantification (LOQ) at 0.1 - 0.2 times the OEL is required; otherwise it will be necessary to undertake more tests and the costs of monitoring increases.

4.9.2 Available analytical standards for monitoring asbestos in workplace air

Analytical methods for monitoring asbestos in the workplace have recently been reviewed by ECHA (2020) and the following description of methods is, to a large extent, based on this review supplemented with information obtained from the stakeholder consultation for this study. Direct citation of the ECHA review is indicated, but also other parts of the text may use phrases from the ECHA review.

As stated by ECHA (2021), at present, the number and size distribution of fibres in a sample can only be determined by direct microscopic examination. This may be performed using either light or electron microscopy.

The ANSES Expert Appraisal for Establishing Occupational Exposure Limit for asbestos fibres (Afsset, 2009b) includes an overview of techniques and analytical methods that can used be to determine the concentration of asbestos fibres in air. The table from ANSES report is reproduced (with slight modifications made by ECHA (2020) and updated in this report) in Table 4.53.

The methods are further discussed below the table.

Table 4.53 Overview of techniques and methods for monitoring of asbestos fibres in air with phase contrast microscopy (PCM), scanning electron microscopy (SEM) and transmission electron microscopy (TEM) (adapted from ECHA, 2021 adapted from Afsset, 2009)

Type of microscopy	Sampling and analysis protocol	Preparation of sample (4)	Magnification for counting	Fibre counting criterion			Minimum measurable diameter, µm	Fibre identification method	Type of information
				L/d	L, µm	d, µm			
PCM	WHO: 1997 (WHO, 1997) ISO 8672: 2014 (ISO, 2014) NIOSH 7400 method A: 1994 (NIOSH, 1994) (1) HSE - MDHS 39/4: (HSE, 1995) IRSST 243: 1995 (IRSST, 1991	Direct	400-500	≥3	>5	<3	0.2	-	Numerical concentration
SEM (5)	ISO 14966: 2019 (ISO, 2019b)	Direct	2000	≥3	>5			Morphology elementary composition via EDXA (2)	Numerical concentration Size Type
	VDI - 3492: 1994 (VDI, 2004)		2000-2500						
	BGI-505-46-02 (DFG, 2009)								
TEM	NIOSH 7402 (NIOSH, 1994)	Direct	10000	≥3	>5		0.25		
	ISO 10312: 2019 Sampling and analysis protocol2019 (ISO, 2019)		20000	≥5	>0.5	<3	0.01		
			5000	≥3	>5		0.03	Morphology elementary composition via EDXA (2) crystallography via SAED (3)	
	ISO 13794: 2019 (ISO, 2019)	Indirect	20000	≥5	>0.5		0.01		
			5000	≥3	>5		0.03		
	NFX 43-050: 1996 (AFNOR, 1996)		10000	≥3	>5		0.01		
			20000-30000		>0.5				

(1) The NIOSH 7400 method does not impose any counting criteria on the diameter.

(2) EDXA: Energy Dispersive X-ray Analysis.

(3) SAED: Selected Area Electron Diffraction.

(4) Direct and indirect sample preparation methods are further explained in the sections below.

(5). The minimum measurable diameter for SEM is depending on the resolution. The indicated diameter is for the resolution applied in the listed standards.

4.9.2.1 Phase contrast microscopy (PCM)

As mentioned above, the AWD states that fibre counting shall be carried out wherever possible by PCM in accordance with the method recommended in 1997 by the World Health Organization (WHO) or any other method giving equivalent results. The phase contrast microscopy method is the main method used today and for the impact assessment of this study, the main questions are whether the method is applicable for monitoring compliance with lower OELs and, if it is, whether there would be any additional costs such as the need for longer sampling time.

In the WHO method, a sample is collected by drawing a known volume of air through a membrane filter by means of a sampling pump. The filter is then rendered transparent ("cleared") and mounted on a microscope slide. Fibres on a measured area of the filter are counted visually using phase-contrast optical microscopy (PCM), and the concentration of fibres in the volume of air is calculated using the number of fibres detected on the counted area of the filter, the fraction of the area counted of the total filter area and the air volume filtered.

The limit of quantification slightly varies depending on the laboratory specific parameters, like the fraction of area of the filter counted. The limit of detection of fibres in the sample is approximately of 13 fibres/mm^2 of filter area which corresponds to different concentrations in the air depending on sample parameters.

"***Limitations****: any fibre (regardless of whether it is asbestos or not) is counted because all particles meeting the dimensional counting criteria are taken into account. Chain-like particles may appear fibrous. High levels of non-fibrous dust particles may obscure fibres in the field of view and increase the detection limit."* (ECHA, 2021)

Tromp and Tempelman (2016) have reviewed the Dutch experience with the applicability of different measuring methods for asbestos. Based on a total of 91 parallel measurements from 46 remediation projects, in which the results by means of standard PCM analysis were compared with the results by means of SEM/EDXA analysis they conclude that PCM is in practice not suitable for measuring asbestos fibre concentrations lower than approx. 0.005 fibres/cm^3. As PCM is a non-specific analysis method, the limit of quantification is in practice determined by the “background noise” of (non-asbestos) fibrous components that are always present in the air. According to the authors, direct testing against the limit value of 0.002 fibres/cm^3 (Dutch OEL), based on PCM, is therefore not possible. As mentioned below in section 0, the current practice in the Netherlands is to use SEM/EDXA for compliance control. Tromp and Tempelman (2016) note that at a fibre concentration of less than 0.01 fibres/cm^3, measured with PCM, the asbestos fibre concentration, measured with SEM/EDXA, in almost all cases remains below the Dutch OEL of 0.002 fibres/cm^3. According to the authors, PCM remains applicable for the time being as an indicator for final checks of remediation of bonded asbestos-containing products containing chrysotile.

According to Afsset (2009), the limit of quantification of the method is 0.01 fibres/cm^3.

A recent guidance on asbestos monitoring and analysis from the Health and Safety executive in the UK (HSE, 2021) notes that due to the presence of some fibres on blank tested filters, the limit of quantification (LOQ) of the method is 0.01 fibres/cm^3. In dusty environments it may only be possible to sample one-tenth of the volume of air so the LOQ values will be increased by a factor of 10. The guidance describes in detail an analysis method combining PCM with polarised light microscopy (PLM). By the PLM method it is possible to identify a single asbestos fibre or bundle of asbestos fibres when fibres are >1 µm width, free of adhering particles and matrix material, and mounted in high-dispersion liquids with a Refractive Index match for a wavelength of light (λ0) in the visible spectrum. PLM is a common analysis for determining asbestos content of bulk building materials. The PLM method may also be applied in addition to the PCM method to discriminate between asbestos fibres and other fibres. The LOQ of the combined PCM/PLM is not described and as the

PLM is applicable for fibres of >1 µm width only, the method will not be further described here.

With a practical limit of quantification at approx. 0.005 - 0.01 fibres/cm^3, the PCM cannot be considered feasible for monitoring compliance with the assessed OEL options of 0.01 fibres/cm^3 or 0.001 fibres/cm^3.

4.9.2.2 Electron microscopy

Two methods of electron microscopy are used: Transmission electron microscopy (TEM) and scanning electron microscopy (SEM). The methods can detect thinner and shorter fibres than PCM and the fibre type can be identified with additional analysers such as methods based on elemental composition and crystal structure. In this way the methods can distinguish between asbestos fibre and other fibre.

However, the fibre counting accuracy is poorer because the smaller area that can be realistically scanned at a higher magnification. Accuracy is more limited with long (>5 µm) fibres.

'Examination of a fibre sample by either TEM or SEM allows the detection of much smaller fibres than light microscopy, and so more thorough data can be collected on fibre length and diameter distribution. Of these two methods, TEM has greater sensitivity for small fibres, and is the most common method for measuring asbestos in non-occupational setting like in ambient air or inside schools or residential buildings. SEM analysis usually images fibres that are more than 0.2 µm in diameter because of contrast limitations, while TEM can visualize fibres of all sizes. In addition, most modern electron microscopes are equipped with instrumentation that allows determination of the crystalline and elemental composition of the fibre (see below).' (ECHA, 2021)

The electron microscopic methods can be coupled with different analytical techniques that allow the discrimination of different types of asbestos fibres from each other and from other fibres as described for the different methods below. This can be done via energy dispersive X-ray microanalysis (EDXA or 'EDX analysis') and/or Selected Area Electron Diffraction (SAED).

The EXDA is based on the elementary analysis of the fibres, the presence of different elements (e.g. Si, Fe, Mg) and the peak height determine the type of asbestos present. (ECHA, 2021)

The Selected Area Electron Diffraction (SAED) technique consists of observation of the pattern of diffraction spots obtained on the TEM viewing screen from a randomly oriented fibre or particle. Such a pattern indicates that the material is crystalline. The pattern is then recorded and its consistency with known mineral structures is checked. (ECHA, 2021)

4.9.2.3 Scanning electron microscopy and energy dispersive X-ray microanalysis

Two standards for SEM are described below. The first is currently used for compliance monitoring in Germany. The latter is an ISO standard and among others used for compliance monitoring in the Netherlands. Both standards combine SEM with EDXA.

"Method BGI 505–46–02 (DFG, 2009). *The sample is collected on a gold coated capillary-pore membrane filter. The fibres collected are counted and analysed by means of scanning electron microscopy and energy dispersive X-ray microanalysis. The method is intended to be used as a complement of the PCM methods for samples where:*

- *different types of inorganic fibres are present, which have to be distinguished from each other and from organic fibres;*
- *the limit of detection of the phase-contrast microscopic method is not sufficient to monitor the compliance of a given threshold limit values and trigger thresholds.*

This method permits the detection and identification of asbestos, calcium sulfate and other inorganic fibres having a width of (D) ≥0.2 µm. Fibrous particles with D < 0.2 µm are not taken into account for the calculation of the measuring result because the method here described may be used instead of the phase-contrast optical microscopy method. The limit of detection at the maximum flow rate recommended would be 0.004 fibres/cm^3 for a 2-hour sample. Interferences: high concentrations of dust interfere with the fibre identification. Mis-interpretations, particularly for the identification of asbestos fibres are possible,

- *if silicate fibres of an elemental composition similar to asbestos are used in work areas;*
- *if the fibres are contaminated (e. g. for mortar, colours and paints, asbestos cement, magnesium plaster floor and thus result in additional peaks);*
- *if non-fibrous particles are lying within the direct neighbourhood of fibres (high loading of the sample collection filter, coarse dust particles, chainlike smoke particles, especially welding fumes, tobacco smoke);*
- *due to non-uniform loading of particles on the filter (as a result of e.g. high air humidity during sampling, presence of mists or aerosol droplets, respectively, in the air sample).*

There have also been attempts to develop automated electron microscopy methods for asbestos identification (Cossio et al., 2018). However, such techniques are not yet in use in routine analysis of air samples. " (ECHA, 2021)

The method may as mentioned above be used as a supplement to the PCM method, however according to information obtained from the stakeholder consultation, SEM/EDXA seems more common to be used as a stand-alone method in order to be able to analyse for asbestos fibres at lower concentration than PCM.

ISO 14966: 2019.[37] The description below is mainly based on ISO's description for the standard. This standard specifies a method using scanning electron microscopy (SEM) for determination of the concentration of inorganic fibrous particles in the air. The method specifies the use of gold-coated, capillary-pore, track-etched membrane filters, through which a known volume of air has been drawn. Using energy-dispersive X-ray (EDX) analysis, the method can discriminate between fibres with compositions consistent with those of the asbestos varieties (e.g. serpentine and amphibole), gypsum, and other inorganic fibres.

This method is applicable to the measurement of the concentrations of inorganic fibrous particles in ambient air. The method is also applicable for determining the numerical concentrations of inorganic fibrous particles in the interior atmospheres of buildings, for example to determine the concentration of airborne inorganic fibrous particles remaining after the removal of asbestos-containing products.

The range of concentrations for fibres with lengths greater than 5 µm, in the range of widths which can be detected under standard measurement conditions (see 7.2), is approximately 3 - 200 fibres/mm^2 of filter area. The air concentrations, in fibres per cubic metre, represented by these values are a function of the volume of air sampled.

According to the standard description, the ability of the method to detect and classify fibres with widths lower than 0.2 µm is limited. If airborne fibres in the atmosphere being sampled are predominantly <0.2 µm in width, a transmission electron microscopy (TEM) method such as ISO 10312 can be used to determine the smaller fibres (see description above).

RAC opinion. According to RAC (20219, the detection limits for SEM of 0.001-0.004 fibres/cm^3 (depending on method) may be achieved in rural environments but not necessarily

[37] https://www.iso.org/standard/75583.html

in dusty environments (for example in mines) with the methods currently used. Achieving these low limits of detection, may necessitate further development of sample treatment practises together with sampling higher volumes and an increase of the number of fields counted (i.e. the area of the filter that is analysed).

Experience from Member States. Related to the practicability of measuring compliance with the Dutch OEL of 0.002 fibres/cm^3, the following observations are based on an initial dialogue with TNO who are responsible for the Dutch exposure database for asbestos (Spaan S, TNO, personal communication):

- The Dutch legislation does not specify the measurement technique to be used, but administrative practice is to use ISO 14966 and SEM/EDXA as the analytical method.
- With this method, it is possible to measure down to 10% of the Dutch OEL (i.e. 0.0002 fibres/cm^3).
- The Dutch Health Counsel has advised an even lower OEL for amphibole asbestos at 0.0003 fibres/cm^3 [38]. Measuring 10% of this level is possible, however, due to the measurement and analytical effort that would be necessary to be able to measure such low concentrations (volume of air that would need to go through the filter and/or the number of fields of the filter that would need to be counted as part of the analysis), this is hard to accomplish in practice using current methods and could affect the reliability of the measurement result.

In Germany, compliance is measured in accordance with the above-mentioned BGI 505–46–02. According to German contribution to the stakeholder consultation, the current German acceptance concentration of 0.01 fibres/cm^3 already represents an ambitious control limit. The compliance with this limit value in work areas is checked according to TRGS 519 with measurements that require individual measured values with a limit of detection of 0.0025 fibres/cm^3. In view of the typical dust exposure on construction sites, measurements of more than half an hour sampling time can only be partially evaluated. According to the contribution, when determining asbestos fibre concentrations with the established analytical method, the analyses reaching this limit of detection usually require a much higher evaluation effort, up to 15 or 20 times the normal effort under standard conditions. With a view to the possible lowering of the acceptable concentrations for carcinogenic substances to be checked according to TRGS 910 in 2018, with regard to asbestos, a factual non-verifiability of low asbestos exposures could result in practice. A reduction in the acceptable concentration to 0.001 fibres/cm^3 for asbestos would in Germany require use of methods which can confirm the evidence that the asbestos fibre concentration has fallen below 0.00025 fibres/cm^3. According to the contribution, such measurements with available filters are only possible in interior rooms such as offices or in the unpolluted outside air. They are typically carried out with a volume flow that is 2 to 4 times higher and a sampling time of at least 3, but typically 8 hours. Measurements with the aim of checking an acceptable concentration of 0.001 fibres/cm^3 would therefore not be possible with the usual activities in the building stock, even using modern processing equipment with suitably coordinated suction. Furthermore, with an asbestos fibre concentration in the range of a few hundred fibres per m^3 to be analysed, the concentration will be close to the background concentration. Experience has shown that this averages around 0.0001 fibres/ cm^3, but sometimes shows significant fluctuations. There are currently no clear criteria for differentiating between background exposure and occupational exposure.

According to a German laboratory specialised in asbestos analysis, the limit of detection of the standard analysis used today by the laboratory is 0.0003 fibres/cm^3. Lowering the

[38] Note Some sources say 420 fibres/m^3. This slight divergence will be clarified in the next phases of the project.

detection limit to 0.0001 fibres/cm^3 would require that a larger filter area is analysed. The increase in the price of the analysis is estimated to be about 30%.

According to the French experience (Afsset, 2009), the limit of detection of the SEM method is higher than the limit of detection of TEM, but the actual limit of detection is not reported.

Based on the Dutch experience, measuring down to 0.0002 fibres/cm^3 is possible by use of SEM/EDXA and the method would be applicable for testing compliance with all of the OEL options assessed in this study. For the lowest of the assessed OELs it cannot be excluded that more than three measurements may be needed if compliance is monitored in accordance with EN-689:2018. The experience from Germany indicates that measuring at these low concentrations could be challenging but different views has been obtained.

It should be noted, that measuring at 1/10 of the OEL would only be necessary under certain circumstances with low concentrations and where RPE is not used. For the majority of measurements, a higher LOQ would be acceptable, and extra costs of the analysis would only be required for a small percentage of all measurements.

4.9.2.4 Transmission electron microscopy - Indirect sample preparation

TEM is currently used for compliance monitoring in France in accordance with the French standard NFX 43-050: 1996. The method allows fibres belonging to different classes to be distributed based on morphological observations, electronic diffraction diagrams (SAED) and EDXA spectra (Affset, 2009).

"***NFX 43-050: 1996 method (AFNOR, 1996).*** *The sample is collected in a mixed cellulose ester (MCE) membrane filter. Then, the membrane, or part of the membrane, is burned after sampling in an oxygen plasma oven. The particles are then recovered from the water then, after manual agitation, filtered through a polycarbonate filter previously coated with a layer of carbon. After filtration, the recovered particles are then covered by a second layer of carbon. The polycarbonate filter is dissolved using a solvent. The fibres and particles are collected on grids for observation using a transmission electron microscope. The method foresees static sampling, and it explicitly mentions three scenarios (sampling outdoors, sampling on buildings containing asbestos materials and sampling in buildings after asbestos removal). The limit of detection is dependent on sampling volume and also on the levels of particle dust. A limit of detection of 0.001 fibres/cm^3 can be achieved when levels of airborne dust are around 10 µg/m^3 (e.g. clean rural environment).*

Interferences*: the method does not distinguish individual asbestiform amphibole fibres from those particles with a longitudinal shape originating from the non-asbestiform amphibole counterpart of the same mineral (cleavage fragments). " (ECHA, 2021)*

Experience from Member State. Affset (2009) concludes that the limit of quantification of TEM (both direct and indirect) following the French Standard NFX 43-050, with the atmospheric measurement conditions of 8-hour individual sampling at a maximum flow of 4 L/min, is 0.0025 fibres/cm^3.

The NFX 43-050: 1996 method is used for monitoring compliance in France. According to the French regulation both the fibres covered by the current AWD (and the WHO method) and thin asbestos fibres (TAF) are measured. Eypert-Blaison et al. (2018) measured workplace concentrations using both PCM and TEM. For the fibres covered by the WHO method the measured concentrations using the TEM method was on average 4-fold higher than the concentrations obtained using PCM. The ratio between the two methods differed by type of fibres and ACM, and the removal technique used. The average ratios for the different types varied from 0.19 (n=12) to 18.6 (n=16).

When thin asbestos fibres (TAF) were included (as prescribed by NFX 43-050), the total concentrations as measured by the TEM were on average 15-fold the concentrations as measured by PCM. The ratio between the 'WHO fibres' and TAF varied by ACM but was according to Eypert-Blaison et al. (2018) overall close to 1:1 (17% TEF vs. 15% 'WHO fibre').

4.9.2.5 Transmission electron microscopy - Direct sampling preparation

Two standards based on the TEM method with direct sampling preparation is described below: The NIOSH method 7402 used in the USA and a new ISO 10312: 2019 standard. No current use of the standards for compliance control in Member States has been identified. The method is basically the same as the method described above but using a direct sampling method (Affset, 2009).

"NIOSH method 7402 (NIOSH, 1994b). *NIOSH 7402 uses transmission electron microscopy (TEM) to qualify and quantify asbestos fibres found in the air. This technique provides complimentary results to fibre counts determined by NIOSH 7400 (PCM) and provides more accurate asbestos fibre counts as non-asbestos particles are identified and excluded. Samples are collected using a 25 mm air monitoring cassette equipped with a 50 mm electrically-conductive cowl and a mixed cellulose ester (MCE) membrane filter. After collection, samples are processed to collapse the filter, creating a non-grainy background for easier fibre counting and identification by transmission electron microscopy. Fibres with a diameter <0.25 µm will not be counted by this method. The method is designed to be used as a complement of NIOSH method 7400 (asbestos and other fibres by PCM). The quantitative working range is 0.04 to 0.5 fibres/cm^3 for a 1000-L air sample. The LOD depends on sample volume and quantity of interfering dust, and is <0.01 fibres/cm^3 for atmospheres free of interferences.*

Interferences*: Other amphibole particles that have aspect ratios greater than 3:1 and elemental compositions similar to the asbestos minerals may interfere in the TEM analysis. Some non-amphibole minerals may give electron diffraction patterns similar to amphiboles. High concentrations of background dust interfere with fibre identification. "*

ISO 10312: 2019[39]. The following description is mainly based on ISO's description for the standard. This standard specifies a reference method using transmission electron microscopy for the determination of airborne asbestos fibres and structures in in a wide range of ambient air situations, including the interior atmospheres of buildings, and for a detailed evaluation for asbestos structures in any atmosphere. The method allows determination of the type(s) of asbestos fibres present and also includes measurement of the lengths, widths and aspect ratios of the asbestos structures. The method cannot discriminate between individual fibres of asbestos and elongate fragments (cleavage fragments and acicular particles) from non-asbestos analogues of the same amphibole mineral. The range of concentration which can be determined is 50 to 7.000 structures/mm^2 on the filter. The air concentrations represented by these values are a function of the volume of air sampled. There is no lower limit to the dimensions of asbestos fibres which can be detected. In practice, microscopists vary in their ability to detect very small asbestos fibres. Therefore, a minimum length of 0.5 µm has been defined as the shortest fibre to be incorporated in the reported results. In practice, the lowest achievable limit of detection for a particular area of TEM specimen examined is controlled by the total suspended particulate concentration. For total suspended particulate concentrations of approximately 0.000001 µg/m^3, corresponding to clean, rural atmospheres, and assuming filtration of 4.000 litres of air, an analytical sensitivity of 0.0005 structure/L can be obtained, equivalent to a limit of detection of 0.0018 structure/L, if an area of 0.195 mm^2 of the TEM specimens is examined. If higher total suspended particulate concentrations are present, the volume of air filtered must be reduced in order to maintain an acceptable particulate loading on the filter, leading to a proportionate increase in the analytical sensitivity. Where this is the case, lower limits of detection can be achieved by increasing the area of the TEM specimens that is examined. In order to achieve

[39] https://www.iso.org/obp/ui/#iso:std:iso:10312:ed-2:v1:en

lower limits of detection for fibres and bundles longer than 5 µm, and for PCM equivalent fibres, lower magnifications are specified which permit more rapid examination of larger areas of the TEM specimens when the examination is limited to these dimensions of fibre. The direct analytical method cannot be used if the general particulate loading of the sample collection filter exceeds approximately 10 µg/cm^2 of filter surface, which corresponds to approximately 10 % coverage of the collection filter by particulate. If the total suspended particulate is largely organic material, the limit of detection can be lowered significantly by using an indirect preparation method.

As indicated above, Affset (2009) concludes that the limit of quantification of the TEM methods is approximately 0.0025 fibres/cm^3 with the atmospheric measurement conditions of 8-hour individual sampling at a maximum flow of 4 L/min.

4.9.2.6 Background levels

An issue raised by the stakeholder consultation is whether, at low exposure levels, it is possible to distinguish between background levels and asbestos releases from work processes. In the Netherlands, the average outdoor background asbestos fibre concentration over seven measurement locations was 0.000035 fibres/cm^3 with a range of <0.000030 – 0.000081 fibres/cm^3 (Trump and Spaan, 2008). Only a small part of these fibres were longer than 5 µm (approx. 16%). The average concentration of asbestos fibres with a length longer than 5 µm was 0.000006 fibres/cm^3. Slightly higher background concentrations have been reported from Germany at concentrations about 0.0001 fibres/cm^3 (Mattenklott, 2018). From Poland, it is reported that the asbestos concentration in ambient air is correlated with the amount of asbestos-cement roofing with measure ambient concentrations (in 2004-2013) above 0.005 fibres/cm^3 in several municipalities (Krówczynska and Wilk, 2019).

On this basis it cannot be excluded that background levels would sometimes be higher than 10% of the OEL (and even be higher than the OEL) if the lowest of the OEL options is introduced.

4.9.3 RAC's opinion

In its opinion, RAC (2021) summarise the situation as follows:

"*At present, PCM is not considered a state of the art measurement method for asbestos in the work environment anymore. In addition to its inability to speciate fibre types it cannot detect fibres thinner than about 0.2 µm. Nowadays measurement techniques based on electron microscopy (EM) have been introduced. These methods can detect thinner and shorter fibres than PCM and are also equipped with analysers able to characterise the elemental composition or crystal structure of the fibres."*

and further:

"Currently there is no uniformly accepted and used international EM method to count asbestos fibres and national bodies have set national standards. Both SEM and TEM can be used to detect fibres thinner than 0.2 µm, but the current SEM standards do not recommend the use of higher magnification which would allow visualization of thinner fibres. Therefore, although SEM is widely used, and an affordable method to quantify asbestos fibre levels in Europe, it is mainly used with a magnification of 2000x allowing the quantification of fibres thicker than 0.2 µm only. As described in Annex 1, using TEM with a magnification of 5000-10000x fibres of 0.01-0.03 µm in diameter can be detected.

When SEM is used with a magnification of 6000x, fibres of ≥0.05 µm in diameter can be detected. The detection limits of 0.001-0.004 fibres/cm^3 (depending on method) may be achieved in rural environments but not necessarily in dusty environments (for example in mines) with the methods currently used. Achieving these low limits of detection, may necessitate further development of sample treatment practises together with sampling higher *volumes and an increase of the number of fields counted (i.e. the area of the filter that is analysed).*

Overall, harmonisation work is required at EU level concerning the different EM methods currently used. That harmonisation concerns also the dimensional fibre definitions, counting rules and other factors that influence the EM asbestos fibre counts. The proportion of fibres thinner than 0.2 µm from all asbestos fibres present varies greatly. Consequently, it is not possible to recommend a precise conversion factor for EM measurements. Transitional provisions seem necessary before that harmonisation work has been conducted."

The possible transitional provisions are not specified by RAC (2021).

In this assessment it has been assumed that introduction of a lower OEL would require use of SEM in accordance with the standards currently used in the Netherlands and Germany. The sensitivity of the final results to this assumption (compared to a situation where PCM remain the reference method) is included in the sensitivity analysis in chapter 10.

4.9.4 Availability of laboratory capacity and sampling equipment

Availability of laboratories that may perform fibres counted using TEM and SEM methods

Electron microscopy for determination of asbestos is today the method of choice for at least France (TEM), Germany (SEM/EDX) and the Netherlands (SEM/EDX). It should be noted that compared to other Member States, the number of measurements in France is high and consequently, the total analysis of asbestos in the three countries may represent more than the 37% which is calculated if a simple per capita approach is used. In Italy SEM and TEM is widely used for monitoring asbestos in the air by tunnel excavations and half of the data reported to the national SIREP database are measured by electron microscopy. An Internet search reveals that analysis of asbestos in workplace air using the EM methods (mainly SEM/EDX) are also available in many other Member States, however the limit of detection of the methods are not indicated. For the stakeholder consultation questionnaire, companies in Romania and Spain (one from each) have indicated that analysis was undertaken using EM. For the stakeholder consultations experts have indicated that apart from France, SEM is more used than TEM.

Unlike other chemicals, a number of small laboratories are specialised in asbestos analysis, which reflect that the equipment used (electron microscopes and EDX) is different from the equipment used for chemical analysis.

In 2012 the method of detection in France was changed from PCM to TEM. In a status from 2017 it is summarised that in the country 180 organisations are accredited for asbestos dust-level control (including 162 accredited organisations for strategy/sampling, 58 for analysis and 18 for strategy/sampling and analysis). The total number of TEM microscopes increased from 30 microscopes in 20 organisations in 2012 to approximately 250 microscopes in 76 organisations in 2017 (Lesterpt and Leray, 2017). The total number of analyses in France have during the period 2012-2019 been on average approximately 36,000 per year. The development in number of microscopes and organisations gives an indication of what could happen in other Member States if a lower OEL is introduced but the numbers cannot be extrapolated to the entire EU27 on a per capita basis as the level of monitoring asbestos and other hazardous substances in general seems to be high in France as compared with many other Member States.

According to stakeholder input from Spain, only two laboratories undertake analysis using EM today. According to the stakeholder, it may take about one year before certified capacity is built up.

It is common that large international laboratory groups such as SGS, Eurofins and Bureau Veritas send samples for analysis in other Member States if the national laboratories do not have the capacity for the analysis. This seems also to some extent to be the situation for asbestos analysis.

If EM becomes the prescribed method, it may have some influence on the market where larger international groups with capacity for SEM/EDX or TEM analysis, and smaller companies specialised in SEM/TEM analysis take over a part of the market today served by smaller laboratories with capacity for PCM analysis only.

As mentioned above, RAC (2021) concludes that harmonisation work is required at EU level concerning the different EM methods currently used. That harmonisation concerns also the dimensional fibre definitions, counting rules and other factors that influence the EM asbestos fibre counts. Consequently, according to RAC, transitional provisions seem necessary before that harmonisation work has been conducted.

Based on this, it is assessed here that sufficient time will be available for building up the capacity for EM analysis in the Member States before the harmonisation work is completed and new requirements concerning analysis methods are transposed into the national legislation.

4.9.5 Summary

With a practical limit of quantification at approx. 0.005 - 0.01 fibres/cm^3, PCM cannot be considered feasible for monitoring compliance with the assessed OEL option of 0.01 fibres/cm^3 or 0.001 fibres/cm^3. RAC concludes that PCM is not state of the art anymore. If the OEL is lowered to 0.01 fibres/cm^3 or lower there would likely be a need for changing the requirements regarding fibre counting in Article 7.6 of the AWD.

SEM or TEM are today the prescribed methods for compliance control in the Netherlands, Germany and France which collectively account for 37% of the EU-27 population. Furthermore, half of the reported exposure concentration in the Italian SIREP database is based on SEM, SEM and TEM is widely used in monitoring asbestos by tunnel excavation and SEM analysis is provided commercially in many other Member States. It is assessed that likely more than half of the asbestos analysis for compliance control today is undertaken by EM methods.

Some uncertainties regarding the applicability of the methods as applied by commercial laboratories today for compliance control at the options of 0.002 and 0.001 fibres/cm^3 have been raised.

Based on the Dutch experience, measuring down to 0.0002 fibres/cm^3 is possible by use of SEM/EDXA. Information from a Dutch laboratory indicates that analysis with a LOQ applicable for compliance control at the 0.001 fibres/cm^3 level can be provided without extra costs compared to the analysis provided today whereas a German laboratory indicates that there might be some extra costs of about 30% when analysing samples with low asbestos concentrations. Contrary to this, according to input from DG BAU in Germany, for processes with high levels of dust it is very challenging to analyse a few fibres of asbestos on a filter filled with dust. It is possible to increase the filter area, but that means also one to several days analysing work for the lab per filter, and analysing costs increase drastically at lower levels due to time consumption needed to analyse bigger filter areas. The methods used in the Netherlands and Germany apply a resolution which allows quantification of fibres with a thickness down to 0.2 µm in accordance with the ISO 14966: 2019 standard. As concluded by RAC, if thinner fibres should be included, a higher resolution would be necessary. Achieving these low limits of detection, may necessitate further development of sample treatment practises together with sampling higher volumes and an increase of the number of fields counted (i.e. the area of the filter that is analysed). This might result in higher costs of analysis. As SEM analysis at this high resolution is not provided by commercial laboratories today, no assessment of the possible extra costs of increasing the resolution and including thinner fibres have been obtained.

Various LOQs are reported for the TEM methods in the range of 0.001 to 0.0025 fibres/cm^3. The method includes thinner fibres, so the questions regarding the applicability of TEM, concern the LOQ only. TEM is today the standard monitoring method for monitoring compliance in France and also widely used for monitoring ambient and workplace asbestos concentrations in tunnel excavation. Even the LOQ of the method as applied today is too high for compliance control at the lowest OEL options, it cannot be ruled out that the method could be optimised for measuring down to at least the same limit of detection as reported for SEM/EDXA. It has been indicated by the stakeholder consultation that some development of sampling methods may be necessary in order to lower the LOQ.

The PCM, TEM and SEM methods result in different measured concentrations.

The TEM method is able to measure fibres of a diameter down to 0.01 µm and can measure 'thin asbestos fibres' (TAF) which cannot be measured by the PCM. The ratio of TAF to 'WHO fibre' varies by ACM, but Eypert-Blaison et al. (2018) found that overall the concentrations of TAF + 'WHO fibre' was about twice the concentration of 'WHO fibre'. This is the background for the conversion factor of 2 between concentrations measured by PCM and TEM, respectively, used by some regulatory bodies. It should be noted that the 'thin asbestos fibres, are within the scope of the AWD (which has no lower limit for diameter), but in practice out of the scope due to the prescribed analytical method.

Available data indicates that the SEM and TEM methods result in different measured concentrations than the PCM in particular at lower concentrations. A French study found that the measured concentrations of fibres which are in practice within the scope of the AWD (the 'WHO fibres') using the TEM method was on average 4-fold higher than the concentrations obtained using PCM (Eypert-Blaison et al., 2018) but the ratio varied considerably between asbestos types and ACMs (note this is in addition to the differences due to including the thinner fibres).

Tromp and Tempelman (2016) note that at a fibre concentration of less than 0.01 fibres/cm^3, measured with PCM, the asbestos fibre concentration, measured with SEM/EDXA, in almost all cases remains below the Dutch OEL of 0.002 fibres/cm^3.

As proposed by RAC harmonisation work is required at EU level concerning the different EM methods currently used and some transitional provisions seem necessary before that harmonisation work has been conducted.

Based on the available information, it is assessed in this study that sufficient time will be available for building up the capacity for EM analysis in the Member States before the harmonisation work is completed and new requirements concerning analysis methods are transposed into the national legislation.

It has in this assessment been assumed that the fibre counting should in the future be carried out by SEM/EDXA analysis in accordance with the standard ISO 14966: 2019 or by other methods giving equivalent results. The SEM method, with the resolution applied in accordance with this standard, does - contrary to the TEM method - not include 'thin asbestos fibre' and the fibres included would in practice be the same as those which are in practice within the scope today. In case methods applicable to measure thin asbestos fibres would be prescribed, significantly higher analysis costs at the OEL options of 0.002 and 0.001 fibres/cm^3 could be anticipated.

4.10 Relevance of REACH Restrictions and Authorisation

Authorisation is not relevant as use of asbestos is no longer allowed. Please refer to section 1.1.2 and 4.2.1 for further details on the REACH restriction.

4.11 Intermediate uses not covered by certain REACH procedures

Not relevant as use of asbestos is banned.

4.12 Market analysis

4.12.1 Business statistics on the number of companies and employees in relevant sectors

An overview of number of companies and employees by NACE code for activities with main risk of exposure as demonstrated by data from national exposure databases are shown in Table 4.54. More detailed data with number of companies by size class is provided in Appendix D. The number of micro-size companies for many of the NACE codes are similar to the number of employees and likely the group would include many companies which are not active. In the remainder of this section, information from other sources on number of companies known to be involved in work with asbestos in the main sectors is reviewed.

Table 4.54 Number of companies and employees by NACE code for activities with main risk of exposure as demonstrated by data from national databases

2-digit NACE category	4-digit NACE category	No of enterprises, EU27	Number of workers, EU27		SME in % of total workers
			Total	SME	
Asbestos in building and construction					
F41 - Construction of buildings	F41.20 - Construction of residential and non-residential buildings	677,446	2,325,033	2,031,511	87%
F43 - Specialised construction activities	F43.11 - Demolition	24,004	74,036	70,979	96%
	F43.12 - Site preparation	157,756	271,822	260,598	96%
	F43.21 - Electrical installation	344,137	1,209,416	1,049,444	87%
	F43.22 - Plumbing, heat and air conditioning installation	348,954	1,063,606	922,919	87%
	F43.29 - Other construction installation	99,570	382,713	380,693	99%
	F43.33 - Floor and wall covering	170,130	276,082	274,625	99%
	F43.34 - Painting and glazing	240,214	410,306	408,141	99%
	F43.39 - Other building completion and finishing	244,028	225,896	224,704	99%
	F43.91 - Roofing activities	116,843	338,190	318,172	94%
	F43.99 - Other specialised construction activities n.e.c.	256,390	775,515	729,611	94%
D35 - Electricity, gas, steam and	D35.11 - Production of electricity	144,783	501,965	139,380	28%

2-digit NACE category	4-digit NACE category	No of enterprises, EU27	Number of workers, EU27		SME in % of total workers
			Total	SME	
air conditioning supply					
E39 - Remediation activities and other waste management services	E39.00 - Remediation activities and other waste management services (includes asbestos, lead paint, and other toxic material abatement)	4,080	31,000	25,315	82%
Asbestos in articles					
C33 - Repair and installation of machinery and equipment	C33.- 14 Repair of electrical equipment	15,299	50,754	37,667	74%
	C33.15 - Repair and maintenance of ships and boats	16,408	79,094	58,701	74%
	C33.16 - Repair and maintenance of aircraft and spacecraft	2,196	66,940	49,680	74%
	C33.17 - Repair and maintenance of other transport equipment	3,400	53,940	40,032	74%
G45 - Wholesale and retail trade and repair of motor vehicles and motorcycles	G45.2 - Maintenance and repair of motor vehicles	452,830	994,874	958,621	96%
Naturally occurring asbestos and asbestos from past intentional use in asphalt					
B08 - Other mining and quarrying	B08.11 - Quarrying of ornamental and building stone, limestone, gypsum, chalk and slate	5,000	47,116	39,771	84%
F42 - Civil engineering	F42.11 - Construction of roads and motorways	33,569	630,759	298,124	52.70%
	F42.12 - Construction of railways and underground railways	2,136	79,751	37,693	47%
	F42.13 - Construction of bridges and tunnel	1,900	36,994	17,485	47%
Waste treatment					
E36 - Water collection, treatment and supply	E36.00 - Water collection, treatment and supply	15,000	348,937	134,553	39%
E38 - Waste collection, treatment and disposal	E38.11 - Collection of non-hazardous waste	17,989	533,581	213,554	40%
	E38.12 - Collection of hazardous waste	1,323	17,803	7,126	40%

2-digit NACE category	4-digit NACE category	No of enterprises, EU27	Number of workers, EU27		SME in % of total workers
			Total	SME	
activities; materials recovery	E38.22 - Treatment and disposal of hazardous waste	1,000	28,660	12,732	44%
	E38.31 - Dismantling of wrecks	3,097	15,798	10,920	69%
	E38.32 - Recovery of sorted materials	16,126	177,712	122,844	69%
Testing					
M71 - Architectural and engineering activities; technical testing and analysis	M71.20 - Technical testing and analysis	68,984	410,396	249,431	61%

Source: Eurostat's Structural Business Statistics database

4.12.2 Stakeholder consultation and public sources on number of enterprises with workers exposed to asbestos

Information on companies undertaking notified work

Some Member States have a certification scheme for companies working with asbestos and public databases with names of the companies (e.g. Belgium, Cyprus, Finland, Lithuania, Poland, France and Slovenia) whereas others have a permit system without a public list of companies (e.g. Germany and Sweden). Some Member States do not have a formal permitting system, but the enterprises should by the notification demonstrate they are qualified to undertake the work with trained workers (e.g. Denmark, Estonia and Latvia).

Information on number of certified companies obtained as part of the stakeholder consultation is summarised in the table below. For Germany, the number apparently indicates the number of companies undertaking notified works (lists of certified companies are confidential).

The total number of companies in the seven Member States representing 57% of the EU27 population is about 27,000. The per capita number differs significantly with a relative high number per million capita in Germany (246) and Spain (102) and low numbers in Belgium (6) and Poland (11). The differences may reflect that in some Member States the asbestos management is concentrated on a fewer specialised companies but may also differs in the definition of which type of activities would need a certification/permit. Due to the large differences between the Member States an extrapolation of the data to the entire EU27 is relatively uncertain. Under the assumption that the number of certified companies represent the companies undertaking notified activities, and using a simple per capita extrapolation, the total number of companies undertaking notified activities is estimated at approximately 48,000. The total number of exposed workers in those companies, which are within building and construction is in section 4.4 estimated at 300,000 - 500,000. To this add workers involved in sampling and analysis, a part of the workers in the waste sector and a part of the workers in the exposure group on asbestos in articles. In total the workers in companies undertaking notified works can be estimated at 350,000 - 550,000. On this basis the average number of exposed workers per company would consequently be in the range of 7-13 workers pr. company. The average per company in Germany, France and Spain (sum of all) shown in the table below is 6. HSE in the UK report that the number of exposed workers per licenced company is 5 per company (HSE, 2017).

The above estimates indicate that the number of companies undertaking notified works is likely in the range of 50,000 - 70,000. It will be assumed that 80% of these are within the building and construction sector corresponding to 40,000 - 56,000 (best estimate 48,000). These 48,000 are based on distribution on sectors reported from France and Spain in the baseline roughly divided on 70% in 'F43 - specialised construction sector', 20% in 'E39 - Remediation activities and other waste management services', 5% in 'F41- construction and building and 5% on various other sectors'.

The number by companies reported above is significantly below the 39 exposed workers per company in companies responding to the questionnaire shown in Table 6.4.

This may reflect the general pattern that more of the larger companies responds to questionnaires for impact assessment studies.

The majority of the companies would be within the specialised construction sector, but other sectors are remediation (remediation of buildings = asbestos removal from buildings) and waste treatment, civil engineering and testing and analysis. Within all these sectors some activities not requiring notification would also take place.

The breakdown of data by company sizes for notifications in France shows that 22% of notifications was from companies with <10 employees, 18 % from companies with 10-19 employees, 56 % from companies with 20-249 employees and 4% from companies >249 employees. In total, SMEs represented 96 % of the notifications (INRS, 2020). The distribution of number of companies by size is not indicated. The data from the Structural business statistics shows that in total 94% of employees in the relevant subsectors in the sector 'Specialised construction activities' are employed in SME's (Table 4.33) while the data in Appendix D shows that more than 99% of the companies in this sector are SMEs.

The companies certified for asbestos management may consist of:

- Companies specialised in asbestos management, where managing asbestos and ACMs account for a major part of the turnover of the company;
- Companies working with demolition, renovation and remediation of buildings and infrastructure where managing asbestos is a significant part of the turnover in addition to managing other hazardous substances such as PCB, lead, PAH, mercury, etc.
- Companies in the building and construction sector where managing asbestos account for a minor part of the activities;
- Companies in other sectors where the building/facility owner's own staff may be exposed to asbestos by various maintenance activities. Managing asbestos account for a minor part of the activities.

The companies may be impacted at different levels of lowering the OEL.

A split between the different types of companies is not available. The HSA in Ireland report for the stakeholder consultation that in Ireland there about 12 asbestos removal specialists which do high-risk asbestos removal (insulation, spray, etc.), whereas the lower-risk ACMs (roof tiles, roof sheets, guttering, etc.) are mainly removed by demolition contractors.

Table 4.55 Number of companies certified for asbestos management in selected Member States

Member State (year)	Number of companies certified for asbestos management	Number of employees	Main sectors	Source
Belgium (2021)	59	No aggregated data	Specialised construction activities	List of certified companies [40]
Finland (2021)	376	3,100-3,300	No aggregated data	List of certified companies, FIOH, 2021
Germany (2017)	20,455 (companies undertaking notified works)	114,431 (workers of these companies)	Percentage of exposed: Building trade (89%), Woodworking and metalworking industries (4%), Transport industry (4%)	BaUA, 2020
France (2017)	1,083	35,000	Percentage of 5,671 companies undertaking notified works during 2012-2020: Specialised construction activities (45%), remediation and waste management (11%), civil engineering (8%), technical testing (6%) construction of buildings (5%) (INRS, 2020)	Lesterpt and Leray, 2017
Poland (2021)	420	Not reported	Removal, protection or transport of asbestos-containing products	List of certified companies [41]
Slovenia (2021)	162	No aggregated data	No aggregated data	List of certified companies [42]
Spain (2017)	4,829	17,645 (2016, workers currently exposed and under surveillance)	Data from 5 regions: Building sector (47%), waste management etc. (31%), public administration (11%), testing (3%)	Spanish Association for Asbestos Removal companies, SANIDAD, 2018

Information on companies undertaking non-notified work in the building and construction sector

Less information is available on the number of companies undertaking non-notified work.

The total number of companies in the EU-27 within subsectors of 'Specialised construction activities' where indication of asbestos related activities is available from exposure databases is 2 million companies with 5 million workers (note that a significant part of micro-

[40] https://emploi.belgique.be/fr/agrements/agrement-amiante-entreprises-agreees-pour-des-travaux-de-demolition-et-retrait-damiante?title_op=none&title=&postcode_op=none&postcode=&city_op=none&city=&page=4

[41] https://www.bazaazbestowa.gov.pl/en/about-asbestos/asbestos-enterprises

[42] https://www.gov.si/assets/organi-v-sestavi/ARSO/Odpadki/Podatki/Odstranjevanje-azbesta-iz-objektov-in-naprav.pdf

sized companies may not be operating). The sector is dominated by SMEs which account for 87 to 99 % of all employees in each of the subsectors.

Some of the activities not subject to notification may also be undertaken by workers within the sector 'Construction of residential and non-residential buildings' with 0.7 million registered companies and 2.3 million workers. On the basis of available data, it is more likely that the work with potential asbestos exposure is undertaken by companies within 'Specialised construction activities'.

According to the European Construction Industry Federation (FIEC) annual report, the total number of employees in the sector in EU27 in 2019 was 12.7 million (FIEC 2020), and the number of companies was 3.2 million. Rehabilitation and maintenance, the activities most likely to involve asbestos (except for naturally occurring asbestos), accounted for 28% of all activities. The number of workers in each of the EU Member States reflects well the total population of the Member States.

Estimates on number of exposed workers undertaking non-notified work is available from Germany and France (see section 4.4.1), but no data on number of companies or number of exposed workers per company is available.

The Health and Safety Executive in Great Britain estimate that approximately half of construction companies occasionally undertake non-notifiable work involving asbestos corresponding to 480,000 companies in the Great Britain (HSE, 2019). For estimating costs, HSE (2017) assumed the companies in total undertake 1.3 million jobs involving asbestos and that only one employee is working with asbestos per job.

In the absence of other data, it will for the costs assessment be assumed that half of the companies within the relevant subsectors in 'F43 - Specialised construction activities' and 30% of the companies in 'F41 - Construction of building' listed in Table 4.54 will occasionally undertake non-notified work. It is furthermore assumed that the distribution on size of companies is the same for companies undertaking work involving asbestos as the subsectors in general. Non-notified work in building and construction may also be undertaken by workers within other sectors, such as maintenance staff within many different sectors, but it is estimated that the major part of the work will be undertaken by staff on companies within 'Specialised construction activities' and consequently the focus will be on this. In total, 1.0 million companies in the 'F43 - Specialised construction activities' and 0.2 million in 'F41-Construction of building' and 0.3 million in various other sectors including for example D35 - Electricity, gas, steam and air conditioning supply and E39 - Remediation activities and other waste management services.

As mentioned in section 4.4 on exposed workforce, work not subject to notification may in principle be undertaken by a large number of workers in the 'Specialised construction activities' sector. In this sector, it is extrapolated on the basis of German data that at EU27 level would add up to about 3.5 million workers. This is well in accordance with the EU27-wide number of 2 million companies with 5 million workers. Of these 5 million workers the actual number of workers exposed at a significant level may be much smaller, but no data are available.

For the companies undertaking non-notifiable work the activities involving asbestos account for a minor part of their activities. If the OEL is lowered, and notification and health surveillance will be required for more activities, likely some of the activities undertaken today by companies within this exposure group would be taken over by companies already notifying and with workers under health surveillance.

Passive exposure

Passive exposure may take place in a large number of sectors as workers in any kind of building containing ACM may be exposed to low levels of asbestos. No data are available to indicate which are the main sectors but the following sectors could be included among others: I - Accommodation and food service activities, K - Financial and insurance activities, N - Administrative and support service activities', 'O - Public administration and defence', 'P - Education', 'S - Other services activities'

Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other

Limited information is available on number of companies involved in activities concerning asbestos in articles. The description of exposure in section 4.3.2 indicates that the number of exposed may be several hundred per company e.g. in railroad companies or metros, but some of the activities of the companies may mainly concern asbestos in buildings and infrastructure. According to the data from France, 85 companies within 'Land transport and transport via pipelines' (2% of total), had notified activities (Table 4.12) to the French SCOLA database between 2012 and 2019. Some of these may be railroad companies, but the type of land transport is not specified. For the sector 'Wholesale and retail trade and repair of motor vehicles and motorcycles', the number of companies were 12.

From Poland it is reported that a few companies are specialised in removal of asbestos in ships but some activities are undertaken by more general asbestos removal companies. The number of workers exposed are estimated at 5,000 - 25,000 and it is roughly estimated that the number of companies could likely be in the range of 100 - 600 (350 as best estimate of these 50 in the sector G45 - Wholesale and retail trade and repair of motor vehicles and motorcycles).

Waste sector and water collection, treatment and supply

According to the data from France, 149 companies in the 'Waste collection, treatment and disposal activities', corresponding to 3% of all notifying companies, had notified activities (Table 4.12) to the French SCOLA database between 2012 and 2019. In total 22 companies within the sector 'Water collection, treatment and supply' corresponding to 0.3% of total had notified activities. More companies were registered within the sector 'Remediation activities and other waste management services' but these companies seem (based on the questionnaire responses) mainly to be involved in the removal of ACMs from buildings. The average number of workers per company for the 19 companies in France answering the questionnaire is 26.

In Spain, in 5 regions the total of notifying companies within the sector 'Water supply, sanitation activities, waste management and decontamination' was 72 accounting for 25% of all notifying companies (Table 4.40). The average number of exposed employees were 13 per company. It is not indicated to what extent 'decontamination' represents asbestos-removal from buildings and in this assessment is included in exposure group 1.

In Italy, 14% of the companies reporting to the SIREP database (49 companies) were companies within the waste sectors while companies within 'Water collection, treatment and supply' accounted for 4% (13 companies) (Table 4.34). The average number of exposed employees per company in the waste sectors were 93 while it was 370 in the 'Water collection, treatment and supply'.

These numbers concern notified activities, but it is assumed that many of the exposed workers undertake activities not notified, e.g. in waste collection points where exposure e.g. may take place by cleaning activities.

Based on the available information it is assumed that the companies on average employ 50 exposed workers and the estimated 50,000 - 200,000 workers are employed in 800 - 3,600 companies in the waste sector (2,200 as the best estimate) and 200-400 companies within 'Water collection, treatment and supply' (300 as best estimate).

Mining and quarrying - naturally occurring asbestos

It is assumed that exposure mainly takes place in quarrying of ornamental and building stone, limestone, gypsum, chalk and slate and less in other type of mining.

In Italy about 30 enterprises are involved in serpentine mining in the Valmalenco area with more than 1,810 workers involved (on average 60 exposed workers per company). Other types of mining activities with asbestos-containing raw materials are reported from Italy, but no data on number of companies are reported. The total number of mines and quarries in Italy with concentrations above 0.001 fibres/cm^3 are likely well above the 30 enterprises in the serpentine mining.

According to BaUA (2000) the German acceptance level of 0.01 fibres/cm^3 during mining and treatment is violated in 10 out of 2,000 active quarries in Germany, but the number with exposure concentrations above 0.001 fibres/cm^3 is not reported.

In France, 29 companies within 'Other mining and quarrying' (1% of total number of companies) had notified activities (Table 4.12) to the French SCOLA database between 2012 and 2019.

According to IMA-Europe, the presence of asbestos is uncommon and considered a geological 'curiosity'. IMA-Europe represent 300 large, medium and small companies or groups operating about 810 mines and quarries across Europe, Norway, Switzerland and Turkey. According to IMA-Europe the sector employs about 100,000 persons.

If an average number of exposed workers per company is assumed to be 50, the total estimated number of workers of 5,000 - 20,000 exposed workers in mining and quarrying correspond to 100 to 400 companies (250 companies as best estimate). The total number of enterprises in the sector in the EU27 is 5,000 (see appendix D) with 47,000 employees.

Tunnel excavation

No data are available on number of enterprises involved in tunnel construction with risk of asbestos exposure. A number of tunnel projects in the Northern Italy with asbestos exposure has been described in the literature but the number of exposed workers pr. project or company is not reported. It is estimated that a very small part of the companies involved in tunnel construction in the EU will work with projects with risk of asbestos exposure. The total number of companies are roughly estimated at 10 - 110 (50 as best estimates; of these 10 involved in construction of railway tunnels).

Road construction and maintenance

According to the data from France, 458 companies within civil engineering, corresponding to 8% of all notifying companies, had notified activities (Table 4.12) to the French SCOLA database between 2012 and 2019. The types of civil engineering activities are not reported, but some may be rad construction and maintenance. According to Lesterpt and Leray (2017), road coatings accounted for 1% of total reported notifications in France. As the exposure concentrations are generally below the OEL in most Member States, limited information on asbestos exposure by road construction and maintenance work. It is estimated that only a few percent of enterprises in the sector would be involved in works with asbestos and the total number of companies are roughly estimated at 200 - 2,000 (1,100 as best estimate).

Sampling and analysis

According to the data from France, 324 companies in the Architectural and engineering activities; technical testing and analysis', corresponding to 6% of all notifying companies, had notified activities (Table 4.12) to the French SCOLA database between 2012 and 2019. In 2017, 256 organisations in France were accredited for asbestos sampling and analysis (Lesterpt and Leray, 2017**).** For the stakeholder consultation, 5 companies in France involved in sampling and analysis have provided data. The total number of exposed employees was 1,094 i.e. the average number of exposed was 219 (2 of 5 companies had below 10 exposed workers). For the stakeholder consultation, two laboratories in Romania and Spain, respectively reported on an average number of exposed employees of 12 per company.

In Italy the number of companies within sampling and analysis reporting to the SIREP database was 10 with an average of 19 workers per company.

On the basis of the estimated 10,000 - 25,000 workers exposed in the sector and an assumption that on average 40 workers per company are exposed, the number of companies are estimated at 440 companies (best estimated).

4.12.3 Total estimated number of companies involved in work with ACMs by size and sector

The estimated number of companies are summarised in Table 4.56. The total number of enterprises involved in work with ACMs is based on the information provided in section 4.12.2, whereas information on size distribution is based on the Structural Business Statistics from Eurostat summarised in Appendix D and in Table 4.54 above. The total number of companies in the EU is derived from the same statistics.

The table below indicates the number of enterprises involved in work with ACMs within the scope of exposure levels at 0.002 fibres/cm^3 or above by size of enterprise by sector. Including exposure levels below 0.002 fibres/cm^3 may significantly increase the number of enterprises, but very limited data are available.

Table 4.56 Number of enterprises involved in work with ACMs within the scope of exposure levels at or above 0.002 fibres/cm[3] by size of enterprise by sector

	Exposure group	Main sectors	Micro and small	Medium	Large	Total No. of enterprises involved in work with ACMs	Total No. of enterprises in the EU27	% of total enterprises in EU27 involved in work with ACMs
1	**Building and construction - exposure situations subject to notification**	F41 - Construction of buildings	2,381	17	1	**2,400**	**677,446**	0.4%
		F43 - Specialised construction activities	33,395	186	19	**33,600**	**2,002,026**	1.7%
		Potentially many sectors (e.g. D35 and E39; SCOLA database lists up to 24 sectors)	11,901	68	32	**12,000**	**n/a**	n/a
2	**Building and construction - exposure situations subject to Article 3(3) waiver, 'incidental' exposure**	F41 - Construction of buildings	198,428	1,454	118	**200,000**	**677,446**	50%
		F43 - Specialised construction activities (selected subsectors)	993,907	5,531	563	**1,000,000**	**2,002,026**	30%
		Potentially many sectors (e.g. D35 and E39; SCOLA database lists up to 24 sectors)	297,517	1,690	793	**300,000**	**n/a**	n/a
3	**Building and construction - passive exposure in buildings**	Many sectors	No data	No data	No data	**No data**	**No data**	No data
4	**Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other**	C33 - Repair and installation of machinery and equipment (selected subsectors)	296	3	1	**300**	**37,303**	0.8%
		G45 - Wholesale and retail trade and repair of motor vehicles and motorcycles	50	0	0	**50**	**452,830**	0.01%
5	**Waste management**	E36 - Water collection, treatment and supply	279	15	6	**300**	**15,000**	2.0%
		E38 - Waste collection, treatment and disposal activities; materials recovery	2,027	138	35	**2,200**	**39,535**	5.6%

	Exposure group	Main sectors	Micro and small	Medium	Large	Total No. of enterprises involved in work with ACMs	Total No. of enterprises in the EU27	% of total enterprises in EU27 involved in work with ACMs
6	**Mining and quarrying - naturally occurring asbestos**	B08.11 - Quarrying of ornamental and building stone, limestone, gypsum, chalk and slate	242	8	1	**250**	**5,000**	5.0%
7	**Tunnel excavation**	F42.12 - Construction of railways and underground railways	9	0	0	**10**	**2,136**	0.5%
		F42.13 - Construction of bridges and tunnel	38	2	0	**40**	**1,900**	2.1%
8	**Road construction and maintenance**	F42.11 - Construction of roads and motorways	1,042	47	11	**1,100**	**33,569**	3.3%
9	**Sampling and analysis**	M71.20 Technical testing and analysis	434	5	1	**440**	**68,984**	0.6%
	Summary (rounded)		**1,540,000***	**9,000***	**1,500***	**1,550,500***		

* These estimates do not include companies with passively exposed workers and companies with workers exposed to concentrations below 0.002 fibres/cm^3
Source: Eurostat; study team's estimates

4.12.4 Cross border aspects

The European Construction Sector Observatory[43] regularly analyses and carries out comparative assessments on the construction sector in all 27 EU countries. According to an analysis on strengthening the Internal Market for construction, the market integration for construction services is very low and the value of import and export of construction services across the EU in 2016 was only 1% of the total turnover (EC SO, 2018). Denmark, Belgium and Germany were among the biggest exporters and importers of construction sector services. As for engineering services, Germany, France and Austria were the top performers in terms of value of intra-EU exports. No data are available for services involving asbestos, but as the services are mainly undertaken by SME, the share of import and export is likely not higher than for the sector in general.

4.13 Impact of Covid 19

The study team is not aware of any Covid-19 effects that are likely to have any significant impact upon this impact assessment.

No data are available specifically for asbestos related work. For the stakeholder consultation, some companies have indicated that they had been hit by the Covid-19 crisis with lower activities in 2020, but there is no indication that this would have any influence on the future trends in activities nor any influence on the exposure levels.

The level of activities are expected to broadly follow the overall trend in the building and construction sector. The 2021 statistical report from FIEC summarise the situation in the European building and construction sector as follows: *'While the lockdown hit all economic sectors some divergence started to emerge during summer with construction recovering more rapidly than others in most of the countries. Overall, construction suffered less than initially expected in summer 2020. In the end, the sector has proved itself more resilient than the economy as a whole. Total investment in construction declined by 5.8% in 2020. Total employment even increased slightly by 0.8% compared to 2019. In 2021, investment in construction is expected to resume growth at a rate of 4.2%. All segments - new housebuilding, renovation, non-residential construction and civil engineering - are expected to recover. In most of the EU countries, the construction market is expected to get back on track. Nevertheless, total investment will not reach the pre-crisis level. For employment in construction, a slight decline of 0.1% is projected with the impact of the crisis being postponed to 2021 for some countries.'* (FIEC, 2021)

The use of face masks may have had a minor positive impact on 'incidental' and passive exposure to asbestos, but as the face masks are not optimised for filtering asbestos fibre and building and construction workers would usually not use medical face mask during work, the positive impact is considered to be negligible.

4.14 Current disease burden (CDB)

The current disease burden is a consequence of exposure to asbestos over many years in many different occupations. Data illustrating the disease burden specifically for the occupations and activities where workers are currently exposed are not available.

The data shown in Table 4.57 illustrates that exposure to asbestos in the past has been widespread among many different occupations. The table shows the observed number of mesotheliomas of the pleura among men and women in Sweden and standardized

[43] https://ec.europa.eu/growth/sectors/construction/observatory_en

incidence ratios for three time periods based on data from a cohort with 6.78 million individuals (Plato et al. 2016). Data from this cohort were linked to the population-based Swedish Cancer Registry and Swedish Total Population Registry for three periods between 1961 and 2009, and then further linked to the Swedish NOCCA job-exposure matrix, which includes 25 carcinogenic substances and the corresponding exposure levels for 280 occupations. Multivariate analysis was used to calculate standardized incidence ratios (SIRs) for mesothelioma of the peritoneum and pleura by gender, occupational category, carcinogenic substance, and for multiple occupational exposures simultaneously. A total of 3,716 incident mesotheliomas were recorded (21.1% in women). The study found a significantly increased risk of mesothelioma in 24 occupations, as well as clear differences between the genders.

For all periods, the occupations with highest number of incidences are chemical engineers, toolmakers, machinery fitters, and metal workers. The sectors, in which the work takes place, are for most occupations not reported. Occupations in the building industry were not among the occupations with the highest numbers but 'insulators' had high incidence rates over the period from 1995 to 2009 with incidence rates above 10 and 'Non-specified other building and construction work' had incidence rates increasing from 0 in 1961-1974 to of 3.0 in 1990-2009.

Table 4.57 Observed number of mesotheliomas of the pleura among men and women in Sweden and standardized incidence ratios for three time periods; 1961-1974, 1975-1989, and 1990-2009

Occupational title	1961-1974		1975-1989		1990-2009	
	Obs	SIR	Obs	SIR	Obs	SIR
Exposed to chemical agents, men						
Mechanical engineers and technicians	4	1.31	42	1.85	112	1.62
Toolmakers, machine-tool setters and operators	4	1.16	40	1.83	76	1.36
Machinery fitters and machine assemblers	10	2.67	52	2.03	118	1.6
Sheet metal workers	4	2.75	38	4.27	98	4.53
Plumbers and pipe fitters	5	4.12	44	5.8	90	4.73
Welders and flame cutters	4	3.9	15	1.83	35	1.39
Electrical fitters and wiremen	4	2.09	27	2.13	88	2.34
Construction carpenters and joiners	3	0.66	34	1.45	61	1.45
Painters	4	1.57	20	1.46	49	1.88
Insulators	0	0	7	12.81	15	10.79
Non-specified other building and construction work	0	0	7	2.7	15	3.04
Chemical process workers	2	3.7	3	1.18	10	2.55
Stationary engine and related equipment operators	5	5.87	5	1.32	8	1.44
Riggers and cable splicers	0	0	0	0	2	16.33
Unexposed to chemical agents, men						
Ships' engineers	0	0.00	7	7.88	12	5.73
Divers and pipelayers			0	0.00	4	4.62
Exposed to chemical agents, women						
Sewing work n.e.c.	4	5.65	9	3.07	5	1.05

SIR: standardized incidence ratio; Obs: observed number; n.e.c., not elsewhere classified. The original table also provides confidence intervals for the SIR

Source: Plato et al., 2016

According to the WHO (2012), the actual number of mesothelioma deaths at ages ≥30 years in Europe during the period 1994-2010 was in total 71,555, and an annual average of 6,864 deaths was recorded with an overall average age at death of 66.1 years. The actual number of asbestosis deaths at ages ≥30 years during the period 1994–2010 was 5,728, with an overall average age at death of 71.6 years.

The WHO mortality database has been consulted for newer data, but data from recent years are only available for a few Member States.

Due to the latency time of the diseases the number of both deaths and recognised occupational cases have been increasing until recent years.

In Germany the recognised cases of mesothelioma, asbestosis/pleura plaques/fibrosis and lung/larynx cancer all increased until 2015 as shown in the figure below (Baur, 2018). The author notes there is evidence for significant underreporting especially of asbestos-related lung cancer since the ratio between this asbestos-related lung cancer and mesothelioma is about 2 but would typically be in the range of 3.0. The total number of recognised cases in 2017 was based on BaUA (2020) 2,108 (see Table 4.58). Please note that the data presented in the table below differs somewhat from the numbers presented by BaUA (2020), as the table has slightly lower values for lung/larynx cancer, and higher values for mesothelioma (about 20% higher in 2010-2015).

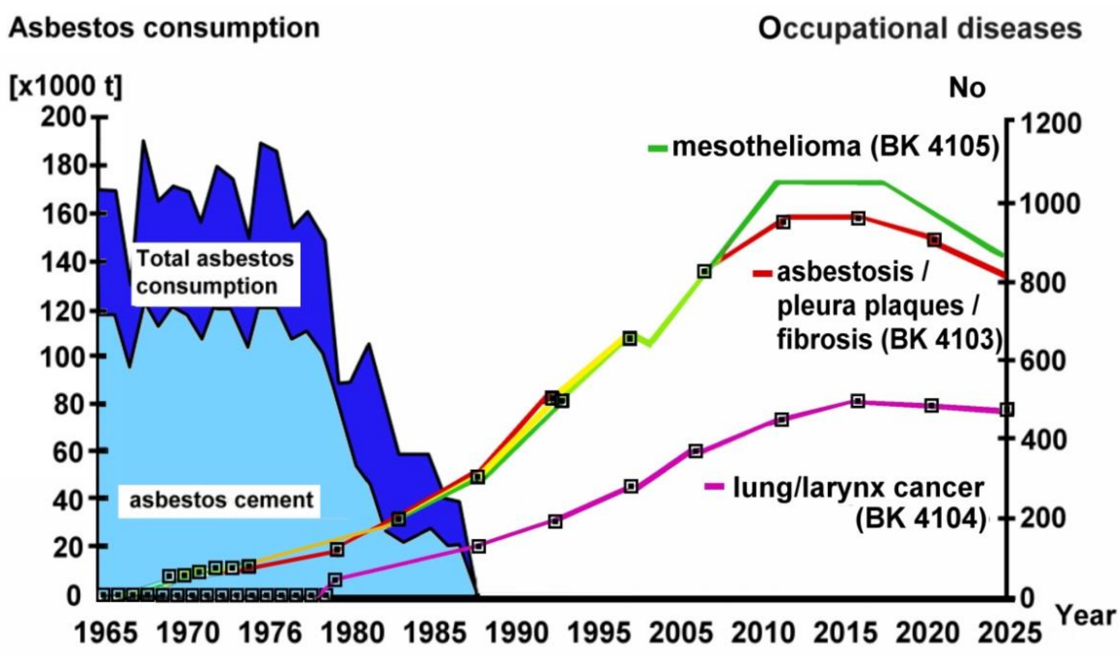

Figure 4.3 Asbestos consumption and recognized occupational diseases in West Germany. K = occupational disease designation. Note, that past and current disease data were used for future estimates. The author notes there is evidence for significant underreporting especially of asbestos-related lung

cancer since the ratio between this asbestos-related lung cancer and mesothelioma is typically in the range of 3.0 (Baur, 2018).

The trend in France in recognised cases of lung cancer, mesothelioma, asbestosis and pleural plaques for the period 2009 to 2019 is shown in the table below. The number of recognised cases of lung cancer has decreased markedly during the period, whereas the numbers for the other asbestos-related has been stable. The number of recognised cases decreased from 5,279 cases in 2009 to 2,881 in 2019 (L'Assurance Maladie, 2020). The decrease in total number of cases is due to a decrease in the number of recognised cases of lung cancer, whereas the numbers for mesothelioma and pleural plaques have been stable.

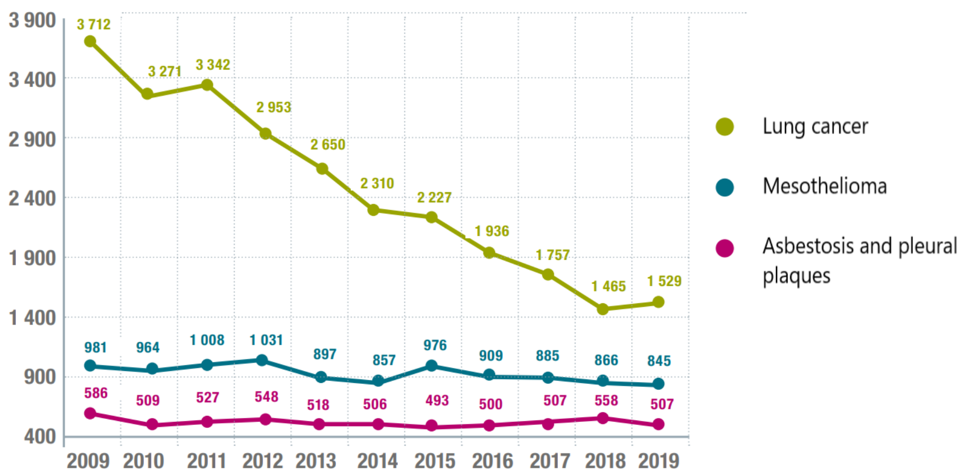

Figure 4.4 Trend in number of recognised asbestos-related diseases in France 2009-2019 (translated from L'Assurance Maladie, 2020)

Data for Great Britain (although not member of the EU) is shown in the following figure because it illustrates both the trend in deaths from asbestos-related mesothelioma, asbestosis and pleural thickening as well as the trends in new recognised cases (Industrial Injuries Benefit Disablement (IIDB) cases) (HSE, 2020). For both deaths and new recognised cases an increasing trend was observed until about 2015 where the curves have levelled off and for the coming years the mesothelioma deaths are projected to decrease. The total number of asbestos related deaths in 2019 was approximately 5,000, of these 2,446 were mesothelioma deaths and a similar number were lung cancer deaths (not shown on the figure). There were 2,025 new cases of mesothelioma assessed for Industrial Injuries Disablement Benefit in 2019. The number of lung cancers are estimated assuming one lung cancer per mesothelioma case, whereas in recent years there have been, on average, around 260 new cases of asbestos-related lung cancer each year recognised within the IIDB scheme (HSE, 2020).

Frost et al. (2008) studied occupational exposure to asbestos and mortality specifically among asbestos removal workers. The study population consisted of 31,302 stripping/removal workers included in the Great Britain Asbestos Survey from 1971 to 2005. Of 3,165 reported deaths during 1971 and 2005, 69 died from mesothelioma, 22 from asbestosis and 373 from cancer in the trachea, bronchus and lungs (no specific data for lung cancer) with corresponding standardised mortality ratios of 808, 5,753 and 201. A comparison with the total number of reported mesothelioma deaths in the Great Britain, which increased from about 500 per year in 1982 to about 1000 per year in 1992, indicates that the asbestos removal workers accounted for a maximum of a few percent of all the mesothelioma deaths.

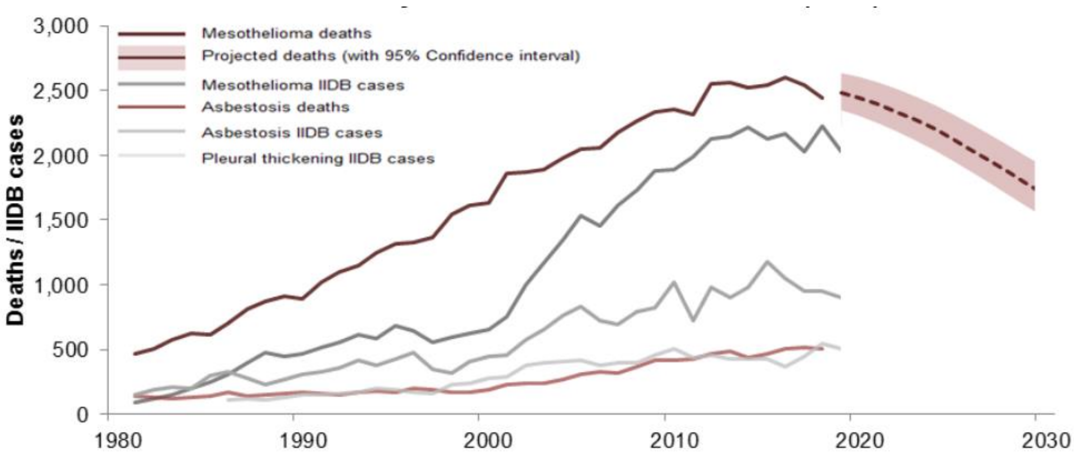

Figure 4.5 Mesothelioma, asbestosis, and pleural thickening: time trends in annual deaths and Industrial Injuries Benefit Disablement (IIDB) cases in Great Britain. (HSE, 2020)

Oddone et al. (2020a) predict an increasing trend in the number of pleural mesothelioma cases in Italy with a peak in 2025-2029 as shown in the figure below. For malignant peritoneal mesothelioma, the number of deaths are expected to constantly decrease throughout the period 2017 to 2040 (Oddone et al., 2020b).

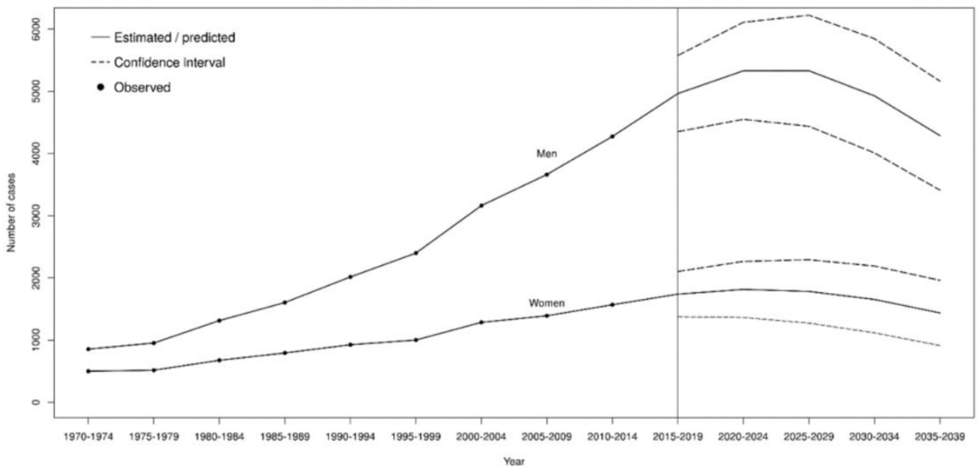

Figure 4.6 Observed and predicted number of cases of malignant pleural mesothelioma in Italy, with 95% predicted intervals. Age–period–cohort model, Italy, 1970–2039. Number of cases pr. 5-year period. (Oddone et at., 2020a)

The trend in mortality rates for mesothelioma in selected European countries is shown in the figure below from Krówczynska and Wilk (2019). The mortality rates and trends are quite similar for most of the countries, but with relatively high rates in the Great Britain and significantly lower rates in Poland. The paper concludes that the reported incidence rates in Poland and other Eastern European countries is relatively low but suggests that the mortality rate in Poland may be underestimated. As the use of asbestos peaked later in Eastern European countries and was used after asbestos was banned in many Western European countries, likely the trend in recognised cases and deaths would level off later.

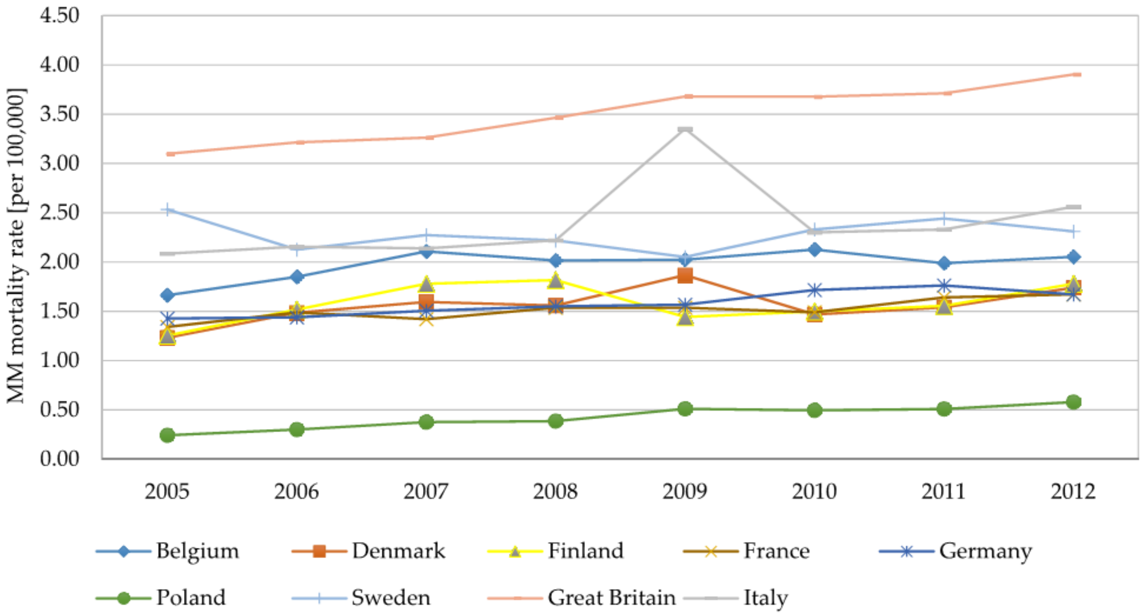

Figure 4.7 Mesothelioma (MM) annual mortality rates in selected European countries in 2005–2012 (Krówczynska and Wilk, 2018 based on WHO Mortality Database).

The number of registered cases of mesothelioma in Bulgaria increased until 2014 but seems then to level of as shown in Figure 4.8 (Vangelova et al, 2019). The registered mesothelioma cases were all morphologically and histologically confirmed, but not studied for occupational ethology. According to the authors, a comparison of the mesothelioma incidence rate among EU countries for the period 2003–2007 shows that the rate in Bulgaria remains lower than in more industrialized countries and recently is discussed in relation to comparatively late start of asbestos use in the country (about 1960), lower consumption and preventive actions in place a decade after the start of production and use of asbestos and asbestos products.

New cases of asbestosis, pleural plaques and thickening varied from 136 to 201 for the period 1980–2000 (Petrova et al, 1994, 1996 as cited by Vangelova et al, 2019), while in recent years the newly registered cases of asbestosis are 1-4 annually. There are no data on incidence of lung cancer among workers exposed to asbestos in Bulgaria, but according the National Cancer Register 3801 new cases of lung cancer of all reasons were reported in 2015. (Vangelova et al, 2019).

The Bulgarian statistics of occupational exposure register asbestosis and pleural plaques but no cases are registered for the most recent year 2018 (one case of asbestosis for 2017) [44]. The statistics has no data specifically for mesothelioma or lung cancer caused by occupational exposure to asbestos. Asbestos is included in a table on 'causing factors' but with no cases for the most recent year 2018.

[44] https://www.nssi.bg/images/bg/about/statisticsandanalysis/statistics/trs/Profesionalni-bolesti_2009-2018.pdf

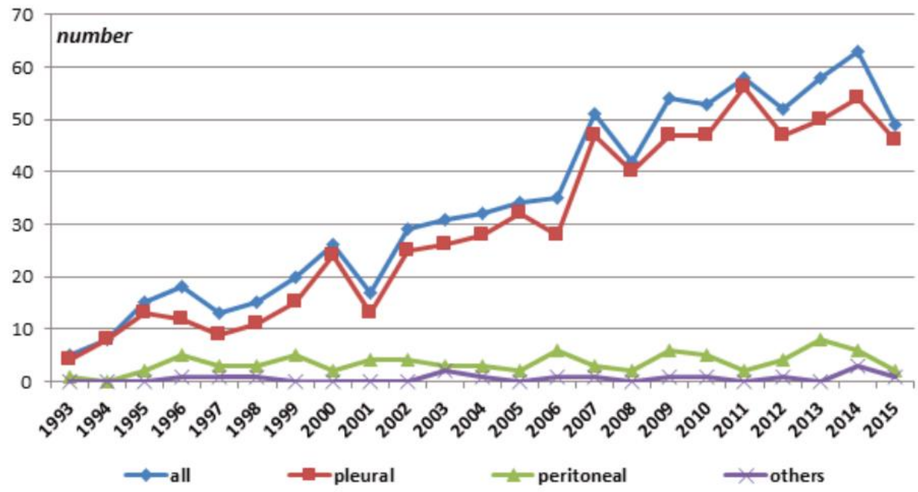

Figure 4.8 Number of registered cases of mesothelioma in Bulgaria for the period 1993 – 2015 (Vangelova et al., 2019)

The number of recognised cases in Member States obtained by the stakeholder consultation is summarised in the table below.

Data from Finland include both recognised and suspected cases (Koskela et al., 2020). A total of 446 recognized cases of asbestos-related disease were registered in 2016 whereas the number of recognised and suspected cases totalled 630. Similar data on suspected cases have not been identified from other Member States.

Data are available for Member States representing 46% of the EU population. The number of recognised cases of cancer and mesothelioma per million inhabitants ranges for four of the Member States from 14.6 to 20.1 per million inhabitants whereas the number for Poland is only 2.2 cases per million. As mentioned above, Poland has also relatively low reported mortality rates for mesothelioma. Extrapolated to the EU27 on a per capita basis gives 7.134 cases. On this basis, the total number of recognised cases of lung cancer and mesothelioma is estimated at 6,000 - 9,000. Total number of recognised cases of asbestosis in the EU27 can be estimated at 1,600 - 2,400.

Table 4.58 Number of recognised cases of asbestos related diseases in EU Member States obtained as part of the stakeholder consultation

	Mesothelioma	Cancer	Asbestosis	Pleural plaques and pleural thickenings	Cases cancer + mesothelioma per. million inh.	Note
Belgium, 2019 (Fedris, 2020)	135	31 lung 2 larynx	3	17	14.6	Recognised cases
Finland, 2016 (Koskela et. al, 2020)	56 (59)	31 (86) lung	37 (81)	342 (409) pleural plaques	15.8	Recognised cases, total suspected and recognised cases in brackets

	Mesotheli-oma	Cancer	Asbestosis	Pleural plaques and pleural thickenings	Cases cancer + mesotheli-oma per. mil-lion inh.	Note
France, 2019 (L'Assurance Maladie, 2020)	367	845 lung 140 other	263	1,262 Pleural plaques and pleural thickenings	20.1	Recognised cases
Germany, 2017 (BAuA, 2020)	866	724 * lung / larynx / ovarian	518	-	19.1	New occupa-tional disease pensions.
Poland, 2019 (GIS, 2020)	69	10 lung/bron-chial	93	4 'extensive pleu-ral or pericardial plaques' 19 'extensive pleu-ral thickening'	2.1	'Occupational diseases caused by work with as-bestos were found with a legally valid decision'
Total, listed Member States **	1,493	1,783	914	1,674	16.0	

* Germany: Number for asbestos are a sum of cancer due to asbestos (702) and due to asbestos + PAH (24).

** Represent in total 46% of the EU population

As shown for France above in Figure 4.4, the number of recognised cases of lung cancer has decreased significantly over the last ten years while the number of mesothelioma cases have been constant and the ratio of cancer to mesothelioma cases in 2019 was about 2:1. In Germany the ratio of cancer to mesothelioma has been fairly constant at 1:1 (BaUA, 2020).

The recognised cases are considered to be lower than the actual number of deaths due to asbestos. As illustrated by the data from the Great Britain above, the number of recognised cases from occupational exposure is lower than the number of reported deaths but still the numbers are quite similar.

For lung cancer and other cancers, more uncertainty exists on the actual deaths due to occupational exposure to asbestos. Several studies reach the conclusion that the number of recognised cases of lung cancer is far below the actual number of lung cancer deaths caused by asbestos. The following describes the results of two studies which indicates that the number of cases may be well above the number of recognised cases, but a review of all studies has been beyond the scope of this impact assessment.

Takala (2015) in a report for ETUI estimates the annual number of mesothelioma deaths in the EU27 (data for UK has here been subtracted) in 2010 at 7,945 and the number of asbestos-related lung cancer deaths at 30,398. In total 38,343 cases. The author notes that other work-related cancers caused by asbestos, such as larynx and ovary, and possibly stomach, colorectal and pharynx cancers are adding to the death toll caused by asbestos. The estimate for mesothelioma is about twice the number of recognised cases but well in accordance with other sources. The estimated number for work-related cancers caused by asbestos, however, is significantly higher than the reported number of recognised cases. According to the author, mesothelioma is much more commonly accepted as compensable, while lung cancers caused by asbestos are not well registered nor compensated due to multiple causes and the lower work-related attributable fraction. Furthermore, it is often very difficult to individualise the disease burden. The ratio between mesothelioma and work-related lung cancer commonly used in the past was 1:1, but Takala (2015) suggest it should be significantly higher. The rationale is based on an assumption that a larger part of the reported occupational cancers would be attributable to asbestos as estimated by McCormack et al. (2012). McCormack et al. (2012) estimated that the ratios between asbestos-related lung cancers and mesothelioma death varied by asbestos type with a mean ratio of 0.7 (95% confidence interval 0.5-1.0) in crocidolite cohorts (n=6 estimates), 6.1 (3.6 -10.5) in chrysotile cohorts (n=16), 4.0 (2.8-5.9) in amosite (n=4) and 1.9 (1.4- 2.6) in mixed asbestos fibre cohorts (n=31). Overall, the authors conclude that all types of asbestos fibres resulted in at least twice as many deaths through lung cancer than through mesothelioma except for crocidolite. Chrysotile was the most commonly used asbestos type accounting for 95% of all uses as indicated in section 4.3, and consequently the data would suggest that on average the ratio was at least above 2.

The Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2019 lead by the University of Washington provides a searchable database, the GBD Wiz hub, which includes data on mortality and morbidity in 204 countries and territories, by 369 diseases and injuries, and by 87 risk factors [45]. The results of the study are among others regularly reported in special issues of the Lancet. Among the risk factors assessed are occupational exposure to asbestos. According to the most recent data in the database, the total deaths from occupational exposure to asbestos in the EU 27 in 2019 was 71,750; divided on mesothelioma (7,510 deaths), ovarian cancer (2,032), tracheal, bronchus and lung cancer (61,035) and larynx cancer (1,173) [46]. The background for the estimates is described in a supplementary appendix to a paper on 'Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019' (GBD 2019 Risk Factors Collaborators, 2020). For occupational asbestos it is indicated that the estimate is based on the proportion of the population occupationally exposed to asbestos, using mesothelioma death rate as an analogue. Prevalence of exposure to asbestos was estimated using the asbestos impact ratio (AIR), which is equivalent to the excess deaths due to mesothelioma observed in a population divided by excess deaths due to mesothelioma in a population heavily exposed to asbestos. Asbestos exposure prevalence created using the AIR was used to estimate population attributable fractions for all asbestos-associated causes except for mesothelioma.

Estimated burden of disease for current exposure situations

For the estimations of future disease burden from current exposure, only cases due to exposure from these activities where exposure take place today will be included as only these cases would be impacted by the introduction of a new OEL and be relevant to the problem definition for this Impact Assessment. Consequently, future cases due to past exposure for other occupations will be excluded from the calculations.

No data are available for estimating the burden of disease in 2020 from the past exposure for the specific activities where exposure takes place today.

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[45] https://vizhub.healthdata.org/gbd-compare/

[46] Calculated by subtracting UK data from the data for the "European Union" in the database.

An estimate has been undertaken in order to illustrate the number of cases within this group and compare it to the total number of recognised cases.

As indicated in section 2.2.4, asbestosis only occurs at exposure levels above the existing OEL. Consequently, introduction of a lower OEL will not impact the number of cases of asbestosis which is due to past exposure at higher level. For this reason, no DRR has been derived for asbestosis and no estimates on current burden of disease from past exposure has been estimated. The number of recognised cases in the table above, indicates that the total number of cases of asbestosis is about 2/3 of the number of mesothelioma cases.

Latency. As indicated in section 2.2, a latency period of ten years for mesothelioma was assumed in the US EPA model. According to HCN the "actual latency period" after exponentiation, is actually 30-40 years. According to Frost (2013) the estimated median latencies by sector in the UK ranged from 8.2 for ship building, repair and braking to 34 years for textile sector. For building and construction, the median was 25.5 years and for removal it was 19.6. Mesothelioma latency tended to be longer for those occupationally exposed to asbestos for 10–19 years compared with those exposed for less than 10 years. The median latency time for lung cancer is estimated at about 30 years. However, for the current calculations the average concentration during the working time of workers diagnosed today will be used. In France in 2018 the average age when mesothelioma was diagnosed was 73 years while it was 66 years for lung cancer (Fiva, 2020). It means that these workers started their active working life in the 1970's where exposure levels were very high as compared with today. It is assumed that the workers have been exposed for a 40-years period from 1975 to 2015.

ERR. The number of cases are calculated using the ERR function derived by ECHA for mesothelioma and lung cancer that is used for estimation of the future burden. In addition, there is evidence for carcinogenic activities in other organs as well and hence the current disease burden has been adjusted to reflect the estimate of ECHA's Committee for Risk Assessment (RAC) that cancers of the ovary and larynx add another 10% to asbestos-induced cancer incidence.

The estimate is sensitive to the assumption on the reduction in number of workers exposed and the concentrations. It is noted by ECHA that this ERR is focused on concentrations at and below the current OEL. Applying it to higher concentrations in the past may lead to errors but is used here in the absence of other established ERRs for higher concentrations. It should be noted that the ERR derived by ECHA for the relevant exposure concentrations are lower than ERRs derived by other organisations and applying the ERR derived by ECHA on higher concentrations may highly underestimate the actual number of cases. Use of the ERR derived by the German AGS for all fibre types would e.g. result in 3.4 times more cases.

Trend in exposure concentrations. Data from the Italian SIREP database indicates that the exposure levels (without taking RPE into consideration) has not changed significantly the recent 20 years (Table 4.35). Kauppinen et al. (2013) demonstrates that the exposure concentrations decreased steeply from 1970 to 1990 with a factor of 10, whereas the concentrations in 2020 are estimated to still be at a level of 43% of the 1990 level (30 years ago).

As the exposure over the entire working life of the workers contributes to the risk of the disease, the latency time is actually a probability distribution and ideally this distribution should be multiplied with the distribution of exposure concentrations over time. With a steep decrease in exposure concentrations from 1970 to 1990, for those diagnosed with the diseases today, the exposure during their first working years (before 1990) would contribute significantly more to the total burden over the entire working life than the exposure in more recent years.

No data are available to estimate the trend in the use of RPE, but the available information suggests a change toward the use of more efficient RPE. For the estimation it is assumed that the effective exposure (taking RPE into account, used in this assessment for estimating future exposure) has decreased more than the reported exposure concentration. Using the Finnish data would lead to a trend in exposure concentration at - 11% for the period 1970-1990 and - 4% for the period 1990 to 2021. Assuming the use of better RPE during the period would result in a steeper decrease. For the calculation it is estimated that the rates may likely have been - 15% for the period 1970-1990 and - 6% for the period 1990 to 2021. A person diagnosed in 2021 at an age of 73 and an assumed working period from 1975 to 2015 would, using these rates, on average have been exposed at a level of 13 times the level today. This concentration will be used for the estimations.

Trend on exposed workforce. For the period 2009 to 2017, the number of registered workers with current exposure in Germany increased with a rate of about 5% per year. An increase in activities is also supported by an increase in the quantities of asbestos-containing waste. The trend in total exposed workforce as reported from Finland has decreased significantly, but for those activities where workers are exposed today this seems not to be the case. In absence of more detailed data for the entire period, it will be assumed that there has been no overall trend in number of exposed workers for the relevant activities.

MaxEX and MinEx. The MaxEX is set at 40 years and MinEX at 2 years. It means that workforce turnover has no significant influence on the number of cases.

Table 4.59 Parameters used for the calculation of current disease burden from past exposure

	Parameter	
	ERR for lung cancer and mesothelioma	$\mathrm{ER(conc)} = 0.0125 * \mathrm{conc}, \quad \mathrm{conc} > 0$
	Threshold	No threshold
	Latency	Median 30 years
	MaxEx	40 years
	MinEx	2 years
	Past trend in exposure concentrations	1990 - 2021: - 6 % per year 1970 - 1990: - 15 % per year
	Past trend in exposed workforce	No trend in exposed workforce

	Activity	Workforce in 2020, medium estimate	Exposure concentration in 2020 (RPE taken into account), fibres/cm^3		
			AM	Median	P95
1	Building and construction - exposure situations subject to notification	400,000	0.028	0.024	0.057
2	Building and construction - exposure situations subject to Article 3(3) waiver	4,500,000	0.02	0.018	0.040

	Activity	Workforce in 2020, medium estimate	Exposure concentration in 2020 (RPE taken into account), fibres/cm³		
			AM	Median	P95
3	Building and construction - passive exposure in buildings	600,000	0.001	0.0009	0.002
4	Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	15,000	0.028	0.024	0.057
5	Waste management	125,000	0.012	0.0105	0.024
6	Mining and quarrying - naturally occurring asbestos	12,500	0.005	0.0045	0.010
7	Tunnel excavation	3,000	0.002	0.0018	0.004
8	Road construction and maintenance	30,000	0.004	0.0035	0.008
9	Sampling and analysis	17,500	0.012	0.011	0.030

The estimated current burden of disease due to past exposure for those activities where exposure takes place today is calculated at 370 as shown in the table below. This corresponds to about 4% of the recognised cases and compared to the actual number of cases it would be even less. When compared to the observed number of cases, it should be taken into account that this estimate only included the activities with exposure today. As shown for Germany, the number of workers exposed in 2017 was 114,000 while the total number of workers still working but exposed in the past was 646,000. The latter group included many sectors where the number of workers exposed today is a few percent of the number exposed in the past. To this add workers who have retired, where also sectors without significant exposure today would dominate. Furthermore, the data from the UK shown above indicates that asbestos removal workers in the past accounted for a maximum of a few percent of all the mesothelioma deaths.

As mentioned above the number may have been underestimated by the use of the ERR derived by ECHA, which applies for lower concentrations only. If this is the situation, the estimated cases may correspond to about 10% of recognised cases which would be well in accordance with the number which could be expected on the basis of the above-mentioned data from Germany and the UK. As discussed above, some studies indicate that for lung cancer the number of cases may be significantly higher than the recognised cases.

Table 4.60 Current burden of disease due to past exposure for those activities where exposure take place today

Endpoint	New cases per year (incidence) in 2021, all occupations where exposure takes place today
Lung cancer and mesothelioma	336
Laryngeal and ovarian cancer	34
TOTAL	**370**

Source: study team's calculation

4.15 Future disease burden (FDB)

For the calculation of future burden of disease, the parameters shown in Table 4.59 are used in addition to the future trends in workforce and exposure concentrations.

Trends in workforce

The trend in number of exposed workers from recent years are available for Finland and Germany. In Germany an increasing trend has been observed from 2009 to 2017 from 73,000 to 114,000 workers corresponding to an increase of 6% per year. In Finland no marked decrease in number of exposed workers was seen between 2007-2009 and 2013-2015. According to stakeholder input from the Spanish Association for Asbestos Removal companies (ES: Asociación de Empresas de Desamiantado, Anedes) the market for asbestos removal has during 2017 to 2021 increased by 10-15% per year. From 2008 to 2017 the number of certified companies in Spain increased from 1,661 to 4,829. The association expect that the increasing trend will continue for the next years. According to stakeholder input from the Danish Association for Demolition and Environmental Remediation (DK: Nedrivning og Miljøsanering) the market for asbestos removal has been increasing during recent years and the trend is expected to continue for the coming years.

These numbers concern activities subject to notification only.

According to stakeholder input from Health & Safety Authority (HSA) in Ireland, the asbestos removal industry (about 12 specialised companies for removal of high risk asbestos) there could still be 8-10 years of higher-risk asbestos materials left to remove in Ireland. Besides that, there could be another ten years beyond that with asbestos cement sitting under cladding, etc. The HSA estimates that Ireland is ahead the removal of asbestos compared to many other Member States; partly because the amount of asbestos used was relatively low as compared to other countries, partly due to a very active asbestos removal programme.

In Denmark and Germany, the amount of asbestos-containing waste has been increasing in recent years which may indicate a more general increase in removal activities. As shown in the section 4.2.4., comparing remaining amounts of ACM with the amount of waste, the amounts of waste correspond to 25-50 years at today's activity level. If the activity level is higher in the coming years, it would correspondingly be lower during the subsequent years and it would for this assessment be assumed that nearly all ACMs are disposed of within the next 40 years.

The future trend in exposed workforce will depend on the trend in the activities with regard to removal of asbestos from buildings and articles. The trend may be impacted by three types of parameters:

- Initiatives for specifically removing ACMs from buildings, articles, etc.,
- Initiatives that more generally concern renovation of buildings, and
- The technical lifetime of the ACMs.

Initiatives for specifically removing ACMs from buildings. A few initiatives for specific removal of asbestos from building have been identified. In Poland, the Programme for Asbestos Abatement in Poland 2009-2032 was introduced by the Ministry of Economy in 2010 (MoE, 2010). One of the goals is removal and disposal of products containing asbestos before 2032. The plan included a financial plan for activities related to training, preparatory work, exposure assessment and monitoring, but not a detailed plan for the costs of removal of asbestos. According to Pawelec (2017) the amounts removed between 2012 and 2015 varied between 6,000 and 9,000 t/y but with no marked trend. According to the database on ACM in Poland 7.0 million tonnes of the inventoried 8.3 million tonnes remain to be removed indicating that the removal activities have to be increased if all ACM should be removed by 2032.

In the Netherlands, recently the government proposed a bill to ban asbestos roofs as of 31 December 2024. But the bill did not make it through the Senate.[47]Until 2018 it was possible to obtain a national grant for asbestos removal, but it is no longer possible.[48]

In Lithuania an asbestos removal action plan 2017 – 2020 has been introduced [49]. The goals of the plan are:

- To seek to remove asbestos-containing products from the environment by giving priority to removing asbestos-containing products from public buildings.
- To strive for the development of the infrastructure necessary for the management of waste from asbestos-containing products The objectives of the plan are:
- Improve the inventory and presentation of data on asbestos-containing products in the environment.
- Assess the existing and develop the necessary safe disposal capacity of asbestos-containing waste products.
- To promote the development and (or) creation of an infrastructure for the collection of asbestos-containing waste products from the population in each municipality.
- Identify sources of financing for the disposal of asbestos-containing products and waste from asbestos-containing products.
- Raising public awareness of the risks to public health from asbestos, the safe handling of asbestos- containing products and their potential for removal from the environment.

The plan has no specific goals for the removal of asbestos from buildings.

In Belgium, the Flemish government added a new section concerning materials containing asbestos to the Flemish Materials Decree in April 2019.The aim of this decree is the creation of an asbestos-safe environment by 2040.The decree sets an obligation for the Flemish public authorities to remove asbestos from all public constructions that were built before the year 2001 (as materials produced or installed between 1945 and 2001 – especially between 1955 and 1985 – are likely to contain asbestos). [50]

European Green Deal. One of the pillars in the European Green Deal is a 'Renovation Wave' for private and public buildings, which will focus attention on improving the insulation and renovation of older buildings. This might have the effect of increasing the potential for exposure to asbestos over the next decade. The European Commission's projections are for a 1% annual energy renovation rate for 2021-2022, an increase to 1.2% per year in 2023-2025 before stabilising at least 2% per year in 2026-2029 [51]. The Commission estimates the potential for an additional 160,000 green jobs in the construction sector in the EU by 2030. Compared to the approximately 5 million workers potentially exposed to

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[47] https://www.government.nl/topics/asbestos/regulations

[48] https://www.government.nl/topics/asbestos/question-and-answer/entitled-to-grant-asbestos

[49] https://www.e-tar.lt/portal/lt/legalAct/09f908400f0811e79800e8266c1e5d1b

[50] Neven, W., Van Herrewegh, K., 2019, “New asbestos removal policy in Flanders”, *International Bar Association*, available at: https://www.ibanet.org/article/26587dea-272e-4d77-b680-eba6169eb954

[51] https://ec.europa.eu/commission/presscorner/detail/en/qanda_20_1836

asbestos, the additional green jobs correspond to approximately 4%. On this basis only a small increasing trend in total exposed workforce would be expected.

According to EFBWW (2020), a building sector 'Renovation Wave' will make it unavoidable that a significant number of workers and inhabitants will get into contact with asbestos fibres. For the circular economy and waste reform strategy, the orderly and safe disposal of asbestos waste from buildings will be of highest importance. The organisation proposes a European approach for the creation of comprehensive and accessible asbestos registries in all EU countries. The organisation suggests that sustainable investment in building renovation should also include support for homeowners to remove asbestos, since this involves significant costs – which are often circumvented by illegal work with and disposal of asbestos-containing materials.

Lifespan of the materials. The technical lifespan of the ACMs may also govern the rate by which the materials are removed. According to the Spanish Association of Asbestos-removal Companies (as quoted in section 4.2.4, nearly 100% of the ACMs would have reached their expected service lifespan in 2040 and it is expected that the majority of the remaining asbestos is removed within the next 20 years[52]. It has not been possible to identify any studies projecting the amount of ACMs to be disposed of the coming years.

Assumed trends. For the estimate of future burden, it is assumed that the number of exposed workers will increase by 4% every year for the first 10 years. This is based on the current increasing trend in amount of asbestos-containing waste and the number of certified workers. This is significantly higher than would be expected on the basis of the projected number of new green jobs. Then the level is assumed to plateau in years 11 – 25 (2032 - 2046), and finally, the number of exposed workers will decrease fairly quickly with an assumed annual decrease of 10% in years 26 – 40 (2046 - 2061). By this, virtually all ACMs would have been removed by 2061.

Trend in exposure concentrations

The available data indicates that the deceasing trend in exposure concentrations have levelled off in recent years and for calculations of future disease burden it is assumed that the concentration will remain at the same level as estimated for today.

ERR

As indicated in the previous section, the number of cases is calculated using the ERR function derived by ECHA for mesothelioma and lung cancer. In addition, there is evidence for carcinogenic activities in other organs as well and hence the future disease burden has been adjusted to reflect the estimate of ECHA's Committee for Risk Assessment (RAC) that cancers of the ovary and larynx add another 10% to asbestos-induced cancer incidence.

The RAC opinion on asbestos only became available shortly before the conclusion of the study. Therefore, full modelling of the monetary value of the estimated future disease burden associated with cases of laryngeal and ovarian cancer could not be carried out – these impacts are approximated in this report by estimating that avoided incidence of laryngeal and ovarian cancer adds another 10% of cases to the estimated incidence of mesothelioma and lung cancer and the associated monetary value. It is recognised that the costs of laryngeal and ovarian cancer may not be the same as those for mesothelioma and lung cancer but, in the context of the overall uncertainty of this study, any potential bias is likely to be minimal.

Calculated number of cases

[52] https://anedes.org/el-65-de-materiales-con-asbesto-agotara-su-vida-util-en-2020/

The calculated number of cases result in 884 cases over a period of 40 years or on average 22.1 cases per year. The major part would be within the exposure group 'Building and construction - exposure situations subject to Article 3(3) waiver and 'incidental' exposure'. Exposure situations with exposure to naturally occurring asbestos account in total for less than 6%.

Compared to the number of recognised cases today, this would correspond to 0.3% and compared to the actual number of cases it would be even less. As discussed in section 4.3.8.1, the so-called national occupational inhalation exposure (NOIE) in Finland, which indicates the future burden of the total exposure the year concerned, was in 2020 at a level of 2% of the 1990 level and at 0.05% of the 1970 level. As the recognised cases today would in particular have been exposed in the period between 1975 and 1990, it is well in accordance with the Finnish estimates that future burden of today's exposure is less than 1% of the recognised cases today.

A calculation of what could be considered a realistic maximum worst case number can be undertaken by assuming compliance with the current OEL i.e. for all activities the P95 is 0.1 fibres/cm^3 (in some Member States it would be less), the AM is 1/2 of this (default value supported by existing datasets) and the exposed workforce is 5,700,000. Under these assumptions, the calculated total number over 40 years would in total be approximately 3,960 (on average 99 per year). Compared to the number of recognised cases today, this would correspond to approximately 1.5%.

Table 4.61 Baseline future burden of disease (cases) for asbestos

	Activity	Number of cases over 40 years Lung cancer and mesothelioma	Number of cases over 40 years Laryngeal cancer and ovarian cancer	Number of cases over 40 years TOTAL
1	Building and construction - exposure situations subject to notification	136	14	**150**
2	Building and construction - exposure situations subject to Article 3(3) waiver and 'incidental' exposure	624	62	**686**
3	Building and construction - passive exposure in buildings	9.3	0.9	**10.2**
4	Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	5.0	0.5	**5.5**
5	Waste management	24	2.4	**26**
6	Mining and quarrying - naturally occurring asbestos	1.2	0.1	**1.3**
7	Tunnel excavation - naturally occurring asbestos	0.1	0.01	**0.1**
8	Road construction and maintenance	1.8	0.2	**2**
9	Sampling and analysis	3.4	0.3	**3.7**
	Total (rounded)	**804**	**80**	**884**

Source: study team's calculation

4.15.1 Summary of the baseline scenario

Table 4.62 below provides a summary of the baseline scenario for this impact assessment.

Table 4.62 Asbestos – summary of the baseline scenario

Item	Detail
Carcinogen	(a) Crocidolite CAS No 12001-28-4 (b) Amosite CAS No 12172-73-5 (c) Anthophyllite CAS No 77536-67-5 (d) Actinolite CAS No 77536-66-4 (e) Tremolite CAS No 77536-68-6 (f) Chrysotile CAS No 12001-29-5 and CAS No 132207-32-0
Classification	Carc. 1A; H350: May cause cancer

Item	Detail
	STOT RE 1; H372: Causes damage to organs through prolonged or re-peated expo-sure
Key sectors with exposure	F41.20 Construction of residential and non-residential buildings F43.11 Demolition F43.12 Site preparation F43.21 Electrical installation F43.22 Plumbing, heat and air conditioning installation F43.29 Other construction installation F43.33 Floor and wall covering F43.34 Painting and glazing F43.39 Other building completion and finishing F43.91 Roofing activities F43.99 Other specialised construction activities n.e.c. D35.11 Production of electricity C33.14 Repair of electrical equipment C33.15 Repair and maintenance of ships and boats C33.16 Repair and maintenance of aircraft and spacecraft C33.17 Repair and maintenance of other transport equipment G45.2 Maintenance and repair of motor vehicles B08.11 Quarrying of ornamental and building stone, limestone, gypsum, chalk and slate F42.11 Construction of roads and motorways F42.12 Construction of railways and underground railways F42.13 Construction of bridges and tunnel E36.00 Water collection, treatment and supply E38.11 Collection of non-hazardous waste E38.12 Collection of hazardous waste E38.22 Treatment and disposal of hazardous waste E38.31 Dismantling of wrecks E38.32 Recovery of sorted materials E39.00 Remediation activities and other waste management services (in-cludes asbestos, lead paint, and other toxic material abatement) M71.20 Technical testing and analysis
Types of ill health	Lung cancer Mesothelioma Laryngeal cancer Ovarian cancer
No. of exposed workers	4,100,000 - 7,300,000

Item	Detail
	More workers may be exposed by passive exposure and exposure from naturally occurring asbestos at concentrations close to 0.001 fibres/cm^3 or lower
Change in future exposure level	No changes
Change in future no. of exposed workers	Next 10 years 4% per year 11 – 25 years: no changes 26 – 40 years: -10% per year
Period of estimation	40 years
Current disease burden (CDB) - all historic exposures	6,000 - 9,000 recognised cases of lung cancer and mesothelioma from occupational exposure The number of actual deaths is significantly higher, but it is uncertain to what extent the cases are due to occupational exposure to asbestos. Several studies indicate the number of annual mesothelioma deaths in the EU 27 from occupational exposure to asbestos to be around 8.500, whereas more uncertainties are related to the number of cancer cases attributable to occupational exposure to asbestos, with the highest estimates at 61,000 lung cancer deaths
Current disease burden (CDB) - all historic exposures for current types of exposure situations	Lung cancer and mesothelioma: 336 (estimated) Laryngeal cancer and ovarian cancer: 34 (estimated)
Future disease burden (FDB) - from for current types of exposure situations	Lung cancer and mesothelioma: 804 over 40 years Laryngeal cancer and ovarian cancer: 80 over 40 years
Expected no. of deaths FBD cancer	707 over 40 years
Monetary value FDB no. of lung cancer, mesothelioma, laryngeal cancer, and ovarian cancer cases	€228 million – €438 million
Monetary value FDB other adverse health effects	Not quantified

5. Benefits assessment

This section comprises the following subsections:

Section 5.1: Summary of the key features of the model.

Section 5.2: Direct benefits – avoided cases of ill health.

Section 5.3: Direct benefits - workers & families.

Section 5.4: Direct benefits - public sector.

Section 5.5: Direct benefits – companies.

Section 5.6: Direct benefits – environmental.

Section 5.7: Direct benefits – market efficiency.

Section 5.8: Indirect benefits.

Section 5.9: Aggregated benefits.

5.1 Summary of the key features of the model

The benefits of the potential measures to reduce worker exposure equal the costs of avoided cases of ill health. The model developed to estimate these costs takes into account the cost categories set out in Table 5.1 below.

Table 5.1 The benefits framework

Category	Cost	Notes
Direct	Healthcare	Cost of medical treatment, including hospitalisation, surgery, consultations, radiation therapy, chemo-therapy/immunotherapy, etc.
	Informal care[53]	Opportunity cost of unpaid care (i.e. the monetary value of the working and/or leisure time that relatives or friends provide to those with cancer)
	Cost for employers (e.g. liability insurance)	Cost to employers due to insurance payments and absence from work
Indirect	Mortality – productivity loss	The economic loss to society due to premature death
	Morbidity – lost working days	Loss of earnings and output due to absence from work due to illness or treatment
Intangible	Approach 1 WTP[54]: Mortality	

[53] A decision has been taken to include informal care costs in this analysis even though some elements of these costs may also have been included in individuals' willingness to pay values to avoid a future case of ill health. This decision may result in an overestimate of the benefits as generated by this study.

[54] Willingness to Pay: The maximum sum an individual is willing to pay for a service/goods to avoid loss, in this case, in terms of health treatment.

Category	Cost	Notes
	Approach 1 WTP: Morbidity	A monetary value of the impact on quality of life of affected workers
	Approach 2 DALY[55]: Mortality	
	Approach 2 DALY: Morbidity	

The total avoided cost of ill health is calculated using the following two methods:

Method 1 (intangible costs estimated based on WTP to avoid a case): *Ctotal= Ch+Ci+Cp+Ce+Cvsl+Cvsm*

Method 2 (intangible costs estimated based on monetised DALYs): *Ctotal= Ch+Ci+Cp+Ce+Cl+Cdaly*

The abbreviations are explained in Table 5.2 below.

Table 5.2 Overview of cost categories

Category	Code	Cost
Direct	*Ch*	Healthcare
	Ci	Informal care
	Ce	Total cost to an employer
Indirect	*Cp*	Productivity loss due to mortality
	Cl	Lost earnings due to morbidity
Intangible	*Cvsl*	Value of statistical life
	Cvsm	Value of cancer morbidity/value of statistical morbidity
	Cdaly	Value of DALYs

The benefit model provides the following two outputs:

- The number of new cases for each health endpoint assigned to a specific year in the 40-year assessment period; and
- The Present Value (PV) of the direct, indirect, and intangible costs of each case.

The model assumes an annual staff turnover of 5%. Despite the fact that this rate is lower than the turnover ratios in the published literature and Eurostat which are typically derived at the level of individual companies rather than sectors, it is deemed that a ratio of 5% is suitable to account for the fact that some workers may continue to work in the same sector and continue to be exposed. Hence, the whole workforce is replaced every 20 years, and within the time period of 40 years, two cohorts of workers are being exposed to asbestos.

55 Disability Adjusted Life Year. One DALY equals one year of health is lost. It is used to calculate the gap between current health status and the ideal health situation (WHO, Metrics: Disability-Adjusted Life Year (DALY)).

The turnover caused by treatment or early retirement due to the conditions considered in this report is not modelled.

A detailed overview of the key features of the model for the estimation of the benefits and the assumptions underpinning it are set out in the methodology report.

5.1.1 Relevant health endpoints for asbestos

As described in Section 2.2, the health endpoints that have been identified for quantification are:

- Mesothelioma (i.e. tumours of the pleura and the peritoneum, i.e., the membrane linings of the lung and abdominal cavities); and
- Lung cancer.

It should be noted that a common ERR (exposure risk relationship) has been derived for lung cancer and mesothelioma and therefore the costs of avoided ill health will be presented combined for both endpoints. The specific data on the characteristics of these health end-points are described in the sections 2.2 and 2.3.

The assessment of the burden of disease and the estimated benefit of introduction of a lower OEL is based primarily on mesothelioma and lung cancer for which an ERR was developed in Section 2. However, there is evidence for carcinogenic activities in other organs as well and the results of this study have been adjusted to reflect the estimate of ECHA's Committee for Risk Assessment (RAC) that cancers of the ovary and larynx add another 10% to asbestos-induced cancer incidence. The RAC opinion on asbestos only became available shortly before the conclusion of the study. Therefore, full modelling of the cost savings due to avoided cases of laryngeal and ovarian cancer could not be carried out – these impacts are approximated in this report by estimating that avoided incidence of laryngeal and ovarian cancer adds another 10% of cases to the estimated incidence of mesothelioma and lung cancer and the associated costs. It is recognised that the costs of laryngeal and ovarian cancer may not be the same as those for mesothelioma and lung cancer but, in the context of the overall uncertainty of this study, any potential bias is likely to be minimal.

5.1.2 Summary of the key assumptions for asbestos

5.1.2.1 Sporadic exposure

As discussed in Section 4.4, the estimated exposed workforce is subject to some uncertainty. For exposure group 2, in addition to the uncertainty on the total number of exposed workers, a major uncertainty is linked to the fact that many of the workers are only exposed sporadically, which influences both the benefits and costs estimated for this group. To take this into account a 50% reduction factor has been applied for this group for both benefits and costs.

5.1.2.2 Compliance with lower OELs (France, Germany, and the Netherlands)

Workers in France, Germany and the Netherlands are exposed to lower concentrations than in the remaining Member States as a consequence of complying with lower occupational limit values. A sense check was carried out to double check that the EU wide distribution of workers over exposure concentrations is consistent with the current OELs in the EU member states. As a result of the sense check, the distributions used for the estimation of the benefits were adjusted. The benefit model typically makes the conservative assumption that 50 per cent of workers are exposed to the P50 value of all the exposure concentrations – however, this assumption was not consistent with the expectation that 37 per cent of EU workers (those based in France, Germany and the Netherlands) are exposed to lower concentrations. The exposure concentration applied to the lower 50 percent of workers was thus adjusted in a manner that assumes that workers in France, Germany and the Netherlands are exposed to their respective national limit value.

5.1.2.3 Onset of the disease

The time required for the endpoints to develop over an average working life takes into account the minimum and maximum time required to develop the condition (MinEx and MaxEx) and the distribution of new cases between these two points in time, combined with the latency period with which the effects are diagnosed.

The MinEx and MaxEx for the two endpoints is summarised in Table 5.3 below.

Table 5.3 Minimum & maximum exposure duration to develop a condition (MinEx & MaxEx) and latency in years

Endpoint	MinEx (years)	MaxEx (years)	Latency
Lung cancer and mesothelioma (combined ERR: 8 hr-TWA)	2 (for practical reasons the model assumes 0)	40	30*

The latency period is different for the two endpoints with significantly longer latency period for mesothelioma than for lung cancer. As explained in Section 4.14, the median latency was estimated at 30 years.

For lung cancer and mesothelioma, it is assumed that the distribution of risk is linear, i.e. 0% of the excess risk arises in year 2 and 100% of the excess risk arises by year 40.

5.1.2.1 Effects of disease

The key assumptions on the effects of the disease entering the model are summarised below:

- Treatment period,
- Years lived with disability of the disease (YLD),
- Fatality rate,
- Additional life expectancy at death, and
- Disability weights during treatment and after treatment.

The table below presents the treatment period, YLD, fatality rate, and additional life expectancy at death for the two endpoints. Both endpoints have a potentially fatal outcome.

Table 5.4 Treatment period, YLD, Fatality rate, and Additional life expectancy at death in years

Endpoint	Treatment period	YLD	Fatality rate	Additional life expectancy at death
Lung cancer and mesothelioma (combined ERR: 8 hr-TWA)	5	5	80%	22

Lung cancer and mesothelioma have different fatality rates. The 5-year survival rate for mesothelioma is 12 to 52%, depending on the type of mesothelioma (pleural or peritoneal) and 25% for lung cancer. Hence, for this assessment a median fatality rate of 80% is assumed.

The average life expectancy used for the calculations in the model is 82 years. In the absence of other information and taking into account the age distribution of cancer deaths, it is assumed that a typical cancer death occurs at the age of 60 and the number of years lost is thus 22.

The table below summarises the disability weights during and after treatment.

Table 5.5 Assigned disability weights during and after treatment

Endpoint	During Treatment	After Treatment
Lung cancer and mesothelioma (combined ERR: 8 hr-TWA)	0.265	0.515

5.2 Direct benefits - avoided cases of ill health

The table below presents the cases of ill health associated with all relevant endpoints and OEL options over the study period of 40 years. The number of cases is further plotted in a continuous form in the figure below.

Table 5.6 Cases by endpoint for each OEL option

Endpoint	Lung cancer and mesothelioma	Laryngeal cancer and ovarian cancer	TOTAL	TOTAL avoided cases of ill health (compared to baseline)
0.001 fibres/cm^3	24	2	**26**	*858*
0.002 fibres/cm^3	48	5	**53**	*831*
0.01 fibres/cm^3	201	20	**221**	*663*
0.1 fibres/cm^3 (baseline)	804	80	**884**	-

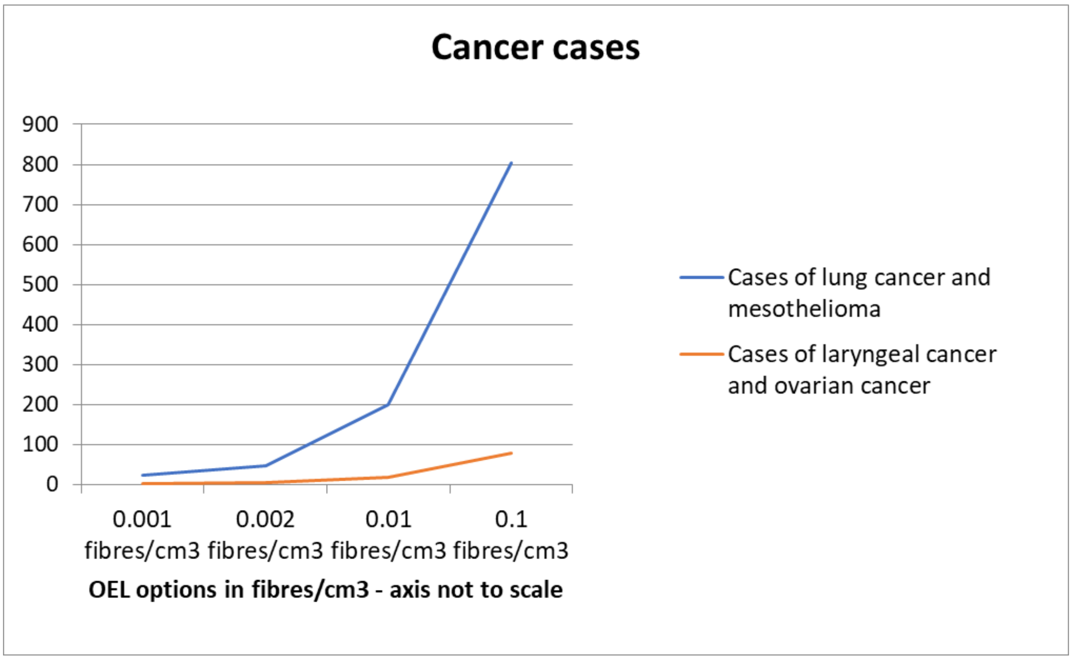

Figure 5.1 Cancer cases for each OEL option. Source: study team's calculation. Source: study team's calculation

5.3 Direct benefits - workers & families

The avoided costs of ill health relative to the baseline for workers and their families are calculated with the benefit approaches described in the table below. The benefits of the avoided cost of ill health are defined as cost of ill health in the baseline scenario, less the cost of ill health following the introduction of an OEL.

Table 5.7 Benefits for workers and their families (avoided cost of ill health)

Stakeholder group	Costs	Method of summation
Workers/family	Ci, Cl, Cvsl, Cvcm, Cdaly	Method 1: CtotalWorker&Family=Ci+Cvsl+Cvcm Method 2: CtotalWorker&Family=Ci+Cl+Cdaly

In the following, the results are presented for respectively method 1 and 2. The table and figure below present the benefits according to method 1.

Table 5.8 METHOD 1: Benefits to WORKERS & FAMILIES (relative to the baseline), € million

Endpoint	Lung cancer and mesothelioma	Laryngeal cancer and ovarian cancer	TOTAL
0.001 fibres/cm^3	380.1	38.0	**418.1**
0.002 fibres/cm^3	368.5	36.9	**405.4**
0.01 fibres/cm^3	293.7	29.4	**323.1**

0.1 fibres/cm³ (baseline)	-	-	**-**

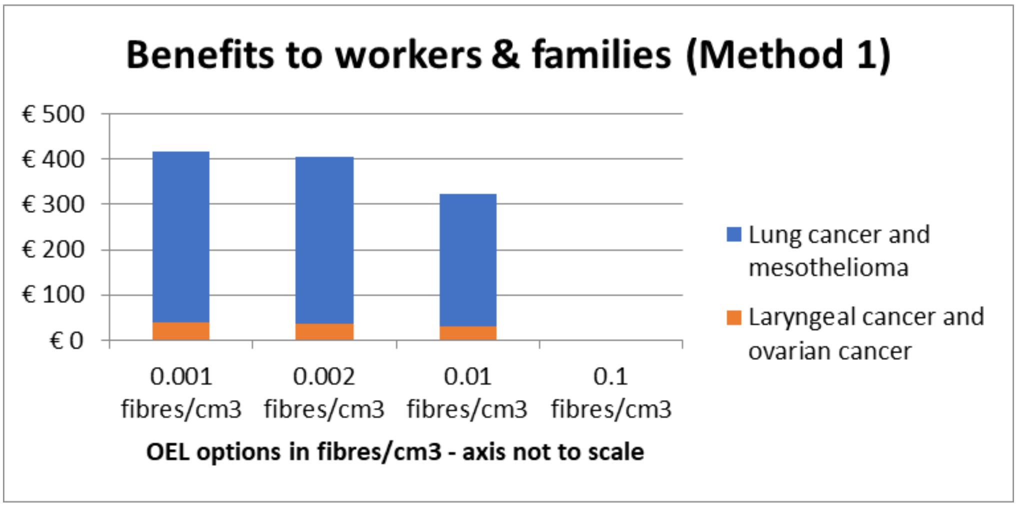

Figure 5.2 METHOD 1: Benefits to WORKERS & FAMILIES (relative to the baseline), € million. Source: study team's calculation.

The following table and figure present the benefits according to method 2. It can be seen that the benefits are lower using method 2 compared to method 1, which can be explained by some limited differences in the unit values of Cvsm in method 1 and Cl and Cdaly in method 2. Method 2 results in a lower monetised value than method 1 for cancer endpoints.

Table 5.9 METHOD 2: Benefits to WORKERS & FAMILIES (relative to the baseline), € million

Endpoint	Lung cancer and mesothelioma	Laryngeal cancer and ovarian cancer	TOTAL
0.001 fibres/cm³	195.2	19.5	**214.7**
0.002 fibres/cm³	189.2	18.9	**208.1**
0.01 fibres/cm³	150.8	15.1	**165.9**
0.1 fibres/cm³ (baseline)	-	-	**-**

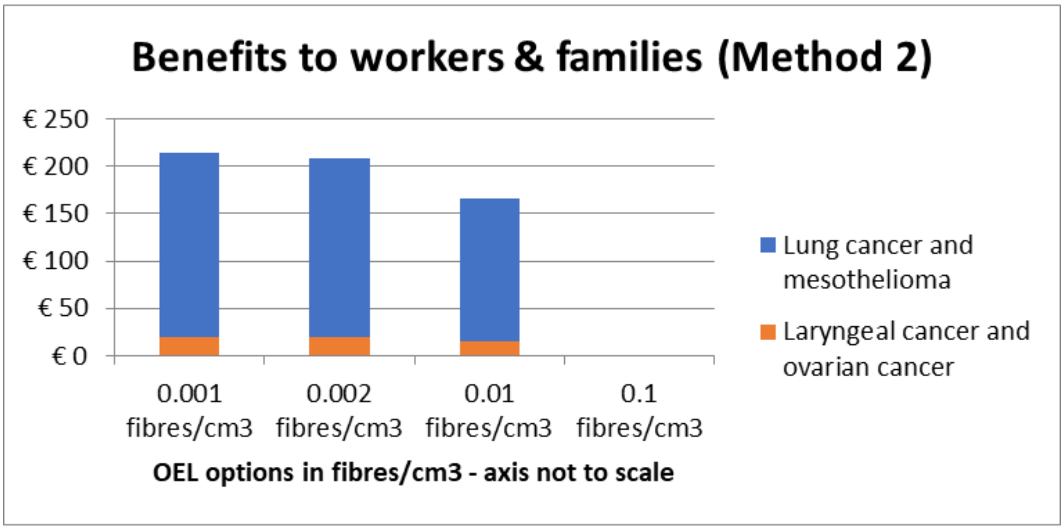

Figure 5.3 METHOD 2: Benefits to WORKERS & FAMILIES (relative to the baseline), € million. Source: study team's calculation.

5.4 Direct benefits - public sector

The benefits of the avoided costs of ill health relative to the baseline to the public sector are composed of cost of treatment and tax revenue, as summarised in the table below. These costs include healthcare treatment costs, which assume that the costs are borne by the public sector. These costs do not include informal care costs, which are costs for workers and families covered in Section 5.3.

Table 5.10 Benefits to the PUBLIC SECTOR (avoided cost of ill health)

Stakeholder group	Costs	Method of summation
Governments	Ch, part of Cp (loss of tax revenue), part of Cl (loss of tax revenue)	*CtotalGov=Ch+0.2(Cp+Cl)*

Note: 20% tax rate assumed

Table 5.11 Benefits to PUBLIC SECTOR (relative to the baseline), € million

Endpoint	Lung cancer and mesothelioma	Laryngeal cancer and ovarian cancer	TOTAL
0.001 fibres/cm^3	4.1	0.4	**4.5**
0.002 fibres/cm^3	3.9	0.4	**4.3**
0.01 fibres/cm^3	3.1	0.3	**3.4**
0.1 fibres/cm^3 (baseline)	-	-	**-**

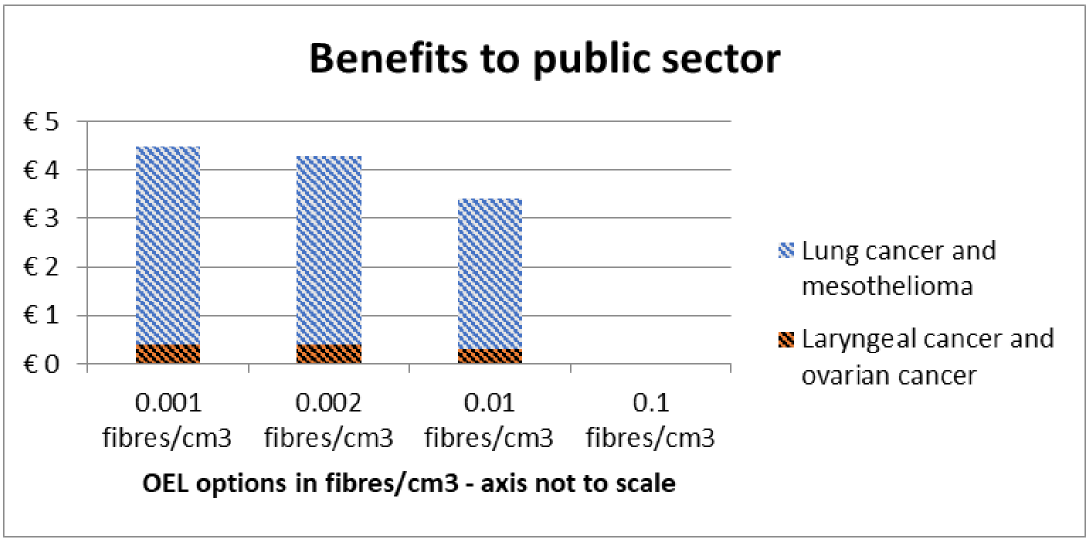

Figure 5.4 Benefits to PUBLIC SECTOR (relative to the baseline), € million. Source: study team's calculation.

5.5 Direct benefits - companies

The benefits of employers are composed of the cost savings for employers (of avoided sick leave, reduced labour productivity, and reduced administrative and legal costs like replacing employees) as well as the loss in labour productivity for a fatality. The table below summarises these benefits.

Table 5.12 Benefits to employers

Stakeholder group	Costs	Method of summation
Employers	Ce, Cp	CtotalEmployer=Ce+0.8*Cp[56]

The resulting benefits for employers are presented in following table and figure.

[56] Ce for cancer is taken from published literature rather than estimated as an output of the benefits model.

Table 5.13 Benefits to EMPLOYERS (relative to the baseline), € million

Endpoint	Lung cancer and mesothelioma	Laryngeal cancer and ovarian cancer	TOTAL
0.001 fibres/cm^3	1.9	0.2	**2.1**
0.002 fibres/cm^3	1.8	0.2	**2.0**
0.01 fibres/cm^3	1.5	0.2	**1.7**
0.1 fibres/cm^3 (baseline)	-	-	**-**

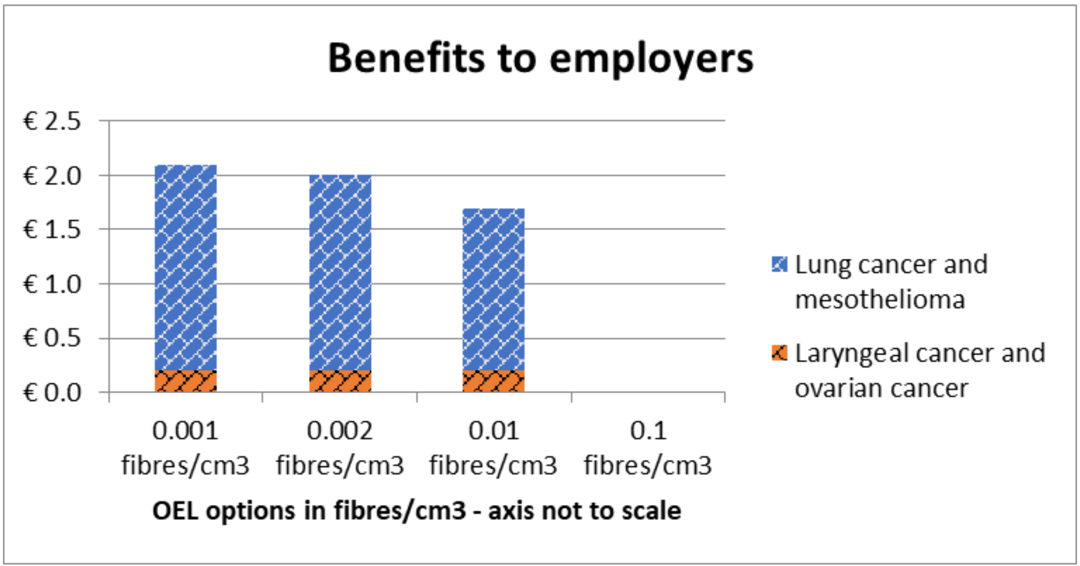

Figure 5.5 Benefits to EMPLOYERS (relative to the baseline), € million. Source: study team's calculation.

5.6 Direct benefits – environmental

Chapter 9 on the environmental impacts provides a detailed assessment of the environmental impacts. Due to these low release levels the environmental impacts of asbestos are believed to be relatively low in spite of asbestos fibres persistence and toxicity. The use of further RMMs may help to marginally improve environmental exposure to asbestos however significant differences are unlikely to be recognised.

5.7 Direct benefits – market efficiency

A reduction of the EU-wide OEL will lead to an increased harmonisation of limit values across Europe. The increased harmonisation will in turn improve the level playing field for enterprises across the internal market, as in some cases this will mean the introduction of a limit and it may close the gap between the lowest and highest OEL in the EU. The level playing field will improve with more stringent OELs. As section 4.1 above shows, only an OEL of 0.002 fibres/cm^3 would introduce a fully levelled playing field (i.e. all Member States having the same limit value). The OEL of 0.01 fibres/cm^3 would provide the greatest marginal gains in terms of the number of Member States with the same limit value and would introduce a nearly completely level playing field, in which only the Netherlands has a lower limit for asbestos.

Medium and large companies with facilities in several different EU Member States can further benefit from a simplification of the applicable limit values, potentially providing savings for research- and design cost, as common solutions can be adopted across facilities, as opposed to designing site-specific solutions to meet different OEL requirements.

5.8 Indirect benefits

5.8.1 Indirect benefits – workers & families

Collateral health benefits for the broader population

The introduction of more efficient RPE and increased use of existing RMMs in order to comply with lower limit values – e.g. more time spent using vacuum cleaners and/or application of various other dust suppression techniques in the construction and building sector, might have a positive impact on the health of people not directly exposed to asbestos. Goldberg and Luce (2009) note that there is some evidence that family members of workers heavily exposed to asbestos face an increased risk of developing mesothelioma. This risk is thought to result from exposure to asbestos fibres brought into the home on the shoes, clothing, skin, and hair of workers. Increased prevention of the spread of asbestos and cleanliness of premises could help decrease such risk.

The measures to prevent the generation and spread of dust in demolition works can also be positive for people living or working in the surroundings.

5.8.2 Indirect benefits – companies

The harmonisation of OELs can make it easier for companies working in more than one EU Member State as only one limit value has to be followed, as also elaborated in the paragraph above. Next to savings in research- and design cost, an administrative simplification can be expected for companies.

The benefits of healthier staff could have indirect effects on the reputation of the sectors and associated companies, as work with asbestos may be less perceived as a risky line of work associated with health issues. As a result of such an improvement in the public image, companies may have it easier to recruit and retain staff, reducing the cost of recruitment and increasing the productivity of workers.

5.8.3 Indirect benefits – public sector

It is possible (but by no means certain) that some of the Member States that currently have an asbestos OEL at the level of the OEL in the AWD (0.1 fibres/cm^3) would follow the example of those Member States that have a lower OEL and develop a new asbestos OEL. An indirect benefit for Member State authorities of the policy options is that there are cost involved in assessing the impact of an OEL value and introducing it – the likelihood of these costs arising would be reduced by the OEL options considered in this study.

Due to the fact these cost savings are highly uncertain, no quantitative estimate has been developed.

5.9 Aggregated benefits

The composition of the aggregated benefits is summarised in the table below. As for the benefits for workers & families, two benefit methods are applied.

Table 5.14 Aggregated benefits

Costs	Method of summation
Aggregated	Method 1: Ctotal= Ch+Ci+Cp+Ce+Cvsl+Cvsm Method 2: Ctotal= Ch+Ci+Cp+Ce+Cl+Cdaly

In the following, the aggregated benefits are presented for respectively method 1 and 2. The table and figure below present the benefits according to method 1.

Table 5.15 METHOD 1: Benefits from avoided ill health (relative to the baseline), € million

Endpoint	Lung cancer and mesothelioma	Laryngeal cancer and ovarian cancer	TOTAL
0.001 fibres/cm^3	386.1	38.6	**424.7**
0.002 fibres/cm^3	374.2	37.4	**411.6**
0.01 fibres/cm^3	298.3	29.8	**328.1**
0.1 fibres/cm^3 (baseline)	-	-	**-**

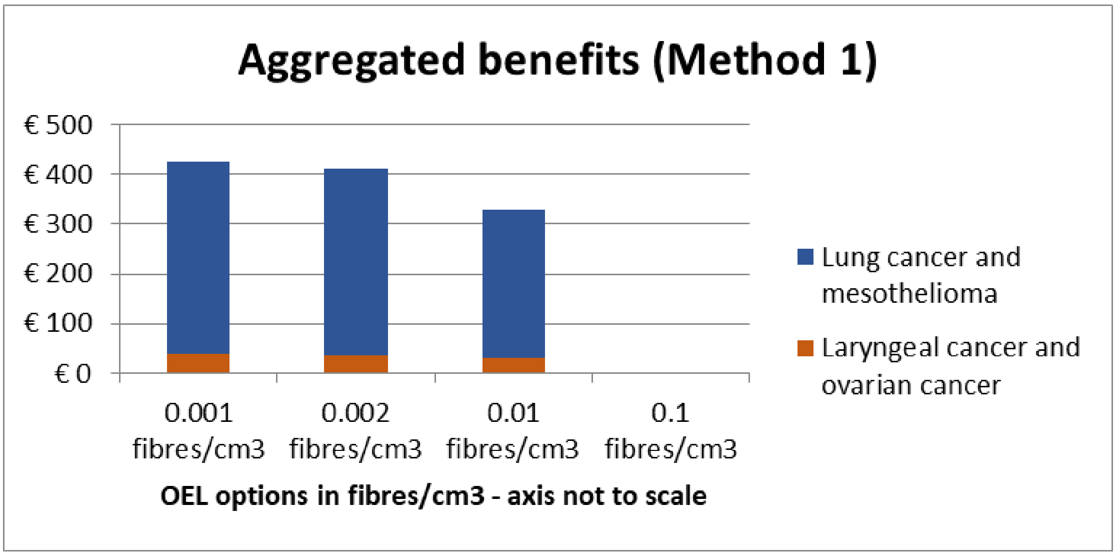

Figure 5.6 METHOD 1: Benefits from avoided ill health (relative to the baseline), € million. Source: study team's calculation.

To provide more sector details, the total aggregated benefits under method 1 are once more presented for each exposure group and OEL in the table below.

Table 5.16 METHOD 1: Benefits avoided ill health by sector and OEL, € million

Exposure Group		0.001 fibres/cm³	0.002 fibres/cm³	0.01 fibres/cm³	0.1 fibres/cm³ (baseline)
1	Building and construction - exposure situations subject to notification	72.50	71.21	60.85	-
2	Building and construction - exposure situations subject to Article 3(3) waiver and 'incidental' exposure	331.17	322.83	256.12	-
3	Building and construction - passive exposure in buildings	2.53	-	-	-
4	Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	2.66	2.62	2.24	-
5	Waste management	12.54	11.99	7.63	-
6	Mining and quarrying - naturally occurring asbestos	0.57	0.51	-	-
7	Tunnel excavation - naturally occurring asbestos	0.04	0.03	-	-
8	Road construction and maintenance	0.87	0.75	-	-
9	Sampling and analysis	1.81	1.74	1.25	-
Total		**424.7**	**411.6**	**328.1**	**-**

Source: study team's calculation.

In the following, the results are presented according to method 2. The table and figure below show the aggregated benefits per endpoint and OEL.

Table 5.17 METHOD 2: Benefits from avoided ill health (relative to the baseline), € million

Endpoint	Lung cancer and mesothelioma	Laryngeal cancer and ovarian cancer	TOTAL
0.001 fibres/cm^3	201.1	20.1	**221.2**
0.002 fibres/cm^3	194.9	19.5	**214.4**
0.01 fibres/cm^3	155.4	15.5	**170.9**
0.1 fibres/cm^3 (baseline)	-	-	**-**

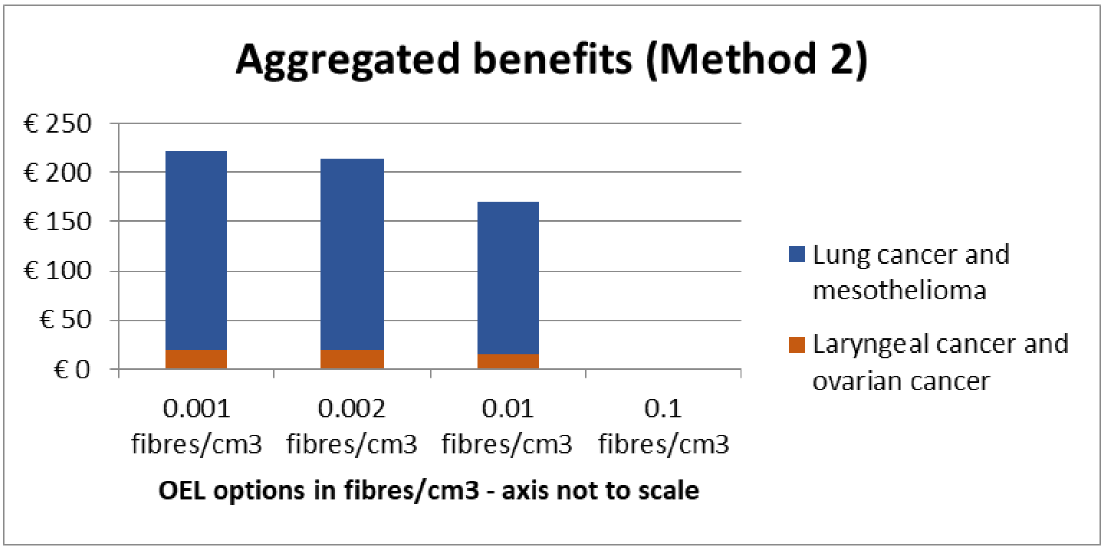

Figure 5.7 METHOD 2: Benefits from avoided ill health (relative to the baseline), € million. Source: study team's calculation.

To provide more sector details, the total aggregated benefits under method 2 are once more presented for each sector and OEL in the table below.

Table 5.18 METHOD 2: Benefits avoided ill health by sector and OEL, € million

Exposure Group		0.001 fibres/cm^3	0.002 fibres/cm^3	0.01 fibres/cm^3	0.1 fibres/cm^3 (baseline)
1	Building and construction - exposure situations subject to notification	37.76	37.09	31.70	-
2	Building and construction - exposure situations subject to Article 3(3) waiver and 'incidental' exposure	172.50	168.16	133.41	-
3	Building and construction - passive exposure in buildings	1.32	-	-	-
4	Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	1.39	1.36	1.16	-
5	Waste management	6.53	6.25	3.97	-
6	Mining and quarrying - naturally occurring asbestos	0.30	0.27	-	-
7	Tunnel excavation - naturally occurring asbestos	0.02	0.01	-	-
8	Road construction and maintenance	0.45	0.39	-	-
9	Sampling and analysis	0.94	0.91	0.65	-
Total		**221.2**	**214.4**	**170.9**	**-**

Source: study team's calculation

6. Costs assessment

6.1 Introduction

This section comprises the following subsections:

- Section 6.2: The cost framework
- Section 6.3: Direct costs – compliance costs for companies
- Section 6.4: Direct costs – administrative burdens and charges
- Section 6.5: Indirect costs for companies
- Section 6.6: Costs for public authorities
- Section 6.7: Aggregated costs

6.2 The cost framework

The overall cost framework is described in the methodological note.

The costs assessed in this section, together with an indication of which stakeholders are likely to be affected, are presented Table 6.1 below.

Table 6.1 Impact of costs on different stakeholders

Type of cost		Consumers	Workers	Enterprises	Public authorities
Direct	Compliance costs Monitoring costs Training costs Administrative burden			✓	✓
Indirect	Price of services	✓		✓	✓
Enforcement	Transposition cost Enforcement, monitoring and adjudication				✓
Employment	Lost wages		✓ (transfer cost)		

These costs are assessed below qualitatively and, whenever possible, quantitatively.

Cost of lowering the concentration by decontamination is not considered in the report. Decontamination would be an additional cost but could also reduce some of the subsequent costs.

6.3 OELs – compliance costs for companies

6.3.1 Introduction

The cost model for the companies' compliance is described below. The cost model takes several inputs and calculates the predicted costs incurred for the target OELs.

The exposure situations for asbestos differ significantly from the general exposure patterns for most other hazardous substances as the activities are not located at specific sites, but the workers are moving from site to site and undertake many different activities, each with its very specific exposure characteristics. The work is in this respect more like the work undertaken by maintenance workers for other substances. Even if the RPE in the general hierarchy of the RMMs is the last resort, in practice most workers exposed to asbestos use RPE in combination with other RMMs to keep the breathing concentration below the OEL. This is recognised in the AWD, Article 12: *"In the case of certain activities such as demolition, asbestos removal work, repairing and maintenance, in respect of which it is foreseeable that the limit value set out in Article 8 will be exceeded despite the use of technical preventive measures for limiting asbestos in air concentrations workers shall be issued with suitable respiratory and other personal protective equipment, which must be worn;'*

It is expected that the measures taken by each company in response to a new OEL would include a combination of more efficient RPE (for some workers) and more efficient technical/organisational RMMs. In order to reflect this, a specific cost model has been developed for asbestos that relies on asbestos specific packages of measures to control exposure.

Furthermore, the asbestos compliance cost estimation model differs from that for other substances under this study (lead and di-isocyanates) in that the information in the baseline is divided into relevant exposure groups which typically encompass more than one sector with the exception of the construction and demolition sector which is spread across several exposure groups.

The model includes the following types of inputs:

- OEL options, see Chapter 3;
- Existing OELs in Member States;
- Number of workers exposed by exposure group;
- Sectors in each of the exposure groups and numbers of companies in these sectors at exposure levels at or above 0.002 fibres/cm^3;
- Number of small, medium and large enterprises in each of the exposure groups and sector at exposure levels at or above 0.002 fibres/cm^3;
- Estimated breakdown of RPE used;
- Effectiveness of RMMs (in particular RPE);
- Cost of RMMs;
- Discount rates;
- Existing level of compliance with the target OEL (i.e. national OELs in France, Germany and the Netherlands);
- Estimated training needs;
- Costs of analysis for compliance monitoring at the different OEL options; and
- Need for compliance monitoring measurements.

The output is the costs of implementing the OEL split by:

- Exposure group;
- Company size: small, medium and large; and
- Capital expenditure (one-off) and operating expenditure (recurrent) costs.

6.3.1.1 Existing OELs in Member States

As shown in Section 4.1, three countries have national limit values lower than the current EU OEL. The Netherlands and France have binding OELs of 0.01 and 0.002 fibres/cm^3, respectively. Germany have a binding OEL at 0.1 fibres/cm^3 and an "acceptable" level at 0.01 fibres/cm^3. According to stakeholder consultation response from DGUV, in Germany, respiratory protection is required if the "acceptable" concentration of 0.01 fibres/cm^3 is exceeded and the use of dust managing-systems is also already required in order to reduce the exposure concentration. In practice, the mandatory measures will be sufficient to ensure the exposure concentration is below the "acceptable" level. According to DGUV, no extra costs of introducing an EU OEL at 0.01 fibres/cm^3 are expected for German companies.

For the OEL option of **0.01** fibres/cm^3 it is therefore reasonable to expect that companies in France, Germany and the Netherlands will have no incremental costs. The three Member States represent 37% of EU population.

For the OEL option of **0.002** fibres/cm^3 it can be expected that companies in the Netherlands will have no incremental costs. For companies in France and Germany the incremental costs of lowering the OEL from 0.01 to 0.002 fibres/cm^3 will be incurred.

For the OEL option of **0.001** fibres/cm^3 it will be assumed that companies in all Member States would incur additional costs. For companies in France and Germany, the incremental costs of lowering the OEL from 0.002 to 0.001 fibres/cm^3 thus needs to be estimated in addition to the costs of lowering the OEL to 0.002 fibres/cm^3.

The EU-wide baseline (exposure concentrations with and without RPE) has been checked to ensure that they are consistent with the expected impacts for France, Germany and the Netherlands outlined above.

6.3.1.2 Questionnaire responses and literature data

Questionnaire responses

Companies in France have provided most of the questionnaire responses. Only the responses from France are presented below as the remaining few responses were from Member States with a higher OEL and consequently cannot be pooled with responses from France.

As the OEL in France is already 0.01 fibres/cm^3, it is expected that the companies would not incur additional costs if a new EU OEL at this level was established. However, 47 of the companies indicated incremental costs at this OEL. The companies may have interpreted the questionnaire in a way that the costs should indicate costs at the current OEL of 0.01 fibres/cm^3. The answers indicate that the companies expect significant increases in costs if an OEL at 0.001 is established with average investment costs per employee (all employees of the companies) at about € 28,000/employee against € 1,300/employee at 0.01 fibres/cm^3. For the recurrent costs, the increase is less marked with an increase from about € 500/employee to € 3,600/employee. The estimates should be interpreted with caution as the questionnaire did ask for a total cost estimate without a disaggregation into each cost element and the companies in this case are likely to overestimate the costs. Please note that the questionnaire did not include questions related to the OEL option of 0.002 fibres/cm^3.

Table 6.2 Reponses to the questionnaire from companies in France and estimated median costs expected by the companies

Range, €	Median, €	D2.1.1 Total initial investment: 0.01 fibres/cm³	D3.1.1 Total recurrent costs: 0.01 fibres/cm³	D2.1.2 Total initial investment: 0.001 fibres/cm³	D3.2.2 Total recurrent costs: 0.001 fibres/cm³
€10,000	5,000	18	22	2	4
€10,000 - €100,000	55,000	24	24	14	17
€100,000 - €1 million	550,000	4	4	15	13
€1 million - €10 million	5,500,000	1	0	4	3
€10million - €100 million	55,000,000	0	0	3	0
Total answer with costs		47	50	38	37
Don't know		6	6	8	8
Empty		44	41	51	52
Total answers		97	97	97	97
Total costs; answers with costs, €		9,110,000	3,630,000	196,030,000	24,605,000
Total number of empl.; answers with costs *		6,918	6,918	6,918	6,918
Costs per empl., € *		1,317	525	28,336	3,557
Costs per company € **		193,830	72,600	5,158,684	665,000

* Total number of employees in companies that provided some information on costs. Approximately 43% of the workers are reported to be exposed to asbestos and the costs per exposed worker is consequently approximately twice.

The responses regarding actual RMMs and expected further RMMs are summarised in the relevant sections below.

Responses, regarding expected extra costs from a site visit in Spain were well in accordance with the estimates shown above. The asbestos removal company had some experience with working in both France (OEL of 0.01 fibres/cm^3) and Spain (OEL of 0.1 fibres/cm^3). According to the company, the prices for asbestos removal in France were in general 3 times higher than in Spain mainly due to higher prices of sampling and analysis, higher costs of waste disposal and higher salaries. Of these cost elements only the costs of analysis would be significantly affected of the introduction of a lower OEL. The applied risk management measures were in general the same, however more enclosures are used when working in France. The company estimates roughly that the total costs may increase by 25 - 50% by the introduction of an OEL at 0.01 fibres/cm^3.

Literature

A study conducted by Health and Safety Executive (HSE) in 2017 aimed to quantify and monetise the current costs and benefits of complying with the Control of Asbestos Regulations 2012 (CAR 2012) in Great Britain. CAR 2012 fully transposed the main elements of Directive 2009/148/EC on the protection of workers from the risks related to exposure to asbestos at work. We recognise that the UK is no longer part of the EU and is out of scope of this study, however, since the UK was subject to the same legislative background in 2017 as other EU Member States, the costs identified in this study are of relevance and are considered a useful tool for the estimation of the current costs of complying with the OEL of 0.1 fibres/cm^3 in the EU27.

HSE has assessed the costs for the following types of work:

- **Licensable work**, i.e. work that can only be undertaken by licensed contractors; this includes most large-scale asbestos removal and building refurbishment/demolition work;
- **Notifiable non-licensable work** (NNLW), which refers to work where concentrations of asbestos fibres in the air during the work activity are unlikely to exceed specified limits and the activity is sporadic and of low intensity; and
- **Non-notifiable work**, which refers to work where the concentrations of asbestos fibres in the air during the work activity undertaken are likely to be low and covers such activity as maintenance and small-scale asbestos work.

It has to be noted that a large proportion of licence holders also undertake NNLW work, so there may be a lot of overlap between the costs of licensable and NNLW work. Furthermore, CAR 2012 also places a duty to manage asbestos on owners of non-domestic buildings (schools, local authorities, hospitals, industrial buildings, etc.) and those in charge of common areas of domestic buildings. This involves identifying, risk assessing, and recording the location and condition of asbestos. The owners must pass the information on to any contractors or workers who may disturb asbestos while they are working on the building, so that they can put in place appropriate control measures. The costs arising from the duty to manage asbestos were estimated at €138 million.

The costs identified for licensable, notifiable non-licensable work (NNLW) and non-notifiable work are summarised in the table below. In case of licensable work and NNLW, the largest share of total costs is associated with the storage, distribution and labelling of raw asbestos and asbestos waste (24.4%) and with putting up barriers and fencing (18.5%) to make sure that areas where asbestos work is being carried out are clearly separated. Other measures used for the prevention or reduction of exposure to asbestos, including the use of RPE and other PPE, constitute 17.8% of the total costs. Costs associated with monitoring of airborne asbestos fibres, standards for analysis[57] and medical surveillance present quite a small share, i.e. 9.4%, 2% and 1.5% of total costs, respectively.

A more detailed overview of the costs is presented in Annex E.

Table 6.3 Summary of costs identified in the HSE (2017) study

*Cost category	Licensable and notifiable work, € million per year			Non-notifiable work, € million per year		
	Best estimate	Range	% of total	Best estimate	Range	% of total
Identification of the presence of asbestos and carrying out a risk assessment	18.3	14.4 - 21.3	7.8%	10.6	n.d.	5.5%

57 Employers performing their own analysis of material are required to check for asbestos in a way that meets the criteria set out in International Organization for Standardization's standard *ISO 17025* (this standard specifies the general requirements for the competence to carry out tests and/or calibrations, including sampling). They also have to make sure any person they engage to perform analysis is accredited to ISO standard by the appropriate body.

*Cost category	Licensable and notifiable work, € million per year			Non-notifiable work, € million per year		
	Best estimate	Range	% of total	Best estimate	Range	% of total
Preparation of a written plan	25.7	20.5 – 30.5	10.9%	-	-	-
Making sure that areas where asbestos work is being carried out are clearly separated and provision of facilities to eat and drink	5.7	0.9 – 10.5	2.4%	-	-	-
Putting up barriers and fencing	43.6	n.d.	18.5%	-	-	-
Obtaining a licence	0.53	n.d.	0.2%	-	-	-
Notification of work with asbestos	2.7	1.6- 3.8	1.1%	-	-	-
Provision of information, instruction and training	3.3	3.1 – 3.5	1.4%	112	n.d.	57.7%
Prevention or reduction of exposure to asbestos	42	6 - 77.7	17.8%	72	n.d.	37.1%
Prevention of the spread or reduction of the spread of asbestos, cleanliness of premises and plan	0.9	n.d.	0.4%	-	-	-
Monitoring of airborne asbestos fibres	22.2	14.6 – 30.2	9.4%	-	-	-
Standards for analysis	4.7	4.4. - 5	2.0%	-	-	-
Health records and medical surveillance	3.6	1.5 – 5.8	1.5%	-	-	-
Provision of suitable and sufficient washing, changing and storage facilities	0.4	0.1 – 0.6	0.2%	-	-	-
Storage, distribution and labelling of raw asbestos and asbestos waste	57.6	48.2 – 67.1	24.4%	-	-	-
TOTAL	236			194		

**The % is calculated based on the sum of best estimates.*

Source: HSE (2017)

6.3.1.3 Numbers of workers and enterprises

The key input parameter for both the cost and benefit estimation models developed for this study are the distribution of the actual exposure levels across workers. In the cost model, this is complemented with the consideration of the numbers of enterprises with workers that are exposed to asbestos.

For the description of exposure concentrations and exposed workforce in the baseline, the activities have been divided by activity groups because information on exposure concentrations and workforce are mainly available by activity groups and not by sectors. As an example, exposure group 1 'Building and construction - exposure situations subject to notification' mainly consists of companies within the sector 'F43 Specialised construction activities', but some maintenance activities will be undertaken by some companies' own staff e.g. within the sector 'D35.11 Production of electricity.

The input for the calculations includes information on:

- Number of companies licensed to undertake notified works and estimates from Member States on number of other companies in the building and construction sector working occasionally with asbestos
- Information on the distribution of companies undertaking notified work by sector
- Number of companies by size in relevant sectors from the Eurostat Structural Business Statistics (shown in Appendix D)
- Estimate of the share of companies within each sector actually working with asbestos (comparing data from Member States on number of companies with data from the Structural Business Statistics.

The data used for the calculations are presented in Section 4.12.

Share of workforce exposed

Data on number of companies and employees by sector based on the questionnaire responses from companies in France is shown in the table below. From other countries responses were obtained from only 6 companies in four Member States with a total of 72 workers only. For this reason, it has been decided to present the data for France only.

In terms of number of companies, the specialised construction sector (F43) accounts for the major part (68% of total) followed by waste collection (20%) and technical testing and analysis (5%). Overall, 43% of the employees are reported to be exposed to asbestos with the highest rates within the sectors 'Testing and Analysis' (83% of the employees exposed) and 'Demolition' (67%).

Table 6.4 Distribution by sector of companies from France responding to the questionnaire

NACE code	Sector	Number of companies	Number of employees	No of employees exposed	% Exposed	Average number of exposed per company
F41.20	Construction of residential and non-residential buildings	2	321	28	9%	14
F43.11	Demolition	23	1,835	1,232	67%	54
F43.12	Site preparation	17	1,946	244	13%	14
F43.91	Roofing activities	8	186	62	33%	8
F43.12 - F43.99	Other specialised construction activities (excl. above)	18	1,318	468	36%	26
C33.14	Repair of electrical equipment	1	80	10	13%	10
F42.11	Construction of roads and motorways	2	310	29	9%	15

NACE code	Sector	Number of companies	Number of employees	No of employees exposed	% Exposed	Average number of exposed per company
E36	Water collection, treatment and supply	1	680	115	17%	115
E38	Waste collection, treatment and disposal activities; materials recovery	19	778	493	63%	26
M71.20	Technical testing and analysis	5	1,312	1,094	83%	219
	Employers organisation	1	3	2	67%	2
	Total	97	8,769	3,777	43%	39

Source: consultation exercise for this study

6.3.2 Use of RPE

Current use of RPE

No overview of current use of RPE in the Member States has been obtained.

Questionnaire response. As mentioned elsewhere questionnaire responses have mainly been obtained from France with a current OEL of 0.01 fibres/cm^3. The answers from 69 companies across sectors which have answered regarding RPE is shown below. The number of answers is too low to provide for any statistically significant distribution but shows that the companies apply different RPE for different tasks. Of the 42 answers indicating the use of HEPA mask, 10 (14% of answers) reported that HEPA mask was the only RPE type applied. It means that 86% of the companies use powered hood/masks or RPE with higher protection factor for at least some of the activities. Only 1 company report that no RPE is used (1.4%). According to INRS (2020), no RPE was used in 4% of the exposure situations in notified work in France. Even though the representativeness is uncertain, the distribution will be used as a rough indication of what could be expected for notified exposure situations if the OEL is lowered to 0.01 fibres/cm^3.

The answers regarding expected RPE and other RMM to be applied if the OEL is lowered to 0.001 fibres/cm^3 cannot readily be interpreted. The answers do not have a tendency showing that RMMs with higher efficiency would be used if the OEL is lowered to 0.001 fibres/cm^3 as compared to the lowering it to 0.01 fibres/cm^3 and it is from the answer not possible to specifically point at which RPE and other RMMs would be used in order to comply with an OEL at 0.001 fibres/cm^3.

Table 6.5 Questionnaire responses from companies in France with information on current use of RPE

	Number	Percentage of those reporting on RPE *
Half mask + P2 or P3 filter	42	61%
Powered hoods/masks and breathing apparatus	46	67%
Constant flow breathing apparatus	41	59%

	Number	Percentage of those reporting on RPE *
Self-contained breathing apparatus	12	17%
No RPE	1	1.4%
Total with information on RPE	69	

** Please note that the companies report on the use of more than one type, so the total should not add up to 100%*

Source: consultation exercise for this study

RPE use in the model

For the estimations of distribution of the current use of RPE it is assumed that for all workers, the exposure concentration when the RPE is taken into account should be below the OEL (so at a maximum 95% of the workers are exposed at concentrations below the OEL). The distribution of RPE is calculated on the basis of the exposure concentration distributions shown in Section 4.3.

It is in the model assumed that RPE with a higher APF would be applied in order to bring the breathing concentration down if the OEL is lowered. It is assumed that the use of more efficient RPE is combined with use of other RMMs, so for some workers the use of more efficient RPE would not on its own bring the concentration sufficiently down. The model assumptions as concern the potential concentrations obtained by use of various RPE are shown in the table below. The costs are calculated on the basis of the exposure concentrations for each exposure group and the differences between the baseline use of RPE and the use of RPE for each OEL option scenario.

Table 6.6 Exposure concentration bands and assumed RPE used in Member States with an OEL of 0.1 fibres/cm^3. Note that the exposure concentrations are actual concentrations in the workplace taking into account the various RMMs used (except for RPE).

Baseline use of RPE a			Lowering to 0.01 fibres/cm^3		Lowering to 0.002 fibres/cm^3	
Exposure concentration, fibre cm^3	APF	Breathing concentration, fibre cm^3	APF	Breathing concentration, fibre cm^3	APF	Breathing concentration, fibre cm^3
0 - 0.001	0	0 - 0.001	0	0 - 0.001	0	0 - 0.001
0.001 - 0.03	0	0.001 - 0.03	0 - 10	0.001 - 0.003	0 - 20	0.001 - 0.0015
0.03 - 0.8	10 - 20	0.003 - 0.04	30 - 60	0.001 - 0.013	250	0.0001 - 0.003
0.8 - 6	30 - 60	0.03 - 0.1	250 – 2,000	0.003 - 0.024	250 – 2,000	0.0004 - 0.003
6 - 20	250	0.024 - 0.08	2,000	0.003 - 0.01	2,000	0.003 - 0.01
20 - 100	2,000	0.01 - 0.05	2,000	0.01 - 0.05	2,000	0.01 - 0.05

Source: study teams' calculation

The model percentage breakdown of RPE currently used by enterprises in Member States with an OEL of 0.1 fibres/cm^3 (excl. France, Germany and the Netherlands) is shown below.

Table 6.7 Percentage breakdown of baseline RPE by enterprises (excl. France, Germany and the Netherlands)

Type of RPE/Exposure Group	No mask	Half mask + P2 or P3 filter (APF 10-20)	Powered hoods/masks and breathing apparatus (APF 30 - 60)	Constant flow breathing apparatus (APF 250)	Self-contained breathing apparatus (APF 2000 or more)
1) Building and construction - exposure situations subject to notification	8	84	8	0.1	0.02
2) Building and construction - exposure situations subject to Article 3(3) waiver	58	42	0.2	0	0
3) Building and construction - passive exposure in buildings	100	0	0	0	0
4) Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	8	84	8	0.1	0.02
5) Waste management and land remediation activities	34	66	0,4	0	0
6) Mining and quarrying - naturally occurring asbestos	60	40	0.1	0	0
7) Tunnel excavation	82	19	0	0	0
8) Road construction and maintenance	90	10	0	0	0
9) Sampling and analysis	49	51	0	0	0

Source: study team's calculation

The model percentage breakdown of RPE currently used by enterprises in France and Germany are shown below. The percentages are calculated on the basis of the distribution in the Member States with an OEL of 0.1 fibres/cm^3 shown above and the assumptions regarding the percentages of the workers in the different exposure bands that step up to an RPE of higher efficiency. The method has been applied in order to use a consistent model even for some of the exposure groups it results in a more diverse use of RPE than has been reported for the stakeholder consultation. For instance, for the group 'Sampling and analysis', it is reported for the stakeholder consultation that half mask with P2 or P3 filters is in general used, whereas the model assumes that some use less or no RPE and other use more efficient RPE.

Table 6.8 Percentage breakdown of RPE currently used by enterprises (France and Germany)

Exposure group	No mask	Half mask + P2 or P3 filter (APF 10-20)	Powered hoods/masks and breathing apparatus (APF 30 - 60)	Constant flow breathing apparatus (APF 250)	Self-contained breathing apparatus (APF 2000 or more)
1) Building and construction - exposure situations subject to notification	4	67	27	2	0.04
2) Building and construction - exposure situations subject to Article 3(3) waiver	28	62	9	0.04	0.00
3) Building and construction - passive exposure in buildings	98	2	0	0	0
4) Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	4	67	27	2	0.04
5) Waste management and land remediation activities	17	66	17	0.01	0.00
6) Mining and quarrying - naturally occurring asbestos	30	60	10	0.01	0.00
7) Tunnel excavation	42	53	5	0.00	0.00
8) Road construction and maintenance	48	50	2	0.00	0.00
9) Sampling and analysis	24	62	13	0.06	0.00

Source: study team's calculation

Costs of RPE resulting from a lower OEL

The costs of the various types of RPE are applied from the general cost model described in the methodological note.

The estimated costs of using more efficient RPE as a result of the different policy options are shown in the table below. The costs presented below are the Present Value of the costs incurred by all the relevant companies over 40 years. The estimates are most uncertain at the target OEL of 0.001 fibres/cm^3 which would be the one that is most difficult to achieve and where it is unclear how many additional workers and companies would be additionally included into the scope of the OEL in Exposure Group 3 – the costs presented below are thus likely to be underestimates.

Table 6.9 The estimated cost of using more efficient RPE (incremental cost, ***PV over 40 years*** *for the different policy options)*

	Total incremental costs PV over 40 years			Average incremental costs per worker per year		
Exposure group	**0.001**	**0.002**	**0.01**	**0.001**	**0.002**	**0.01**
1) Building and construction - exposure situations subject to notification	€ 21,220,424,271	€ 19,100,603,325	€ 2,702,621,769	€ 2,577	€ 2,320	€ 328
2) Building and construction - exposure situations subject to Article 3(3) waiver & incidental exposure	€ 24,534,394,818	€ 21,809,207,299	€ 7,697,815,305	€ 265	€ 235	€ 83
3) Building and construction - passive exposure in buildings	€ 681,802,378	€ 613,622,169	€ 68,180,209	€ 55	€ 50	€ 6
4) Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	€ 811,707,535	€ 732,214,250	€ 110,912,845	€ 2,629	€ 2,371	€ 359
5) Waste management and land remediation activities	€ 4,425,530,821	€ 3,944,317,164	€ 561,419,430	€ 1,720	€ 1,533	€ 218
6) Mining and quarrying - naturally occurring asbestos	€ 318,477,479	€ 284,335,660	€ 47,382,273	€ 1,238	€ 1,105	€ 184
7) Tunnel excavation	€ 52,140,305	€ 46,681,901	€ 9,564,572	€ 844	€ 756	€ 155
8) Road construction and maintenance	€ 417,832,810	€ 374,584,265	€ 86,918,687	€ 677	€ 607	€ 141
9) Sampling and analysis	€ 521,027,498	€ 464,900,761	€ 71,780,343	€ 1,446	€ 1,291	€ 199
TOTAL	**€ 52,983,337,917**	**€ 47,370,466,795**	**€ 11,356,595,433**	**€ 451**	**€ 404**	**€ 97**

Source: study team's calculation

Cost efficiency of the use of RPE

The cost efficiency of using more efficient RPE depends on the baseline exposure concentration. Cost efficiencies are illustrated in the table below. For two different baseline exposure concentrations, the cost efficiency of going from the baseline use of RPE with an APF of 10 to a scenario with RPE with an APF of 40 is shown. The incremental costs are estimated as the difference in cost between the two types of RPE, using the general costs of RPE from the cost model. The benefits are calculated on the basis of the differences in breathing concentrations between the baseline (RPE of an APF of 10) and the scenario (RPE of an APF of 40) using the applied ERR and costs per case use in the benefits assessment in chapter 4. As shown for the baseline, where the exposure concentration is 1 fibre /cm^3 and a RPE with an APF of 10 which is replaced with a RPE with an APF of 40, the incremental costs to benefits ratio is calculated at 50 - 87. With a baseline exposure concentration of 0.1 fibres/cm^3 and similar change in the use of RPE, the incremental costs to benefits ratio is 250-655.

This illustrates, that unless some RMMs with significantly lower cost to benefits ratios can be used, the cost of lowering the OEL would be significantly higher than the benefits and with higher costs to benefits ratios at lower OELs.

Table 6.10 Illustrative incremental costs to benefits ratios of replacing a RPE with a APF of 10 with a RPE with an APF of 40.

	Baseline exposure concentration, fibres/cm^3	
	1.0	0.1
Baseline use of RPE, APF	10	10
Baseline breathing concentration, fibres/cm^3	0.1	0.01
Scenario RPE, APF	40	40
Scenario breathing concentration, fibres/cm^3	0.025	0.0025
Incremental costs / benefit ratio	50-87	250-655

6.3.3 Use of RMMs other than RPE

It is expected that the measures taken by each company in response to a new OEL would include a combination of more efficient RPE (for some workers) and more efficient technical/organisational RMMs. More specifically, it is expected that increased costs would be incurred to more extensive use of dust suppression and vacuum cleaning techniques – it is assumed that no new equipment would be needed but staff would have to spend more time using existing vacuum cleaning and dust suppression equipment. These costs are therefore approximated by focusing on the share of staff costs in the total cost of asbestos control. The HSE (2017) data presented in Annex E do not disaggregate between the different RMMs but provide an indication of the relative shares of cash and staff costs in the total cost of control measures. Using these data, it is estimated that staff costs account for around 10% of the total costs. It is therefore expected that the costs of additional RPE account for only around 90% of the total additional costs and the costs of RPE estimated in the preceding section are correspondingly adjusted.

The estimated costs of additional staff time associated with increased time spent operating vacuum cleaning and dust suppression equipment are shown in the table below. The costs presented below are the Present Value of the costs incurred by all the relevant companies over 40 years.

*Table 6.11 The estimated staff costs due to increased use of vacuum cleaning and dust suppression techniques (incremental cost, **PV over 40 years**)*

	Total incremental costs PV over 40 years			Average incremental costs per worker per year		
Exposure group	**0.001**	**0.002**	**0.01**	**0.001**	**0.002**	**0.01**
1) Building and construction - exposure situations subject to notification	€ 2,122,042,427	€ 1,910,060,333	€ 270,262,177	€ 258	€ 232	€ 33
2) Building and construction - exposure situations subject to	€ 2,453,439,482	€ 2,180,920,730	€ 769,781,531	€ 27	€ 24	€ 8

	Total incremental costs PV over 40 years			Average incremental costs per worker per year		
Exposure group	**0.001**	**0.002**	**0.01**	**0.001**	**0.002**	**0.01**
Article 3(3) waiver & incidental exposure						
3) Building and construction - passive exposure in buildings	€ 68,180,238	€ 61,362,217	€ 6,818,021	€ 6	€ 5	€ 1
4) Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	€ 81,170,754	€ 73,221,425	€ 11,091,285	€ 263	€ 237	€ 36
5) Waste management and land remediation activities	€ 442,553,082	€ 394,431,716	€ 56,141,943	€ 172	€ 153	€ 22
6) Mining and quarrying - naturally occurring asbestos	€ 31,847,748	€ 28,433,566	€ 4,738,227	€ 124	€ 111	€ 18
7) Tunnel excavation	€ 5,214,031	€ 4,668,190	€ 956,457	€ 84	€ 76	€ 16
8) Road construction and maintenance	€ 41,783,281	€ 37,458,427	€ 8,691,869	€ 68	€ 61	€ 14
9) Sampling and analysis	€ 52,102,750	€ 46,490,076	€ 7,178,034	€ 145	€ 129	€ 20
TOTAL	**€ 5,298,333,792**	**€ 4,737,046,680**	**€ 1,135,659,543**	**€ 45**	**€ 40**	**€ 10**

Source: study team's calculation

6.3.4 Total additional costs of all RMMs (RPE and other RMMs)

The estimated additional costs of using more efficient RPE and increased use of other RMMs are shown in the table below. The costs presented below are the Present Value of the costs incurred by all the relevant companies over 40 years. The estimates are most uncertain at the target OEL of 0.001 fibres/cm^3 which would be the one that is most difficult to achieve and where it is unclear how many additional workers and companies would be included into the scope of the OEL in Exposure Group 3 – the costs presented below are thus likely to be underestimates. On the other hand, some of the costs modelled in this study for Exposure Group 2 are likely to be lower if some of the work currently undertaken by workers in Exposure Group 2 is taken up by companies in Exposure Group 1 which specialise in asbestos removal, and it can be expected that they can carry out the work more effectively due to greater economies of scale. A reasonable assumption would be that 50% of the costs for Exposure Group 2 would be transferred to Exposure Group 1.

*Table 6.12 The estimated additional cost of RPE and other RMMs (incremental cost, **PV over 40 years** for the different policy options)*

	Total incremental costs PV over 40 years			Average incremental costs per worker per year		
Exposure group	**0.001**	**0.002**	**0.01**	**0.001**	**0.002**	**0.01**
1) Building and construction - exposure situations subject to notification	€ 23,342,466,698	€ 21,010,663,658	€ 2,972,883,946	€ 2,835	€ 2,552	€ 361

	Total incremental costs PV over 40 years			Average incremental costs per worker per year		
Exposure group	**0.001**	**0.002**	**0.01**	**0.001**	**0.002**	**0.01**
2) Building and construction - exposure situations subject to Article 3(3) waiver & incidental exposure	€ 26,987,834,300	€ 23,990,128,029	€ 8,467,596,836	€ 292	€ 259	€ 91
3) Building and construction - passive exposure in buildings	€ 749,982,616	€ 674,984,386	€ 74,998,230	€ 61	€ 55	€ 7
4) Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	€ 892,878,289	€ 805,435,675	€ 122,004,130	€ 2,892	€ 2,608	€ 395
5) Waste management and land remediation activities	€ 4,868,083,903	€ 4,338,748,880	€ 617,561,373	€ 1,892	€ 1,686	€ 240
6) Mining and quarrying - naturally occurring asbestos	€ 350,325,227	€ 312,769,226	€ 52,120,500	€ 1,362	€ 1,216	€ 202
7) Tunnel excavation	€ 57,354,336	€ 51,350,091	€ 10,521,029	€ 928	€ 832	€ 171
8) Road construction and maintenance	€ 459,616,091	€ 412,042,692	€ 95,610,556	€ 745	€ 668	€ 155
9) Sampling and analysis	€ 573,130,248	€ 511,390,837	€ 78,958,377	€ 1,591	€ 1,420	€ 219
TOTAL	**€ 58,281,671,709**	**€ 52,107,513,475**	**€ 12,492,254,976**	**€ 496**	**€ 444**	**€ 107**

Source: study team's calculation

6.3.5 Costs of notification and health surveillance of activities currently subject to Article 3 waiver

Lowering the OEL is likely to have influence on activities subject to the Article 3(3) waiver from the requirements regarding notification and health surveillance. Article 3(3) also waives the requirement that the employer must keep a register of workers carrying out the relevant activities. The cost of keeping this register is considered low compared to the two other requirements and not further assessed.

According to expert input to the stakeholder consultation, lowering of the OEL in the Netherlands and France did not result in a significant increase in the number of notified contracts or workers under health surveillance. However, lowering the OEL in France did not involve changes to the risk categorisation system (and thus no changes to the relevant risk categorisations) and thereby did not result in changes in the requirements concerning notification.

In Article 3(3) of the AWD, the application of the waiver is linked to the OEL and it is therefore assumed that lowering the OEL would imply that more workers should be under health surveillance and more works be notified. However, this is not necessarily the intention of lowering the OEL and some consideration could be given to the possibility of revising the

AWD to specify a higher concentration limit for the Article 3(3) waiver by, for example, keeping the concentration limit of 0.1 fibres/cm^3 for the waiver.

Stakeholder consultation input from the HSA in Ireland notes that the limit value being reduced to 0.01 fibres/cm^3 would bring all the lower-risk materials into a higher-risk category, even though their exposure-risk has not changed. It will, according to the HSA, make it very hard to remove a roof and be exempt from having to use a specialist contractor or notify the HSA 14 days in advance.

For the purposes of this assessment, it is assumed that Article 3(3) is not changed and the requirement for the risk assessment to conclude that the exposure limit for asbestos will not be exceeded in the air of the working area is retained.

No overall data on number of non-notifiable asbestos-related contracts are available.

The impact assessment of the current asbestos regulation in Great Britain estimates the numbers of contracts for three types of activities involving asbestos (HSE, 2017):

- Licenced contracts: 37,500 per year;
- Notified non-licenced works: 28,400 per year; and
- Non-notifiable projects: 1.3 million per year.

The non-notifiable contracts last for shorter time and involve fewer workers; the assessment from the HSE assumes that each contract involves one worker only. The non-notifiable projects are works where a risk assessment is undertaken and various measures are taken in order to comply with the UK asbestos regulation. In addition, it must be expected that there would be a large number of occasions where workers are in contact with asbestos-containing materials for a shorter time and no written risk assessment is prepared. The significance of the costs of compliance for non-notifiable work is illustrated in the impact assessment by the HSE (2017) which estimates that the total compliance costs for non-notified work (€194 million per year in Great Britain) is nearly the same as for notified work (€236 million per year).

If the estimated number of non-notifiable projects in the Great Britain is extrapolated on a per capita basis to EU27, the total number would be approximately 8.7 million. Although as noted above the criterion for notifying work with asbestos did not change in France when the OEL of 0.01 fibres/cm^3 was introduced, it is possible (but not confirmed) that work with asbestos at levels below the current EU OEL already have to be notified in Germany and the Netherlands, although the number of additional notifications appears to be limited in the Netherlands. It is therefore assumed that the number of non-notified contracts in the EU27 is currently around 5 million per year and these would be additionally notified under an OEL of 0.001 fibres/cm^3 (at a cost of €30, i.e. approximately 30 mins of work). As noted above, to this should be added a large number of occasions where workers are in contact with asbestos, but no risk assessment is undertaken.

It is expected that additional notifications would mainly relate to Exposure Groups 2 and 9 (Exposure Group 2: Building and construction - exposure situations subject to Article 3(3) waiver, 'incidental' exposure, Exposure Group 9: Sampling and analysis). It is expected that all workers involved in sampling and analysis are already under health surveillance due to the fact that they routinely come into contact with hazardous substances. Between 3.5 and 5.5 million workers currently work in Exposure Group 2; of those that are currently subject to the Article 3(3) waiver, it is expected that 50% would stop accepting contracts involving exposure to asbestos and these contracts would be taken up by companies in Exposure Group 1 whose workers are already under medical surveillance. Incidental exposure in Exposure Group 2 is unlikely to be covered by medical surveillance under any OEL scenario. For the purposes of modelling in this study, it is therefore estimated that approximately 1.5 million workers would be additionally brought into the scope of medical surveillance. The cost of medical surveillance is estimated to be around €600 per year[58] which amounts to a Present Value cost of € 12,350 per worker over 40 years.

For a rough estimation of the possible costs of further notification and health surveillance the following is assumed:

- 0.01 fibres/cm^3: Additional 1.7 million contracts per year in EU27 (1/3 of the total of 5 million, prior to adjusting for future trends) would be notified and approximately additional 0.5 million workers per year should be subject to health surveillance.
- 0.002 fibres/cm^3: Additional 3.3 million contracts per year in EU27 (2/3 of the total of 5 million, prior to adjusting for future trends) would be notified and approximately additional 1 million workers per year should be subject to health surveillance.
- 0.001 fibres/cm^3: Additional 5 million contracts per year in EU27 (prior to adjusting for future trends) would be notified and approximately additional 0.5 - 5 million workers per year would be subject to health surveillance.

The estimated costs of additional notification and medical surveillance are presented in the table below. The costs presented below are the Present Value of the costs incurred by all the relevant companies over 40 years. The estimates are most uncertain at the target OEL of 0.001 fibres/cm^3 which would be the one that is most difficult to achieve and where it is unclear how many additional contracts and workers would be additionally included into the scope of the OEL.

*Table 6.13 The estimated cost of additional notification and medical surveillance (incremental cost, **PV over 40 years** for the different policy options)*

	Total incremental costs PV over 40 years		
Exposure group	**0.001**	**0.002**	**0.01**
Notification	€6,530,000,000	€4,350,000,000	€2,180,000,000
Medical surveillance	€21,860,000,000	€14,570,000,000	€7,290,000,000
TOTAL	**€ 28,390,000,000**	**€ 18,920,000,000**	**€ 9,470,000,000**

Source: study team's calculation

6.3.6 Training costs

It is expected that if the OELs were lowered, workers would start using more effective RPE and apply other RMMs more efficiently and would therefore have to be trained in the correct use of the RMMs. Limited data are available to support the estimation of these costs. A stakeholder consultation response from Spain estimated the additional training time at 5 days per worker whereas a response from an association in Denmark indicated that no additional training was expected as the new requirements would be introduced in the regular updates of training. The estimate from Spain is likely to represent the high end of training needs with many companies requiring shorter training and retraining sessions.

As shown in the table below, information from literature review indicates that a typical asbestos training course lasts between one and five days and costs between €150 and €1,000.

[58] A wide range of estimates of medical surveillance costs has been identified (costs per worker ranging between € 400 and € 1,500 have been identified, see data for the UK retrieved from a study conducted for the HSE presented in Annex E). It is recognised that the costs may be lower in some other countries and that medical surveillance in small companies that only deal with asbestos occasionally is likely to be less extensive than in companies specialised in asbestos removal.

Table 6.14 Cost and duration of some asbestos training courses (Italy, Spain, and the UK)

Course run by	Country	Course Name	Length	Cost
Ente di formazione – Centro di addestramento	IT	Corso Generale Amianto	32 hours (4 days)	Not indicated
		Corso Aggiornamento Amianto	8 hours (1 day)	Not indicated
		Corso Preposti per l'amianto	16 hours (2 days)	Not indicated
		Corso aggiornamento preposti lavorazioni amianto	8 hours (1 day)	Not indicated
Time Vision - Agenzia Formativa e di Intermediazione Lavoro		Dirigente Amianto – Addetto alla Gestione delle Attività di Rimozione, Smaltimento e Bonifica dei Materiali Contenenti Amianto (Dirigente/Coordinatore Amianto)	50 hours (~6 days)	€301-€500
ISEA		Bonifica Amianto – Operatori	30 hours (~4 days)	€301-€500
ECOL STUDIO		Dirigente per le Operazioni di Rimozione, Smaltimento e Bonifica Amianto	50 hours (~6 days)	€990
		Addetto Alle Operazioni di Rimozione, Smaltimento e Bonifica Amianto	30 hours (~4 days)	€500
INESEM -Formación bonificada para empresas	ES	Técnico en Prevención de Riesgos Laborales en Gestión y Retirada de Amianto (Online)	Not indicated	€300
PREVENFORMAT		Prevención Riesgos Laborales especialidad trabajos de amianto	6 hours (~1 day)	€150
Icam - Ingeniería y control ambiental		Supervisor Técnico en Proyectos de Gestión y Retirada de Amianto - PRESENCIAL CANTABRIA	40 hours (5 days)	€180
Asbestos Removal Contractors Association (ARCA)	UK	New Operative Course	3 days	£425 - £475 (€549 – €614)
		Industry Based Operative Refresher	1 days	£155 - £175 (€200 – €226)
		New Supervisor	3 days	£425 - £475 (€549 – €614)
		Industry Based Supervisor Refresher	1 day	£195 - £230 (€252 – €297)
		Asbestos Awareness Course	1 day	Not indicated
		Health & Safety Management for Senior Managers & Directors	1 day	£195 - £230 (€252 – €297)
		Risk Assessment & Plans of Work	1 day	£155 - £175 (€200 – €226)

Course run by	Country	Course Name	Length	Cost
		IOSH Managing Safely in Construction	4 days	£685 (€885)
		RSPH Certificate in Asbestos Project Management	2 days	£355 - £405 (€459 – €524)
		RSPH Certificate in Asbestos Surveying	3 days	£520 - £570 (€672 – €737)
		RSPH Level 3 Certificate for Asbestos Duty Holder	4 days	£720 - £770 (€931 – €995)
Sources: ARCA (2016): Asbestos removal, supervision, surveying & management training, available at: http://www.arca.org.uk/asbestos-removal-contractors-association/asbestos-training-courses.asp Ente di formazione – Centro di addestramento (2016): Corso di formazione per addetti alla bonifica amianto, available at: http://www.enteformazione.it/bonifica-amianto/ Emagister (2016a): Corsi bonifica amianto, available at: http://www.emagister.it/bonifica_amianto-eh.htm Emagister (2016b): Cursos amianto, available at: http://www.emagister.com/amianto-tps-4895.htm				

From the table above, the cost of a day of training (not counting the cost to the employer due to lost working time) is estimated to be around €170 (the midpoint for the cost of a training course is €600 [€150- €1,000] and the midpoint in terms of the course duration is 3.5 days [1-5 days]). This is the time spent on training workers some of whom may not have been trained before. Additional costs of the policy options would likely relate to a more limited update rather than full training session.

It is therefore estimated that training a worker to correctly use new RPE and other RMMs would take:

- 0.01 fibres/cm^3: 0.5 day.
- 0.002 fibres/cm^3: 1 days.
- 0.001 fibres/cm^3: 2 days.

This is expected to be an additional one-off cost for retraining an existing worker or an additional one-off training need for new starters joining these companies in the future.

The resulting costs of additional training required due to the introduction of a stricter OEL are estimated in the table below.

Table 6.15 Cost of training (incremental cost, PV over 40 years for the different policy options)

	Total incremental costs PV over 40 years		
Exposure group	**0.001**	**0.002**	**0.01**
1) Building and construction - exposure situations subject to notification	€ 244,800,000	€ 122,400,000	€ 61,200,000
2) Building and construction - exposure situations subject to Article 3(3) waiver & incidental exposure	€ 1,377,000,000	€ 688,500,000	€ 344,250,000
3) Building and construction - passive exposure in buildings	€ 367,200,000	€ 183,600,000	€ 91,800,000

	Total incremental costs PV over 40 years	€ 4,590,000	€ 2,295,000
Exposure group	**0.001**	**0.002**	**0.01**
6) Mining and quarrying - naturally occurring asbestos	€ 7,650,000	€ 3,825,000	€ 1,912,000
7) Tunnel excavation	€ 1,836,000	€ 920,000	€ 459,000
8) Road construction and maintenance	€ 18,360,000	€ 9,180,000	€ 4,590,000
9) Sampling and analysis	€ 10,710,000	€ 5,355,000	€ 2,680,000
TOTAL	**€ 2,037,000,000**	**€ 1,060,000,000**	**€ 528,310,000**

Source: study team's calculation

6.3.7 Discontinuation costs

Limited discontinuations are expected under the policy options considered in this study. However, it should be noted that the uncertainty regarding this conclusion increases with decreasing OEL values.

The introduction of lower OELs may result in a shift where more activities would be undertaken by specialised companies (e.g. a shift of business from enterprises in Exposure Group 2 to enterprises in Exposure Group 1). This is not expected to lead to discontinuation of other companies as working with ACMs is only a minor and not key activity for these companies. An assessment of the shift in the market for asbestos removal services is included in chapter 7 on market effects.

6.3.8 Monitoring costs

Monitoring costs consist of costs of planning, sampling, analysis and reporting. For those companies already monitoring compliance with the existing OEL, incremental costs are considered mainly to be due to higher price of analysis, whereas the planning, sampling and reporting is considered to be the same. As discussed below, lowering the LOQ of the analysis as compared to the methods used today may require additional filter area or sampling time, but it is assumed that it will be less expensive to analyse a larger filter area than sampling for more time, and the additional costs are therefore included in the costs of analysis.

As described in Section 6.3.1.2, air sampling is done for both monitoring compliance with the OEL and site clearance certification i.e. quality control the level in the indoor environment after the work is finalised. Lowering the OEL may also lower the target concentration for the asbestos removal work, but the current analytical methods may still be used for quality control because the levels of both asbestos and other fibres is low. Consequently, no extra costs of site clearance certification are foreseen.

For some companies undertaking activities where the exposure concentrations are well below the current OEL, lowering the OEL may imply that asbestos would have to be monitored for more activities.

The assessment below consists of the following elements:

- Incremental costs of analyses from changing the analytical method and lowering the LOQ.

- Incremental costs of monitoring for activities with asbestos concentrations below the current OEL.

Costs of analysis

Lowering the OEL to 0.01 fibres/cm^3 would require use of analytical methods with a LOQ of 0.001 fibres/cm^3. PCM which is today widely used in the Members States (except for France, the Netherlands and Germany) can in principle measure concentrations below this level if the level of other dust particles is low. However, in practice as discussed in Section 4.9.2. in many samples the dust level is so high that the method is not sufficiently sensitive. With a practical limit of quantification at approx. 0.005 - 0.01 fibres/cm^3, the PCM is not considered feasible for monitoring compliance with the assessed OEL options of 0.01 fibres/cm^3 or 0.001 fibres/cm^3. In accordance with this, electron microscopy is the prescribed analysis method in those Member States that have limit values at 0.01 fibres/cm^3 or lower. PCM may remain in use for final check of remediation, because the low concentration of other dust allows for the method to be used. It will be assumed that lowering the OEL will not have any impact on the need for final check of remediation.

The first, and less expensive choice of analysis method will be SEM/EDX which are currently prescribed in Germany and the Netherlands, but also widely used in other Member States. TEM which is prescribed in France is a more expensive method but is used because of the ability to determine fibres of a smaller diameter.

As mentioned by RAC (2021), both SEM and TEM can be used to detect fibres thinner than 0.2 µm, but the current SEM standards do not recommend the use of higher magnification which would allow visualization of thinner fibres. SEM is currently widely used with a magnification of 2000x allowing the quantification of fibres thicker than 0.2 µm only. If thinner fibres should be included in would be necessary to increase the magnification and the costs of analysis would increase. For the current assessment, it is assumed that the SEM is applied with the resolution currently used in the Netherlands and Germany and that no further requirements to the analysis method will be prescribed.

PCM. According to two contacted laboratories, the price of a PCM analysis is in the range of € 60 - 100 per sample depending on sample sizes. For the assessment it will be assumed that usually more than one sample is analysed and the costs per sample is estimated at 70 € per analysis.

SEM/EDX. Prices on SEM/EDX analysis have been obtained from a large international group of laboratories with laboratories in many Member States (prices obtained for samples analysed in the Netherlands) and from a smaller German laboratory specialised in asbestos analyses with SEM/EDX. The analysis is performed in accordance with ISO 14966. The price of a standard analysis with a detection limit down to 0.0003 fibres/cm^3 (at a sample volume of 3.84 m^3) is reported to be € 165 and 185, respectively, per sample and not depending on the number of samples. A price of €175 will be used for the costs assessment. This standard analysis is from one of the laboratories reported to be applicable for monitoring compliance with an OEL of 0.01 fibres/cm^3. From the other laboratory the analysis is reported to be appliable for monitoring compliance down to the lowest OEL option of 0.001 fibres/cm^3 (with a sampling volume of 1.500 m^3 and an airflow of 10 L/sec). If the LOQ should be lowered to 0.0001 fibres/cm^3 this would, according to one of the laboratories require that a larger area of the filter is analysed. The extra costs are indicated to be approximately € 50 per sample i.e. the price for monitoring compliance with the OELs of 0.002 or 0.001 fibres/cm^3 would for some samples require analysis of costs of € 215 per sample for this laboratories. A price of € 210 (average of the two laboratories) will be used for the costs assessment. However, for most samples, a higher LOQ would be sufficient as the actual concentrations in the workplace is often higher than 1/10 of the OEL and the breathing concentration is lowered by the use of RPE. No data are available to indicate to what extent lowering the LOQ is required, but it will be roughly estimated that it could be relevant for 20% of the samples.

In some instances, the samples are not analysable for various reasons. One of the laboratories reported that that 3% of the air samples are not analysable. This is an average for all types of samples: Workplace monitoring, final check of remediation, and test of releases from ACMs (e.g. stabilised ACMs) to the indoor environment. The main reasons for non-analysable samples are, according to the laboratory, the presence of sprayed fibre binders and insufficient cleaning after maintenance work. The laboratory does not expect the number of non-analysable samples to be significantly higher if the LOQ for some samples should be lowered from the current 0.0003 to 0.0001 fibres/cm^3.

According to RAC (2001), the detection limits of 0.001-0.004 fibres/cm^3 (depending on method) may be achieved in rural environments, but not necessarily in dusty environments (for example in mines) with the methods currently used. Achieving these low limits of detection, may necessitate further development of sample treatment practises together with sampling higher volumes and an increase of the number of fields counted (i.e. the area of the filter that is analysed). According to a German expert, (Mattenklott, 2021) monitoring compliance with an OEL of 0.001 or 0.002 fibres/cm^3 would require much higher analysis efforts for exposure situations with high dust and low content of asbestos fibres as compared to other dust. Such situations could be mining and tunnelling, construction work, and work with building materials with low concentrations of asbestos e.g. in pasters or gypsum boards. Based on German experience, the time needed to undertake the analysis could be ten times the time needed for more conventional analysis undertaken today. The reason that this is not reflected in the cost estimates obtained from commercial laboratories could likely be that only a few samples from the relevant exposure situations are analysed today. No data are available to indicate the number of samples for which the significantly higher costs of analysis would apply. In the absence of more exact data, it will in the assessment be assumed that for 20% of all samples analysis for monitoring compliance with the two lowest OEL options would be 10 times higher than the costs of analysis at commercial laboratories today. The assumption that the costs instantly step up by a factor of ten is of cause a simplification but is used in order to take significantly higher costs of some samples into account.

TEM. It is in general reported that TEM analyses are more expensive than SEM analyses. The price of TEM analysis has been obtained from a smaller Belgian laboratory specialised in asbestos analysis. The prices of analysis per sample is indicated to be in the range about € 330 per sample. It will for the assessment be assumed that it will not be required to use TEM for monitoring compliance and the costs estimate will consequently be based on the costs of the less expensive SEM/EDX analysis. Even the costs of TEM analysis will increase if the LOQ should be lowered to 0.0001 fibres/cm^3, it will be assumed that these extra costs cannot be attributed to changes in the EU OEL as the extra costs of TEM analysis is a consequence of national legislation. The price of SEM/EDX analysis with the required LOQ would still be lower than the price of TEM analysis with today's LOQ in France. Based on the information on extra costs of analysis

Costs of sampling

The costs of sampling per sample will depend on a number of factors: Number of samples per campaign, whether internal or external staff is used for sampling, the necessary sampling time, salaries of staff, etc. No detailed analysis of sampling costs has been undertaken. As part of previous assessments (CMD 3 and CMD 4) more detailed analysis has been undertaken. For CMD 4 it was for the substances nickel compounds, acrylonitrile and benzene (with costs of analysis comparable to SEM analysis for asbestos) that the total sampling costs including reporting were for each of the substances approximately twice the costs of analysis. The same ratio will be applied in this assessment.

Current number of measurements per year

No data are available on the total number of measurements undertaken for compliance control across the EU. In some Member States workplace concentrations are measured for each notified work e.g. in France and Spain. In others, e.g. Denmark samples of workplace air are in general not taken if the prescribed risk management measures are followed (Aldrich et. al., 2020).

Data on number of analysis for notified works are available for a few Member States.

As mentioned, in France measurements are mandatory for each notified work. In total 273,000 analytical results from 5,327 enterprises have been entered into the asbestos database (Scol@miante) over the period 1 July 2012 to 31 December 2019 (INRS, 2020). This corresponds to an average of approximately 36,000 measurements pr. year. The number has been increasing with 43,800 measurements in 2019 (calculated as the difference between the accumulated totals for the two recent reports) (INRS, 2019 , 2020).

In Spain, sampling is mandatory as well for each work plan. According to a report from the Ministry of Employment in Spain (MTMSS; 2018), in 2017 4,551 exposure data were notified. It is here assumed that the exposure data represents actual measurements and the number indicates the number of measurement.

Scarselli at al. (2020) report that 19,704 measurements from the period 1996 - 2016 from the SIREP database were used for analysis. This corresponds to about 1,000 measurements per year, but it is not indicated to what extent the data in the SIREP database reflects the actual number of measurements undertaken.

For Germany, Mattenklott (2021) informs that measurements are mainly taken in order to demonstrate site clearance i.e. after the work is finalised. Only relatively few measurements are taken in the work situation in order to demonstrate compliance with the OEL. The same has been reported from Denmark where samples of workplace air are in general not taken if the prescribed risk management measures are followed (Aldrich et. al., 2020).

Based on the available data it will be assumed that the total number of measurements for compliance monitoring undertaken today by use of SEM/EDX and TEM, first of all in in France, the Netherlands and Germany, but also in other Member States, is in the range of 50,000 - 100,000 per year. It will be assumed that even at the lowest OEL the costs of analysis will not increase in France and the Netherlands.

For Members States where PCM is today the main method of choice, the number of measurements per capita seems to be lower than in France and Germany, and it will be assumed that the number per capita in Spain is more representative for this group of Member States. On this basis, the total number of PCM analysis for compliance monitoring in total is estimated to be in the range of 20,000 - 50,000 analyses per year. An average of 35,000 will be used for the cost estimate.

Additional measurements as consequence of lowering the OEL

It is assumed that lowering the OEL would require additional monitoring in exposure situations where the concentration is today considered to be well below the existing OEL and no monitoring is done. According to the AWD article 7 measurements of asbestos fibres in the air shall be carried out regularly: "Depending on the results of the initial risk assessment, and in order to ensure compliance with the limit value laid down in Article 8, measurement of asbestos fibres in the air at the workplace shall be carried out regularly". The requirements for measurements are not waived by the Article 3(3) waiver and in principle the requirements concerning monitoring apply to any exposure situation. However, the need for monitoring would depend on the initial risk assessment, and the certainty of the risk assessment as to the compliance with the OEL. If the OEL is lowered, for more work situations it would be uncertain whether the asbestos concentrations in the workplace are below the OEL. It will therefore be assumed that more measurements would be needed. No data are available to demonstrate that the number of measurements actually increased when lower

OELs were introduced in the Netherlands and France but it is noted that the number of measurements in France are relatively high as compared with other Member States.

It will be assumed that for the first two years after introduction of a lower OEL there will be a need for additional measurements in order to adjust the working procedures and the use of RMMs for works situations with exposure concentrations below current OELs but possibly above a new OEL. It will be assumed that for most companies it would, for non-notifiable work, not be required to make measurements of each job because the companies would rather change work procedures based on revisions of guidelines from public authorities. However, some companies, which frequently undertake non-notifiable work, would likely need to make measurements of typical jobs involving asbestos. Furthermore, lowering the OEL would likely have the consequence that more jobs would be undertaken by specialised companies, as compliance with the lower OEL would be more challenging for the non-specialised companies. The specialised companies, following more strict procedures, would likely monitor exposure concentrations for some jobs where the exposure concentration is not monitored today. It is roughly estimated that the number of additional measurements would be below the number of measurements taken for monitoring compliance with the current OEL and is estimated to be in the range of 5,000 - 25,000 per year (for the first two years after introduction of new OEL) for an OEL of 0.01 fibres/cm^3 and 20,000 - 60,000 for an OEL of 0.002 or 0.001 fibres/cm^3.

It will be assumed, that high costs of analysis will apply for 20% of all measurements at the OEL options of 0.002 and 0.001 fibres/cm^3.

For the additional measurements, all steps would be required: planning, sampling, analysis and reporting. The costs include both own staff costs, costs of external experts for planning, sampling and reporting, and laboratory analysis.

Estimate of incremental costs

The estimates of the additional monitoring costs are presented in the table below. The costs presented below are the Present Value of the costs incurred by all the relevant companies over 40 years. It should be noted that the uncertainty regarding this conclusion increases with decreasing OEL values.

*Table 6.16 Additional costs of monitoring (incremental cost of increased cost of analysis and additional measurements, **PV over 40 years** for the different policy options)*

Total incremental costs PV over 40 years			
	0.001 fibres/cm^3	0.002 fibres/cm^3	0.01 fibres/cm^3
TOTAL	**€640,000,000**	**€560,000,000**	**€110,000,000**
Assumptions about existing measurements	28,000 existing PCM analyses require SEM/EDX at extra cost of €105 7,000 existing PCM analyses require SEM/EDX at extra cost of €2,430 No extra costs of sampling	28,000 existing PCM analyses require SEM/EDX at extra cost of €105 7,000 existing PCM analyses require SEM/EDX at extra cost of €2,430 No extra costs of sampling	35,000 existing PCM analyses require SEM/EDX at extra cost of €105 No extra costs of sampling
Assumptions about additional measurements	48,000 additional analysis a year for the first two years at a cost of €275 per analysis 12,000 additional analysis a year for the first two years at a cost of €2,500 per analysis	24,000 additional analysis a year for the first two years at a cost of €275 per analysis 6,000 additional analysis a year for the first two years at a cost of €2,500 per analysis	15,000 additional measurements a year for the first two years at a cost of €275 per analysis and €550 per sample

	60,000 additional samples a year for the first two years at a cost of €550 per sample	30,000 additional samples a year for the first two years at a cost of €550 per sample	

Source: study team's calculation

6.3.9 Additional workers within the scope at lower OELs

As indicated in the baseline, there are large uncertainties regarding workers exposed at levels close to the lowest OEL option of 0.001 fibres/cm^3.

Exposure situations where it is uncertain how many workers could be exposed at such levels include:

- Passive exposure indoors in buildings with ACMs;
- Passive exposure outdoors in urban areas with relatively high ambient air concentrations e.g. from asbestos-containing roof materials or close to former sites where asbestos was used
- Quarrying of industrial minerals with a low concentration of naturally occurring asbestos;
- Use of industrial minerals with low concentration of naturally occurring asbestos e.g. for road construction;
- Tunnel construction in areas with low concentration of naturally occurring asbestos;
- Remediation of sites contaminated with asbestos e.g. in the soil;
- Waste management of materials with low asbestos content e.g. at waste collection points;
- Road maintenance of roads with paving with intentionally added asbestos or construction materials with low concentration of naturally occurring asbestos.

The number of workers exposed at concentrations close to 0.001 fibres/cm^3 may potentially be millions, but limited data are available because measuring occupational exposure at these concentrations has not been required to date.

Due to the uncertainties, it would likely be necessary to prepare initial risk assessments and undertake measurements of asbestos in materials and workplace air in order to demonstrate that the exposure concentrations are below the OEL, in particularly for the OEL option of 0.001 fibres/cm^3. Depending on the results of the measurements, a workplan and implementation of RMMs or other remediations measures in order to bring the concentrations below the OEL may be necessary.

It will be assumed that it will not be needed to prepare risk assessments and work plans and take measurements for all contracts, but companies with workers with a risk of exposure above 0.001 fibres/cm^3 would need to do some risk assessments and measurements at least the first two years after implementation of the OEL in order to be sure the concentrations are below the OEL and to adjust the working procedures (incl. use of RMMs) or otherwise reduce the risk of asbestos exposure (e.g. by removing the asbestos or avoid use of raw materials with low asbestos concentrations).

It will roughly be assumed that it the first two years after the implementation would be needed to make workplans, measurements and risk assessments for 100,000 to 1,000,000 contracts per year. Furthermore, it is assumed that for some of the work situations it will be needed to apply RPE or other RMMs which can bring down the exposure concentrations below the OEL.

Although these costs are highly uncertain and have thus not been added to the total compliance costs, these costs are roughly approximated in the table below.

*Table 6.17 Indicative approximation of the additional cost of workplans, measurements and risk assessments, RPE and other RMMs at 0.001 fibres/cm[3] (incremental cost, **PV over 40 years** for the different policy options)*

	Total incremental costs PV over 40 years 100,000 additional contracts per year	Total incremental costs PV over 40 years 1,000,000 additional contracts per year
Workplans, measurements and risk assessments*	€3 billion	€33 billion
RPE and dust extraction/vacuum cleaning**	€540 million	€5.4 billion
Other RMMs***	€3 billion	€33 billion
TOTAL	€7 billion	€72 billion

Notes:
*Estimated at €1,000 for each contract based on data from HSE (2017) in Annex E
** estimated from data for Exposure Group 2 in Section 6.3.4
*** For example, setting up barriers and fencing. Estimated at €1,000 per contract based on data from HSE (2017) in Annex E

Source: study team's calculation

6.3.10 Total compliance costs for companies

The total aggregated compliance costs for companies are summarised in the table below.

*Table 6.18 Total compliance cost (incremental cost, **PV over 40 years** for the different policy options)*

	Total incremental costs PV over 40 years		
Cost category	**0.001**	**0.002**	**0.01**
RPE and other RMMs	€ 58,281,671,709	€ 52,107,513,475	€ 12,492,254,976
Notification	€ 6,530,000,000	€ 4,350,000,000	€ 2,180,000,000
Health surveillance	€ 21,860,000,000	€ 14,570,000,000	€ 7,290,000,000
Training	€ 2,037,000,000	€ 1,060,000,000	€ 528,310,000
Monitoring	€ 640,000,000	€ 560,000,000	€ 110,000,000
TOTAL	**€ 89 billion**	**€ 73 billion**	**€ 23 billion**

Source: study team's calculation

6.4 Direct costs – administrative burdens and charges

The administrative burdens are the administrative costs for companies and Member State authorities (MSAs).

MSAs could incur admin costs if, for example, they have to do more reporting back to the EU for example or there are other additional administrative burdens. No significant additional reporting is anticipated and any other administrative burdens for MSAs cannot be identified or quantified (with the exception of the costs assessed in Section 6.6).

For enterprises, the cost of planning, executing and reporting the sampling and analysis of monitoring is part of compliance costs and is usually done by a specialist company.

Consequently, the administrative burden of arranging measurements is likely to be limited since the vast majority of planning and execution would be carried out by a specialist external contractor. For this reason, one day per company (estimated at €500 in order to ensure consistency with the di-isocyanates report) is taken as an approximation of the administrative burden of arranging monitoring – this estimate is applied to the additional measurements that would be required under the OEL options, and the relevant costs are estimated below.

*Table 6.19 Administrative costs of additional monitoring (incremental cost of increased cost of analysis and additional measurements, **PV over 40 years** for the different policy options)*

Total incremental costs PV over 40 years			
	0.001 fibres/cm³	0.002 fibres/cm³	0.01 fibres/cm³
TOTAL	€ 60,000,000	€ 30,000,000	€ 15,000,000
Assumptions about additional measurements	60,000 additional measurements a year for the first two years	30,000 additional measurements a year for the first two years	15,000 additional measurements a year for the first two years

Source: study team's calculation

6.5 OELs – indirect costs for companies

The category of indirect costs includes impacts such as the availability of products, the choice and quality of products, as well as possible ripple effects through the value chain. These types of costs are considered in Chapter 7 on market effects and Chapter 8 on distributional effects.

An indirect impact that is not considered in Chapter 7 is the potential for laboratories and companies that provide sampling services to build up capacity. However, since the number of additional samples and measurements estimated in Section 6.3.8 is relatively low, this cost is unlikely to be significant.

6.6 OELs – costs for public authorities

6.6.1 Costs of transposition

Member States would incur costs transposing the relevant changes into national legislation. In practice, the exact costs depend on the specific changes agreed in the final version of the Directive and the regulatory model used in each country to implement the Directive (i.e. the number of departments involved in transposition or implementing the Directive). These costs are likely to vary significantly between Member States (for example, some Member States are obliged to carry out an impact assessment on new EU legislation).

Of the 27 EU Member States, only two Member States (France and the Netherlands) currently have an OEL in place that is different to the current OEL in the AWD (and Germany has an additional "acceptable" value in addition to a "tolerable" value that is the same as the current OEL in the AWD). It is thus expected that 25 EU Member States (all except FR and NL) would incur transposition costs under the OEL option of 0.01 fibres/cm^3, 26 Member States would incur transposition costs if the value of 0.002 fibres/cm^3 were to be adopted and all Member States would incur transposition costs if the value of 0.001 fibres/cm^3 were adopted.

Specific data on the costs of transposition of EU legislation by Member States and their relevant departments/ministries are not readily available. As noted in RPA (2012), one UK impact assessment states that *"the costs of amending current regulations to implement a Directive are thought to be around £700,000"* (around €900,000 in €2017). Although no details are given on the basis for this calculation, it is expected that these costs relate to a rather substantial legislative change and would include those costs of making (including preparing an impact assessment, drafting a substantial bill and presenting the legislation before parliament), printing and publishing the legislation. This estimate is significantly higher than the cost estimated in UK Department for Transport (2011) which notes that *"a combination of legal and technical resources as well as policy advisors are usually required to implement such a change, costing approximately £15,687 per amendment"* (approximately €20,000 in €2017).

Considering that all Member States have transposed the AWD which already contains an OEL, it appears more likely that the cost of transposing an additional OEL would be closer to the low-end estimate. However, it also appears that there has been a general trend towards increased impact assessment in the Member States (see, for example, RPA 2015), which suggests that the costs would likely be higher than €20,000.

This study thus takes €30,000 per Member State as an approximation of the general order of magnitude of the applicable transposition costs for Member States since they all already have an existing OEL. More significant changes are expected to be required at the two lower OEL options and a cost of €50,000 per Member State is assumed.

Table 6.20 Transposition costs for Member State authorities

OEL option	Number of Member States	Transposition cost per Member State	Total cost across the EU
0.001 fibres/cm^3	27	€50,000	**€ 1,350,000**
0.002 fibres/cm^3	26	€50,000	**€ 1,300,000**
0.01 fibres/cm^3	25	€30,000	**€ 750,000**

Source: study team's calculation

6.6.2 Costs of changing of guidelines

Guidelines from public authorities would need to be changed as a consequence of lowering the OEL. Even the objective, irrespective of the OEL level, is to keep exposure concentrations as low as possible, the guidelines typically include some recommendations of measures to be taken to ensure that the occupational exposure concentrations are well below the OEL. Lowering the OEL by a factor of 10 or 100 would have significant impact on the measures to be taken and would require a thorough revision of the guidelines from national authorities and national Health and Safety institutes.

It is likely that each Member State would have to elaborate and publish guidelines which take into account a large number of exposure scenarios across a range of sectors relevant to the specific Member State. Although some synergies could be achieved, e.g. by learning from the French, German and Dutch experience, it is likely that these activities could entail a significant cost that may exceed the cost of transposition of the new OEL. As a rough approximation, it is assumed that the cost of changing guidelines would be approximately the same as that of transposition of the new OEL. These costs are estimated in the table below.

Table 6.21 Cost of elaborating new guidance documents

OEL option	Number of Member States	Cost per Member State	Total cost across the EU
0.001 fibres/cm^3	27	€50,000	**€ 1,350,000**
0.002 fibres/cm^3	26	€50,000	**€ 1,300,000**
0.01 fibres/cm^3	25	€30,000-	**€ 750,000**

Source: study team's calculation

6.6.3 Enforcement, monitoring and adjudication costs

All Member States have transposed the AWD and have an OEL for asbestos. The Member States are principally already required to inspect associated companies. The introduction of a reduced limit value on its own should therefore not lead to additional cost of enforcement or monitoring. However, should the number of companies and activities that are notified increase, the costs for Member States would also increase.

As noted in section 6.3.5, the number of notified contracts is estimated to increase under each of the policy options as follows:

- 0.01 fibres/cm^3: Additional 1.7 million contracts per year in EU27 would be notified.
- 0.002 fibres/cm^3: Additional 3.3 million contracts per year in EU27 would be notified.
- 0.001 fibres/cm^3: Additional 5 million contracts per year in EU27 would be notified.

It is assumed that it takes the authorities around 0.5 hour of staff time to process a notification. At a cost of €50 per hour, this equates to a cost of €25 for processing a notification. The relevant costs for Member State authorities are estimated below.

*Table 6.22 The estimated cost of **processing additional notifications** (incremental cost, **PV over 40 years** for the different policy options)*

	Total incremental costs PV over 40 years		
	0.001	**0.002**	**0.01**
Processing notifications	€4,200,000,000	€2,800,000,000	€1,400,000,000

Source: study team's calculation

There could be an additional cost due to bringing additional activities in Exposure Group 3 (passive exposure in buildings into the scope of the AWD) – these costs are not included in the table above.

6.7 Aggregated costs

The total aggregated costs for companies and public authorities are shown in the table below. The disaggregation of the costs by company size and type (one-off and recurring) is considered in Chapters 7 and 8 and are not reproduced here. Please note that, due to the large uncertainty about the costs and benefits for Exposure Group 3 (passive exposure in buildings), the costs and benefits considered in Chapters 7, 8 and 11 exclude data for Exposure Group 3 whilst this group is included in the cost data in this section.

The estimated additional costs for enterprises (compliance and administrative) are shown in the table below.

*Table 6.23 Total compliance and administrative costs for enterprises (incremental cost, **PV over 40 years** for the different policy options)*

Cost category	Total incremental costs PV over 40 years		
	0.001	0.002	0.01
RPE and other RMMs	€ 58,281,671,709	€ 52,107,513,475	€ 12,492,254,976
Notification	€ 6,530,000,000	€ 4,350,000,000	€ 2,180,000,000
Health surveillance	€ 21,860,000,000	€ 14,570,000,000	€ 7,290,000,000
Training	€ 2,037,000,000	€ 1,060,000,000	€ 528,310,000
Monitoring - compliance	€ 640,000,000	€ 560,000,000	€ 110,000,000
Monitoring - administrative	€ 60,000,000	€ 30,000,000	€ 15,000,000
TOTAL (PV CAPEX)	€ 7 billion	€ 5 billion	€ 3 billion
TOTAL (PV OPEX)	€ 82 billion	€ 68 billion	€ 20 billion
TOTAL (PV – CAPEX and OPEX)	**€ 89 billion**	**€ 73 billion**	**€ 23 billion**

Source: study team's calculation

Table 6.24 PV compliance and administrative burden costs incurred by companies over 40 years for the OEL options by exposure group

Exposure Group		0.001 fibres/cm³	0.002 fibres/cm³	0.01 fibres/cm³
1	Building and construction - exposure situations subject to notification	€ 23,608,910,756	€ 21,151,306,507	€ 3,037,948,956
2	Building and construction - exposure situations subject to Article 3(3) waiver and 'incidental' exposure	€ 57,419,442,396	€ 44,160,869,424	€ 18,398,706,769
3	Building and construction - passive exposure in buildings	Not possible to estimate due to limited data	Not possible to estimate due to limited data	Not possible to estimate due to limited data
4	Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	€ 902,215,527	€ 810,158,204	€ 124,327,208
5	Waste management	€ 4,945,630,665	€ 4,377,881,151	€ 636,873,295
6	Mining and quarrying - naturally occurring asbestos	€ 358,084,957	€ 316,686,712	€ 54,052,595
7	Tunnel excavation - naturally occurring asbestos	€ 59,211,835	€ 52,286,212	€ 10,983,868
8	Road construction and maintenance	€ 478,449,060	€ 421,621,337	€ 100,285,015
9	Sampling and analysis	€ 595,779,897	€ 524,737,541	€ 85,588,041

Exposure Group	0.001 fibres/cm³	0.002 fibres/cm³	0.01 fibres/cm³
Total (rounded)	**€ 89 billion**	**€ 73 billion**	**€ 23 billion**

Source: study team's calculation

The PV40 values in this study are also converted into annual values by dividing the PV40 values by 40, for more detail about annualised costs, see the methodological note.

Table 6.25 Annual compliance and administrative burden costs for the OEL options by exposure group

	Exposure Group	0.001 fibres/cm³	0.002 fibres/cm³	0.01 fibres/cm³
1	Building and construction - exposure situations subject to notification	€ 590,222,769	€ 528,782,663	€ 75,948,724
2	Building and construction - exposure situations subject to Article 3(3) waiver and 'incidental' exposure	€ 1,435,486,060	€ 1,104,021,736	€ 459,967,669
3	Building and construction - passive exposure in buildings	Not possible to estimate due to limited data	Not possible to estimate due to limited data	Not possible to estimate due to limited data
4	Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	€ 22,555,388	€ 20,253,955	€ 3,108,180
5	Waste management	€ 123,640,767	€ 109,447,029	€ 15,921,832
6	Mining and quarrying - naturally occurring asbestos	€ 8,952,124	€ 7,917,168	€ 1,351,315
7	Tunnel excavation - naturally occurring asbestos	€ 1,480,296	€ 1,307,155	€ 274,597
8	Road construction and maintenance	€ 11,961,227	€ 10,540,533	€ 2,507,125
9	Sampling and analysis	€ 14,894,497	€ 13,118,439	€ 2,139,701
Total (rounded)		**€ 2.23 billion**	**€ 1.83 billion**	**€ 0.6 billion**

Source: study team's calculation

The total additional costs for the authorities are summarised below.

*Table 6.26 Total costs for Member State authorities (incremental cost, **PV over 40 years** for the different policy options)*

Cost category	Total incremental costs PV over 40 years		
	0.001	0.002	0.01
Transposition costs	€ 1,350,000	€ 1,300,000	€ 750,000

Cost category	Total incremental costs PV over 40 years		
	0.001	0.002	0.01
Changing guidance documents	€ 1,350,000	€ 1,300,000	€ 750,000
Processing additional notifications	€ 4,200,000,000	€ 2,800,000,000	€ 1,400,000,000
TOTAL	**€ 4.2 billion**	**€ 2.8 billion**	**€ 1.4 billion**

Source: study team's calculation

7. Market effects

This section is divided into the following sub-sections:

- Section 7.1: Overall impact
- Section 7.2: Innovation and Growth
- Section 7.3: Single market
- Section 7.4: Competitiveness of EU businesses
- Section 7.5: Employment

7.1 Overall impact

Overall, market impacts (in terms of the effect on the single market, R&D, competitiveness of EU businesses and employment) are strongly influenced by two key drivers: the extent to which costs are incurred to comply with the OELs and by the feasibility of meeting the required air concentrations. In extreme cases, companies could be forced out of business if they are unable to meet the OELs at a cost that maintains profitability.

The likely costs that would be incurred at each of the OELs considered in this study are set out in Chapter 6 above.

Table 7.1 provides estimates of the total compliance costs that are estimated to be incurred (discounted at 4% over 40 years). These include incremental costs of RMMs (including RPE), cost of notification and medical surveillance, monitoring costs and training costs.

The rest of this section provides an analysis of the likely impacts arising from the key drivers of competition in both the EU and overseas markets.

Due to the large uncertainty surrounding the estimates for Exposure Group 3 (passive exposure in buildings), these costs are not considered in this section even where their approximation is provided in Section 6 on costs.

Table 7.1 PV Compliance costs of OELs

Sector	Total incremental costs PV over 40 years		
	0.001 fibre/cm^3	0.002 fibre/cm^3	0.01 fibre/cm^3
1. Building and construction - exposure situations subject to notification	€ 23,608,910,756	€ 21,151,306,507	€ 3,037,948,956
2. Building and construction - exposure situations subject to Article 3(3) waiver, ''incidental' exposure'	€ 57,419,442,396	€ 44,160,869,424	€ 18,398,706,769
3. Building and construction - passive exposure in buildings	Not possible to estimate due to limited data	Not possible to estimate due to limited data	Not possible to estimate due to limited data
4. Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	€ 902,215,527	€ 810,158,204	€ 124,327,208
5. Waste management and land remediation activities	€ 4,945,630,665	€ 4,377,881,151	€ 636,873,295
6. Mining and quarrying - naturally occurring asbestos	€ 358,084,957	€ 316,686,712	€ 54,052,595
7. Tunnel excavation	€ 59,211,835	€ 52,286,212	€ 10,983,868

Sector	Total incremental costs PV over 40 years		
	0.001 fibre/cm³	0.002 fibre/cm³	0.01 fibre/cm³
8. Road maintenance and construction	€ 478,449,060	€ 421,621,337	€ 100,285,015
9. Sampling and analysis	€ 595,779,897	€ 524,737,541	€ 85,588,041
Total	**€ 88,367,725,092**	**€ 71,815,547,088**	**€ 22,448,765,747**

Source: Study team's calculations

Note: The total figures do not include the estimates for Exposure Group 3 (Passive exposure in buildings), which were presented in the previous section as they are highly uncertain and thus have been excluded from the market effects analysis.

Table 7.2 provides estimates of the total compliance costs per company that are estimated to be incurred (discounted at 4% over 40 years). These include: incremental costs of RMMs (including RPE), cost of notification and medical surveillance, monitoring costs and training costs.

Table 7.2 PV Compliance costs per company of OELs

Sector	Total incremental costs PV per company over 40 years		
	0.001 fibre/cm³	0.002 fibre/cm³	0.01 fibre/cm³
1. Building and construction - exposure situations subject to notification	€ 491,852	€ 440,652	€ 63,291
2. Building and construction - exposure situations subject to Article 3(3) waiver, ''incidental' exposure'	€ 38,280	€ 29,441	€ 12,266
3. Building and construction - passive exposure in buildings	Not possible to estimate due to limited data	Not possible to estimate due to limited data	Not possible to estimate due to limited data
4. Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	€ 2,577,759	€ 2,314,738	€ 355,221
5. Waste management and land remediation activities	€ 1,978,252	€ 1,751,152	€ 254,749
6. Mining and quarrying - naturally occurring asbestos	€ 1,432,340	€ 1,266,747	€ 216,210
7. Tunnel excavation	€ 1,184,237	€ 1,045,724	€ 219,677
8. Road maintenance and construction	€ 434,954	€ 383,292	€ 91,168
9. Sampling and analysis	€ 1,354,045	€ 1,192,585	€ 194,518
Total (average PV cost per company across all exposure groups)	**€ 56,913**	**€ 46,252**	**€ 14,458**

Source: Study team's calculations

Note: The total figures do not include the estimates for Exposure Group 3 (Passive exposure in buildings), which were presented in the previous section as they are highly uncertain and thus have been excluded from the market effects analysis.

Table 7.3 provides estimates of the total compliance costs per company per annum that are estimated to be incurred (calculated as total PV divided by 40). These include: incremental costs of RMMs (including RPE), cost of notification and medical surveillance, monitoring costs and training costs.

Table 7.3 Total PV divided by 40 as "annual cost" per business per OEL

Sector	Total incremental costs PV per company divided by 40		
	0.001 fibre/cm^3	0.002 fibre/cm^3	0.01 fibre/cm^3
1. Building and construction - exposure situations subject to notification	€ 12,296	€ 11,016	€ 1,582
2. Building and construction - exposure situations subject to Article 3(3) waiver, ''incidental' exposure'	€ 957	€ 736	€ 307
3. Building and construction - passive exposure in buildings	Not possible to estimate due to limited data	Not possible to estimate due to limited data	Not possible to estimate due to limited data
4. Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	€ 64,444	€ 57,868	€ 8,881
5. Waste management and land remediation activities	€ 49,456	€ 43,779	€ 6,369
6. Mining and quarrying - naturally occurring asbestos	€ 35,809	€ 31,669	€ 5,405
7. Tunnel excavation	€ 29,606	€ 26,143	€ 5,492
8. Road maintenance and construction	€ 10,874	€ 9,582	€ 2,279
9. Sampling and analysis	€ 33,851	€ 29,815	€ 4,863
Total (average annual cost per company across all exposure groups)	**€ 1,423**	**€ 1,156**	**€ 361**

Source: Study team's calculations

Note: The total figures do not include the estimates for Exposure Group 3 (Passive exposure in buildings), which were presented in the previous section as they are highly uncertain and thus have been excluded from the market effects analysis.

7.2 Innovation and growth

Research and development (R&D) are key activities in an industry's capacity to develop new products and produce existing ones more efficiently and sustainably, in a way that protects the safety of workers. The ability of the different sectors to engage in R&D activities is likely to be affected by:

- The availability of financial resources to invest in R&D;
- The availability of human resources to conduct R&D activities;
- The regulatory environment and whether or not it is conducive to investing in R&D activities.

In most cases, R&D expenditure is not available at the level of the specific subsector in Eurostat, and even at the overall sector level, there are significant data gaps, at both EU and Member State levels, requiring assumptions to be made or utilising previous or subsequent years' data to be utilised. Therefore, no estimates have been generated for R&D expenditures in the sectors where there is exposure to asbestos.

However, Better Regulation Tool #21 indicates that "All compliance costs divert resources from other purposes, potentially including research and innovation." As detailed below, the costs involved in complying with the lower OELs of 0.001 fibres/cm^3 and 0.002 fibres/cm^3 are significant and in many cases represent a significant proportion of companies' turnover.

7.3 Single market

7.3.1 Competition

Table 7.4 below includes the initial screening of impacts on competition in order to focus the analysis on those impacts likely to be the most significant. The most significant impacts are further explored in the following paragraphs.

Table 7.4 Screening of competition impacts

Impacts	Key questions	Yes/No
Existing firms	Additional costs?	Yes
	Scale of costs significant?	Yes
	Old firms affected more than new?	Unknown
	Location influences?	Yes (dependent on existing OELs in different Member States)
	Some firms will exit the market?	Unlikely
	Are competitors limited in growth potential?	No
	Increased collusion likely?	Unknown
New entrants	Restrict entry?	Possibly
Prices	Increased prices for consumers	Likely yes
Non-price impacts	Product quality/variety affected?	No
	Impact on innovation	Yes
Upstream and downstream market	Will OELs affect vertically integrated companies more or less than non-integrated ones?	Unknown
	Will OELs encourage greater integration and market barriers?	Unknown
	Will OELs affect bargaining power of buyers or suppliers?	Unknown

7.3.1.1 Additional costs and their significance

Chapter 6 sets out the likely cost of compliance with OELs at the three levels being considered, and the cost model provides data on the average cost per company (by size of company) for each exposure group. In order to understand the significance of these costs for the companies operating with workers exposed to asbestos, the Better Regulation Guidelines suggest comparing the costs with levels of turnover. Table 7.5 below sets out average levels for turnover in the sectors where it has been determined workers are exposed to asbestos.

Table 7.5 Average turnover for companies operating in sectors working with asbestos by size class in € million

Sector	Average turnover per company (€ million)		
	Small	Medium	Large
F41.20 Construction of residential and non-residential buildings	0.34	18.22	269.97
F43.11 Demolition	0.30	19.01	347.44
F43.12 Site preparation	0.20	13.01	237.70
F43.21 Electrical installation	0.29	11.95	163.68
F43.22 Plumbing, heat and air conditioning installation	0.28	11.41	156.26
F43.29 Other construction installation	0.34	50.58	285.74
F43.33 Floor and wall covering	0.13	19.96	112.77
F43.34 Painting and glazing	0.13	18.72	105.76
F43.39 Other building completion and finishing	0.09	13.19	74.51
F43.91 Roofing activities	0.28	12.52	103.34
F43.99 Other specialised construction activities n.e.c.	0.33	14.88	122.84
F42.12 - Construction of railways and underground railways	1.72	37.45	523.50
F42.13 - Construction of bridges and tunnels	0.82	17.86	249.60
B08.11 - Quarrying of ornamental and building stone, limestone, gypsum, chalk and slate	0.85	16.21	182.80
C33.14 Repair of electrical equipment	0.19	8.77	87.76
C33.15 Repair and maintenance of ships and boats	0.27	12.18	121.93
C33.16 Repair and maintenance of aircraft and spacecraft	3.82	172.56	1727.48
C33.17 Repair and maintenance of other transport equipment	0.91	41.30	413.47

Sector	Average turnover per company (€ million)		
	Small	Medium	Large
D35.11 Production of electricity	0.38	74.60	1089.22
E36.00 Water collection, treatment and supply	0.74	13.10	99.86
E38.11 Collection of non-hazardous waste	0.71	10.10	132.34
E38.12 Collection of hazardous waste	0.48	6.84	89.65
E38.22 Treatment and disposal of hazardous waste	1.53	20.38	204.77
E38.31 Dismantling of wrecks	0.39	10.97	88.53
E38.32 Recovery of sorted materials	1.48	41.96	338.60
E39.00 Remediation activities and other waste management services	0.77	13.99	68.23
G45.2 Maintenance and repair of motor vehicles	0.22	14.97	24.99
M71.20 Technical testing and analysis	0.24	9.84	104.86
F42.11 - Construction of roads and motorways	0.74	15.99	223.46

Source: Eurostat (2018 data) and study team's calculations

Note: Turnover data by size class is mostly available for sectors at the NACE 3-digit level as opposed to the 4-digit level. Where this is the case, the share of turnover between the different size classes at the 4-digit level has been assumed to be the same as at the 3-digit level and then applied to the overall turnover level at the 4-digit level to generate estimates at sub-sector levels.

As explained in Chapter 6, due to lack of data, it has only been possible to estimate costs on the basis of exposure groups. For the purposes of generating estimates of the significance of the likely costs to be incurred with respect to turnover in the different sub-sectors, it has been assumed that the costs associated with each exposure group will be the same for all the sectors/sub-sectors within that exposure group.

On the basis of the cost model estimates for average cost for a company in each exposure group and utilising the average turnover for different sized companies in Table 7.5 above, the following table sets out estimates of the average annual costs predicted to be incurred as a percentage of average annual turnover.

The results show that at an OEL of 0.01 fibres/cm^3, almost all companies of all sizes in the exposure groups “Building and construction - exposure situations subject to notification” and “Building and construction - exposure situations subject to Article 3(3) waiver, 'incidental' exposure” would have a cost/turnover ratio of less than 1%, with only small companies in the first group in sectors “F43.33 Floor and wall covering”, “F43.34 Painting and glazing” and “F43.39 Other building completion and finishing” having results above 1% but below 2%.

“M71.20 Technical testing and analysis” in the exposure group “Sampling and analysis” shows a similar result to these groups. The only exposure group where costs in relation to turnover appear to be higher than 2% at an OEL of 0.01 fibres/cm^3 is “Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other”. Small enterprises in sectors “C33.14 Repair of electrical equipment” and “C33.15 Repair and maintenance of ships and boats” show costs/turnover in the 2% to 5% category. Similarly, Sector G45.2 Maintenance and repair of motor vehicles” also shows a cost/turnover in the same 2-5% category. Table 4.56 in Chapter 4 indicates that the vast majority of companies working with asbestos in these sectors are small companies.

With respect to Sector G45.2, the compliance costs per company are expected to be lower than the costs per company calculated for that whole exposure group, which also includes the C33.1 sectors (repair of ships, trains etc). Workers in C33.1 sectors are much more likely to come into contact with asbestos then the ones in G45.2 since in G45.2 workers would be most likely to come into contact with asbestos when they are repairing old 'veteran' cars, and number of these are limited.

At OELs of 0.002 and 0.001 fibres/cm^3, more sectors exhibit higher levels of costs/turnover as might be expected, and this extends to medium and large companies in addition to small ones. Small companies exhibiting higher cost/turnover ratios even at the highest OEL under consideration in sectors such as C33.14 and C33.15 would face significantly greater challenges under OELs of 0.002 and 0.001 fibres/cm^3, with cost/turnover ratio results calculated between 18% and almost 30%.

When expressed as % of profits or investment, these costs are even greater. Although these costs are likely to be, to a large extent, passed on to the customers, they may result in some companies abandoning the market and the transfer of the relevant activities to other companies. However, significant price increases may result in consumers putting off asbestos work and as a result spread the demand over greater period of time, thus reducing the market available each year. This may result in a reduction of firms in the market. These issues appear to be more significant for small companies.

Table 7.6 Costs as percentage of turnover (Source: study team's calculation)

Exposure group	4-digit NACE category	Cost as a % of turnover								
		0.001 fibres/cm^3			0.002 fibres/cm^3			0.01 fibres/cm^3		
		Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Building and construction - exposure situations subject to notification	F41.20 Construction of residential and non-residential buildings	3.42%	0.32%	0.09%	3.06%	0.29%	0.08%	0.44%	0.04%	0.01%
	F43.11 Demolition	3.95%	0.31%	0.07%	3.54%	0.28%	0.06%	0.51%	0.04%	0.01%
	F43.12 Site preparation	5.78%	0.45%	0.10%	5.18%	0.41%	0.09%	0.74%	0.06%	0.01%
	F43.21 Electrical installation	4.02%	0.49%	0.14%	3.60%	0.44%	0.13%	0.52%	0.06%	0.02%
	F43.22 Plumbing, heat and air conditioning installation	4.21%	0.52%	0.15%	3.78%	0.46%	0.14%	0.54%	0.07%	0.02%
	F43.29 Other construction installation	3.49%	0.12%	0.08%	3.12%	0.10%	0.07%	0.45%	0.01%	0.01%
	F43.33 Floor and wall covering	8.83%	0.30%	0.21%	7.91%	0.26%	0.19%	1.14%	0.04%	0.03%
	F43.34 Painting and glazing	9.42%	0.31%	0.22%	8.44%	0.28%	0.20%	1.21%	0.04%	0.03%
	F43.39 Other building completion and finishing	13.37%	0.45%	0.32%	11.98%	0.40%	0.28%	1.72%	0.06%	0.04%
	F43.91 Roofing activities	4.21%	0.47%	0.23%	3.78%	0.42%	0.20%	0.54%	0.06%	0.03%
	F43.99 Other specialised construction activities n.e.c.	3.54%	0.40%	0.19%	3.18%	0.35%	0.17%	0.46%	0.05%	0.02%
	D35.11 Production of electricity	3.09%	0.08%	0.02%	2.77%	0.07%	0.02%	0.40%	0.01%	0.003%
	E39.00 Remediation activities and other waste management services	1.54%	0.42%	0.35%	1.38%	0.38%	0.31%	0.20%	0.05%	0.04%
Building and construction - exposure situations subject to Article 3(3) waiver, 'incidental' exposure	F41.20 Construction of residential and non-residential buildings	0.27%	0.03%	0.01%	0.21%	0.02%	0.01%	0.09%	0.01%	0.002%
	F43.11 Demolition	0.31%	0.02%	0.01%	0.24%	0.02%	0.004%	0.10%	0.01%	0.002%
	F43.12 Site preparation	0.45%	0.04%	0.01%	0.35%	0.03%	0.01%	0.14%	0.01%	0.002%
	F43.21 Electrical installation	0.31%	0.04%	0.01%	0.24%	0.03%	0.01%	0.10%	0.01%	0.004%
	F43.22 Plumbing, heat and air conditioning installation	0.33%	0.04%	0.01%	0.25%	0.03%	0.01%	0.11%	0.01%	0.004%
	F43.29 Other construction installation	0.27%	0.01%	0.01%	0.21%	0.01%	0.005%	0.09%	0.003%	0.002%
	F43.33 Floor and wall covering	0.69%	0.02%	0.02%	0.53%	0.02%	0.01%	0.22%	0.01%	0.01%
	F43.34 Painting and glazing	0.73%	0.02%	0.02%	0.56%	0.02%	0.01%	0.24%	0.01%	0.01%
	F43.39 Other building completion and finishing	1.04%	0.03%	0.02%	0.80%	0.03%	0.02%	0.33%	0.01%	0.01%
	F43.91 Roofing activities	0.33%	0.04%	0.02%	0.25%	0.03%	0.01%	0.11%	0.01%	0.01%
	F43.99 Other specialised construction activities n.e.c.	0.28%	0.03%	0.01%	0.21%	0.02%	0.01%	0.09%	0.01%	0.005%
	D35.11 Production of electricity	0.24%	0.01%	0.002%	0.19%	0.005%	0.001%	0.08%	0.002%	0.001%

Exposure group	4-digit NACE category	Cost as a % of turnover								
		0.001 fibres/cm^3			0.002 fibres/cm^3			0.01 fibres/cm^3		
		Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
	E39.00 Remediation activities and other waste management services	0.12%	0.03%	0.03%	0.09%	0.03%	0.02%	0.04%	0.01%	0.01%
Building and construction - passive exposure in buildings	Many sectors	No data	No data	No data	No data	No data	No data	No data	No data	No data
Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	C33.14 Repair of electrical equipment	28.50%	8.51%	2.36%	25.60%	7.64%	2.12%	3.93%	1.17%	0.33%
	C33.15 Repair and maintenance of ships and boats	20.52%	6.13%	1.70%	18.42%	5.50%	1.53%	2.83%	0.84%	0.23%
	C33.16 Repair and maintenance of aircraft and spacecraft	1.45%	0.43%	0.12%	1.30%	0.39%	0.11%	0.20%	0.06%	0.02%
	C33.17 Repair and maintenance of other transport equipment	6.05%	1.81%	0.50%	5.43%	1.62%	0.45%	0.83%	0.25%	0.07%
	G45.2 Maintenance and repair of motor vehicles	24.60%	4.98%	8.29%	22.09%	4.47%	7.45%	3.39%	0.69%	1.14%
Waste management	E36.00 Water collection, treatment and supply	2.82%	2.15%	0.78%	2.50%	1.91%	0.69%	0.36%	0.28%	0.10%
	E38.11 Collection of non-hazardous waste	2.95%	2.79%	0.59%	2.61%	2.47%	0.52%	0.38%	0.36%	0.08%
	E38.12 Collection of hazardous waste	4.35%	4.12%	0.87%	3.85%	3.65%	0.77%	0.56%	0.53%	0.11%
	E38.22 Treatment and disposal of hazardous waste	1.37%	1.38%	0.38%	1.21%	1.23%	0.34%	0.18%	0.18%	0.05%
	E38.31 Dismantling of wrecks	5.39%	2.57%	0.88%	4.77%	2.28%	0.78%	0.69%	0.33%	0.11%
	E38.32 Recovery of sorted materials	1.41%	0.67%	0.23%	1.25%	0.59%	0.20%	0.18%	0.09%	0.03%
Mining and quarrying - naturally occurring asbestos	B08.11 - Quarrying of ornamental and building stone, limestone, gypsum, chalk and slate	2.88%	2.03%	0.50%	2.55%	1.80%	0.44%	0.43%	0.31%	0.08%
Tunnel excavation	F42.12 - Construction of railways and underground railways	0.91%	0.56%	0.11%	0.80%	0.50%	0.10%	0.17%	0.10%	0.02%
	F42.13 - Construction of bridges and tunnels	1.90%	1.18%	0.23%	1.68%	1.04%	0.21%	0.35%	0.22%	0.04%
Road construction and maintenance	F42.11 - Construction of roads and motorways	0.78%	0.48%	0.10%	0.69%	0.43%	0.08%	0.16%	0.10%	0.02%
Sampling and analysis	M71.20 Technical testing and analysis	11.57%	3.74%	0.98%	10.19%	3.29%	0.86%	1.66%	0.54%	0.14%

Key:

< 1% No colour	1-2%	2-5%	5-10%	>10%

It is noted that for the exposure group "Building and construction - exposure situations subject to Article 3(3) waiver, 'incidental' exposure", the cost/turnover ratio remains below 1%, even at the strictest OEL across all company sizes in all sectors. These companies will deal with asbestos occasionally but not as a major part of their operations, and the increase in costs associated with potential moves to lower OELs are expected to be significantly less than for companies in the exposure group "Building and construction - exposure situations subject to notification", where work with asbestos will likely form a much greater significance in their overall portfolio. The corresponding significantly lower cost/turnover ratios in sectors in the exposure group involving incidental exposure is therefore to be expected. However, whilst the cost/turnover ratios for the exposure group "Building and construction - exposure situations subject to Article 3(3) waiver, 'incidental' exposure" are lower across the different OELs than in the other exposure groups, this does not necessarily mean that companies operating in these sectors will be unaffected by the increases in costs associated with having to comply with progressively lower OELs.

Compliance costs are made up of a number of different types of costs, including both capital and operational expenses. Capital expenses need to be paid upfront or periodically whilst the operational expenses (such as RPE) will be ongoing in accordance with the levels of work that is undertaken. Table 7.7 below shows the ratio of capital to operational expenses (based on the cost model developed for the study) associated with the different OELs across the different exposure groups.

In fact, as noted further down in this section, it is likely that many of these companies may refuse to take on work involving exposure to asbestos most likely resulting in a transfer of this part of the market to specialised firms in Exposure Group 1.

Table 7.7 Ratio of Capital to Operational Expenditure

Sector	Ratio of Capital to Operational Expenditure		
	0.001 fibre/cm^3	0.002 fibre/cm^3	0.01 fibre/cm^3
1. Building and construction - exposure situations subject to notification	6.70%	5.60%	3.70%
2. Building and construction - exposure situations subject to Article 3(3) waiver, ''incidental' exposure'	8.46%	8.33%	17.23%
3. Building and construction - passive exposure in buildings	Not possible to estimate due to limited data	Not possible to estimate due to limited data	Not possible to estimate due to limited data
4. Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	7.62%	6.64%	10.39%
5. Waste management and land remediation activities	8.18%	7.04%	13.69%
6. Mining and quarrying - naturally occurring asbestos	13.93%	13.40%	40.06%
7. Tunnel excavation	24.43%	25.14%	87.04%
8. Road maintenance and construction	33.17%	35.02%	125.22%
9. Sampling and analysis	10.75%	9.97%	24.95%

Source: study team's calculation

Table 7.7 above shows that the profile of capital and operational measures needed for Group 1 companies to meet each of the OELs has the lowest capex/opex ratio across all of the groups. Group 2 companies, which from a sectoral perspective cover the same sectors, have a much higher ratio, indicating that capital expenditures required would be a significantly higher proportion. Companies operating in this group will only periodically engage in activities that involve exposure of workers to asbestos, and whilst the Table 7.4 above indicates that overall, costs relative to turnover are lower in this group than in the group operating under notifications, the significantly higher ratio of capital expenditure required could prove a disincentive or even prevent these companies from continuing with asbestos relating activities themselves. Rather they may step back from working with asbestos, bringing in more specialised companies which operate under Group 1 (“Building and construction - exposure situations subject to notification”).

This being the case, it is expected that a larger share of work with asbestos in building and construction under exposure situations subject to Article 3(3) waiver will be undertaken by companies who have traditionally been focused on notified work, who will be more likely to have in place (or be willing to put in place through greater capital investment due to their increased potential for work) the necessary measures to comply with stricter OELs. This shift would likely be enhanced if the OEL is lowered and notification and health surveillance were to be required for more activities.

An important point to note across all of the different sectors is that working with asbestos across all of the different exposure groups is not something that can be avoided i.e. if asbestos is discovered in an old building being refurbished, a mine, a tunnel etc. then it must be safely treated and dealt with. The only alternative for clients would be to utilise a different company, who would be subject to meeting the same OELs (and by definition, subject to a similar set of costs to meet stricter OELs should they be introduced). This puts companies working with asbestos in a strong position when it comes to negotiating with clients (developers, public authorities, landowners, building owners, travel companies etc.) in terms of the increased costs of dealing with it. As such, it is highly likely that companies working in all sectors will be able to pass on any increased costs arising from stricter OELs (or at least a significant proportion of them), thereby bringing down the ratio of costs relative to turnover by increasing their turnover.

However, it is noted that if the cost increase were to be significant, it is possible that consumers may delay or abandon plans to, for example, carry out construction activities.

7.3.1.2 Firms exiting the market

As indicated in Chapter 6, it is not expected that significant numbers of companies would discontinue operation under the policy options considered in this study. However, it should be noted that the uncertainty regarding this conclusion increases with decreasing OELs. As indicated above, it is expected that companies operating in the sectors with workers exposed to asbestos would be able to pass on the increased costs to their clients due to the fact that it is not an option to not treat/remove/deal with asbestos. Where price rises result in consumers postponing or avoiding asbestos removal (reduction in the annual market), it is likely that the costs estimated in this report (which, as a proportion of turnover are more significant for SMEs), are likely to be more difficult for companies to absorb. SMEs involved in work with asbestos will find it more difficult to absorb the required cost increases and SME clients will find it more difficult to fund the costs of asbestos removal potentially impacting their activities.

It is possible that some of the companies operating in the exposure group “Building and construction - exposure situations subject to Article 3(3) waiver, 'incidental' exposure” might choose not to invest in RMMs and RPE required to meet the required lower OELs to enable them to carry on work with asbestos themselves. The introduction of lower OELs may result in a shift where more activities would be undertaken by specialised companies. This is not expected to lead to discontinuation of other companies working with waivers as working with ACMs is only a minor and not key activity for these companies.

7.3.1.3 Existing firms and new entrants

The analysis presented indicates that companies are not expected to leave the market at any of the OELs being suggested. However, there will likely be significant capital expenditures required for start-ups (to ensure that exposure to asbestos is within the OELs), and these will represent a barrier to trade for potential new entrants to the market, especially in case of SMEs. As OELs become stricter, the investment required increases, making entry to the market more difficult. Chapter 6 provides details on the levels of capital and operational expenditures required in the different exposure groups in order for companies to meet the OEL option, and as Table 7.7 above shows, in many sectors the ratio of capital to operational expenditure is relatively high. This suggests that it will be difficult for some new entrants to enter the market in all of the sectors identified as working with asbestos.

7.3.2 Consumers

As stated above in Section 7.3.1, it is expected that enterprises working with asbestos will be able to pass on costs arising from having to introduce additional RMMs and RPE in order to be able to comply with all of the stricter OELs. The nature of the activities involving asbestos means that the vast majority of works are carried out in-situ, which means that any international competitors would not be able to benefit from less strict regulatory regimes in third countries and would be required to operate under the same conditions (i.e. whichever EU OEL is adopted) as EU companies, incurring the same costs.

Customers of companies working with asbestos in each of the sectors (e.g. developers, public authorities, landowners, building owners, travel companies etc.) are therefore likely to face rises in prices at lower OELs.

Where price rises are more significant (especially under options 0.002 fibres/cm^3 and 0.001 fibres/cm^3, it is possible that customers may avoid or delay removing asbestos, thus resulting in a reduction in the annual demand for such services.

7.3.3 Internal market

Table 4.1 in Chapter 4 above sets out the different OELs identified as being applicable in EU Member States. As noted, only France (0.001 fibres/cm^3), the Netherlands (0.002 fibres/cm^3) and Germany (a binding OEL at 0.1 fibres/cm^3 and an "acceptance level" at 0.01 fibres/cm^3) have implemented OELs below the EU OEL of 0.1 fibres/cm^3.

Since there is a high degree of consistency across the EU in the limit values (albeit with some limited variance in specification of the OEL), companies operating with asbestos are required to do so on broadly similar terms in respect of the OELs, with those operating in France and the Netherlands on the face of it being at a disadvantage as they would be required to undertake stronger RMMs in order to comply with the regulations in their respective countries. However, the vast majority of work involving exposure of workers to asbestos is undertaken in situ, meaning that any company undertaking work that exposes workers to asbestos would be required to operate under the OEL imposed by the relevant Member State. Only limited activities, such as those within the exposure group “Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other” could conceivably be undertaken in a different Member State, although the associated transportation costs may be prohibitive. Companies carrying out activities in the exposure group “Sampling and analysis” would be more likely to be able to benefit from less strict regulations in their own Member State. In this case, the proposed significant reductions in the EU OEL will make it less likely for Member States to introduce their own stricter OELs (due to the difficulty in achieving them) and work to strengthen the level playing field across the EU.

The relative consistency already in OELs across Member States means that any benefit to the internal market that would arise from setting a harmonised OEL at a lower level (in terms of savings for companies researching OEL requirements in other Member States, being able to standardise operations in different Member States) would be limited and would most likely apply to situations where companies in Member States with a more stringent OEL send workers to carry out work in another Member State with a less stringent OEL but this work is carried with more effective RMMs than legally required due to the fact that it is not possible for this company to vary RMMs used by Member State. As can be seen in Table 7.8 below, in the majority of sectors, the numbers of large companies (most likely to be operating in more than one Member State) are limited, with less than 1% of all enterprises being large ones. Large companies represent between approximately 1.5% to 2.1% of all companies in four of the waste management sectors: E36.00 - Water collection, treatment and supply (2.1%), E38.11 - Collection of non-hazardous waste (1.6%), E38.12 - Collection of hazardous waste (1.6%) and E38.22 - Treatment and disposal of hazardous waste (1.5%). These same sectors, also have a larger share of medium sized companies than other sectors, ranging from 5% to 7.1%, with the only other sectors having higher shares of medium sized companies being F42.12 - Construction of railways and underground railways, F42.13 - Construction of bridges and tunnels and F42.11 - Construction of roads and motorways, in which it is estimated that 4.3% of companies are medium sized companies.

Table 7.8 Percentage share of companies in sectors working with asbestos, by size class (Source: Eurostat (2018) – Structural business statistics database)

Sector	Percentage of companies in sector		
	Small	Medium	Large
F41.20 Construction of residential and non-residential buildings	99.21%	0.73%	0.06%
F43.11 Demolition	99.60%	0.38%	0.02%
F43.12 Site preparation	99.60%	0.38%	0.02%
F43.21 Electrical installation	99.39%	0.55%	0.06%
F43.22 Plumbing, heat and air conditioning installation	99.39%	0.55%	0.06%
F43.29 Other construction installation	99.81%	0.15%	0.04%
F43.33 Floor and wall covering	99.81%	0.15%	0.04%
F43.34 Painting and glazing	99.81%	0.15%	0.04%
F43.39 Other building completion and finishing	99.81%	0.15%	0.04%
F43.91 Roofing activities	99.47%	0.49%	0.04%
F43.99 Other specialised construction activities n.e.c.	99.47%	0.49%	0.04%
F42.12 - Construction of railways and underground railways	94.71%	4.32%	0.97%
F42.13 - Construction of bridges and tunnels	94.71%	4.32%	0.97%
B08.11 - Quarrying of ornamental and building stone, limestone, gypsum, chalk and slate	96.68%	3.10%	0.22%
C33.14 Repair of electrical equipment	98.83%	1.00%	0.17%
C33.15 Repair and maintenance of ships and boats	98.83%	1.00%	0.17%
C33.16 Repair and maintenance of aircraft and spacecraft	98.83%	1.00%	0.17%
C33.17 Repair and maintenance of other transport equipment	98.83%	1.00%	0.17%

Sector	Percentage of companies in sector		
	Small	Medium	Large
D35.11 Production of electricity	99.23%	0.51%	0.26%
E36.00 Water collection, treatment and supply	92.87%	4.99%	2.14%
E38.11 Collection of non-hazardous waste	92.14%	6.27%	1.58%
E38.12 Collection of hazardous waste	92.14%	6.27%	1.58%
E38.22 Treatment and disposal of hazardous waste	91.47%	7.06%	1.47%
E38.31 Dismantling of wrecks	97.11%	2.56%	0.32%
E38.32 Recovery of sorted materials	97.11%	2.56%	0.32%
E39.00 Remediation activities and other waste management services	97.01%	2.65%	0.34%
G45.2 Maintenance and repair of motor vehicles	99.76%	0.20%	0.05%
M71.20 Technical testing and analysis	98.59%	1.15%	0.27%
F42.11 - Construction of roads and motorways	94.71%	4.32%	0.97%

7.4 Competitiveness of EU businesses

7.4.1 Cost competitiveness

A business's cost competitiveness can be negatively affected when its costs are raised in relation to their competitors. However, the introduction of stricter EU-wide OELs will apply to all companies engaged in work with asbestos, leading to cost increases for all those which do not currently meet the requirements.

It is noted that the cost model developed for this study assumes that within an exposure group, costs per company within a size category are the same (but different across size categories). This is irrespective of the specific sub-sector within the exposure group and of any variation in the current level of exposure at a particular company. In reality, different companies will be further or closer to achieving a particular OEL, with this leading to different levels of costs for individual companies in order to become compliant at lower OELs. Those companies which are already closer to any OEL being introduced will therefore be impacted less in terms of their cost competitiveness following the introduction of lower OELs. This is particularly relevant for companies working in France, the Netherlands and Germany where OELs are lower than the EU OEL of 0.1 fibres/cm^3. However, whilst on the face of it this might make them more cost competitive against companies traditionally working in other Member States, most of the work done with asbestos is carried out in-situ. For companies to secure work in other Member States they will need to travel, incurring additional costs as a result which would act to temper any advantage they might have from already having work systems set up to operate at reduced OELs, thereby not incurring additional costs.

7.4.2 Capacity to innovate

Potential impacts on companies' capacity to innovate have been outlined in Section 7.2 above. Primarily, the diversion of costs away from R&D may occur due to overall cost impacts of having to invest in RMMs in order to meet the prescribed OELs. However, in the case of asbestos related activities, it is considered possible/likely that companies will be able to pass on the costs to customers (as asbestos will need to be removed from buildings, made “safe” etc. in order for activities to be completed) and consequently any impact on R&D could be tempered.

7.4.3 International competitiveness

As the following figure shows, companies surveyed[59] for this study identified a greater impact on competitiveness outside the EU arising from the stricter OEL, although as indicated previously, most of the activities involving exposure to asbestos will be required to be undertaken in-situ, with limited opportunities for third country companies to compete with EU ones from a base outside the EU. A number of French companies identified significant negative impacts would arise from an EU OEL of 0.01 fibres/cm^3 across the EU, even though this is the current limit in France, potentially reflecting views on the current burden in France (as opposed to this limit being introduced across the EU) or maybe attempting to predict for other companies in other EU Member States. The number of responses from companies in other EU Member States was low, making it difficult to draw any specific conclusions.

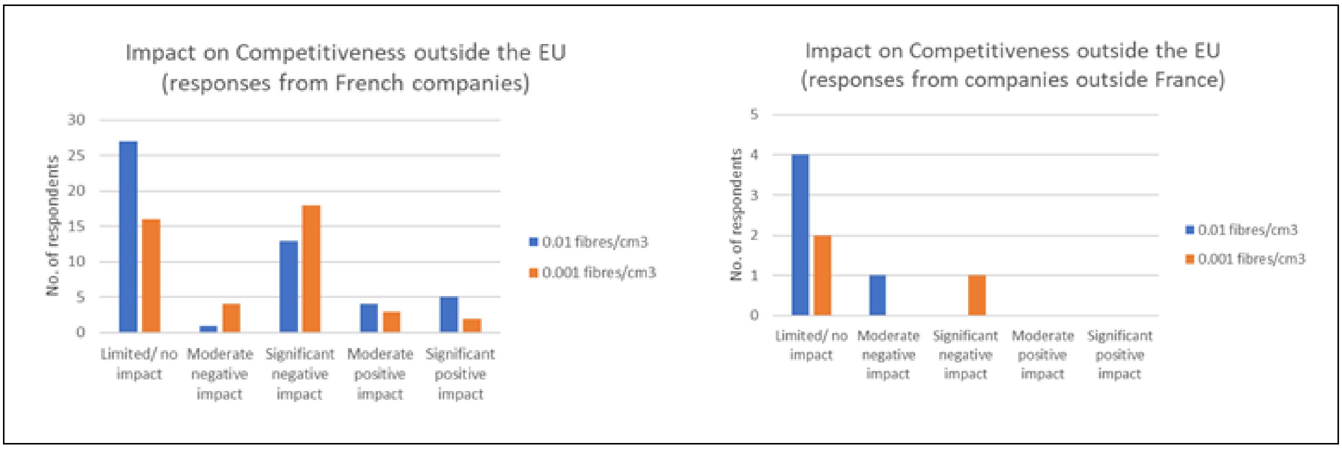

Figure 7.1 Impacts on competitiveness outside the EU (Source: consultation exercise for this study)

Regulatory differences in other parts of the world can potentially put EU companies at a disadvantage against third country competitors, particularly when regulations are less strict, enabling competitors to operate with lower costs. However, as stated above, most of the activities carried out in the sectors where workers are exposed to asbestos in the EU require being in-situ (e.g. repairing buildings, tunnelling, electrical installation etc.), where third country competitors would need to operate under the regulations of the EU. In this sense, there would be limited negative impacts on competitiveness of EU companies if the EU OELs were reduced from their current levels as foreign competitors would be required to operate under the same conditions, with all of the requisite RMMs to keep exposure below the EU OELs. It would appear that there are limited sectors where activities involving exposure to asbestos could be undertaken outside of the EU (potentially some under exposure group “Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other”.

In any event, a review of Table 4.1 shows that a significant number of third countries for which data has been identified have OELs of similar levels the EU OEL of 0.1 fibres/cm^3.

[59] Only a limited number of responses to the survey on asbestos were received. The majority of respondents to the survey were from France and as a result, the results have been separated to account for any potential bias arising from the particular circumstances existing in France, where the OEL for asbestos is below the EU OEL.

Only Switzerland (0.01 fibres/cm^3) and Japan (0.03$^+$ and 0.003^{++} fibres/cm^3)[60] have stricter OELs, with Canada, China, India and Russia having less strict requirements.

7.5 Employment

Under the proposed EU OELs, employment conditions and workers health are expected to improve. This is covered in further detail regarding the benefits (cost savings due to reduced ill health) of the EU OELs in Chapter 5. As indicated previously, it is not expected that a significant number of companies would discontinue operations as a result of the introduction of the stricter OELs being considered. Consequently, no significant net loss of employment is being predicted. However, it is possible that some jobs may move between the different exposure groups identified, with companies that have concentrated on carrying out notified work taking up some of the work that might previously have been carried out by companies operating under waivers. As companies in the latter group take on less of this work, there may be some resulting redundancies, but new jobs would be created in the more specialised companies that would likely carry out this work instead.

Specialised companies may be able to carry out the work with greater economies of scale than companies subject to Article 3(3) waiver and the net impact on employment may thus be negative.

As a consequence, there may be some impacts involved as listed below, but it has not been possible to determine the extent to which this shift in work will take place and consequently, no estimates have been made in terms of the valuation of these impacts.

- The value of output/wages lost during the period of unemployment;
- The costs of job search, hiring and firing employees;
- The “scarring effect”, i.e. the impact of being made unemployed on future employment and earnings; and
- The value of leisure time during the period of unemployment.

[60] Specification of OEL: - except chrysotile; fibres length > 5 µm; aspect ratio ≥3:1; K. $^+$Reference value corresponding to an individual excess lifetime risk of cancer 10^{-3}. $^{++}$Reference value corresponding to an individual excess lifetime risk of cancer 10^{-4}.

8. Distributional effects

The impacts identified under the previous tasks will be broken down by stakeholder type and an analysis of who will bear the costs and accrue the benefits will be provided.

This section comprises the following subsections:

- Section 8.1: Businesses
- Section 8.2: SMEs
- Section 8.3: Workers
- Section 0: Consumers
- Section 8.5: Taxpayers/public authorities
- Section 8.6: Specific Member States/regions
- Section 8.7: Different timeframes for costs and benefits

8.1 Businesses

The benefits (i.e. cost savings due to reduced ill health) to businesses from the introduction of stricter OELs, set out in Section 5.5 above, are composed of cost savings (arising from avoided sick leave, improved labour productivity and reduced administrative and legal costs like replacing employees), as well improvements in labour productivity.

Costs to businesses arise from making adjustments to working practices in order to comply with the EU OEL and consist of incremental costs of RMMs (including RPE), cost of notification and medical surveillance, monitoring costs and training costs. A summary of costs and benefits for businesses are included in Table 8.1 below.

Table 8.1 Costs and benefits to businesses

Sector	0.001 fibre/cm^3	0.002 fibre/cm^3	0.01 fibre/cm^3
Benefits	**€2,100,000**	**€2,000,000**	**€1,700,000**
Compliance costs	**€89,000,000,000**	**€ 73,000,000,000**	**€ 23,000,000,000**
Net benefit (benefits – costs)	-€ 88,997,900,000	-€ 72,998,000,000	-€ 22,998,300,000

Note: The figures for compliance costs differ slightly from those presented in Table 6.18 in Section 6.3. This is due to the fact that the figures in Table 6.18 do include broad estimates for Exposure Group 3, but these are extremely uncertain and have not been included in the above figures.

Source: study team's calculation

The benefits of healthier staff could have indirect effects on the reputation of the sectors and associated companies, as work with asbestos may be less perceived as a risky line of work associated with health issues. As a result of such an improvement in their public image, companies may find it easier to recruit and retain staff, reducing the cost of recruitment and increasing the productivity of workers.

8.2 SMEs

The numbers of small, medium and large enterprises likely to have workers exposed to asbestos in the EU is estimated in Table 4.54 in Section 4.12. Table 8.2 below shows that the vast majority of companies with exposed workers and which will likely be affected by the reduction in OELs are small companies. Across all sectors, 99.32% of these companies are small companies.

Setting OELs at lower levels will require companies to adopt new and a greater number of RMMs and provide more RPE, resulting in increased costs. Table 7.6 above in Section

7.3.1.1 draws out the significance of those increased costs in respect of the average turnover of companies operating in the sectors using asbestos. The results show that the ratio of costs/turnover for small companies is greater than for medium and large companies at all OELs and in some cases (in sectors F43.39 Other building completion and finishing, C33.14 Repair of electrical equipment, C33.15 Repair and maintenance of ships and boats, M71.20 Technical testing and analysis and G45.2 Maintenance and repair of motor vehicles), the ratio of costs/turnover is predicted to be over 10% for both the 0.002 and 0.001 fibres/cm^3 OELs and up to close to 30% for the latter.

Table 8.2 Companies involved in work with asbestos within the scope of exposure levels at or above 0.002 fibres/cm^3 by size of company and by sector

Exposure group	Main sectors	Total	Small	%	Medium	%	Large	%
Building and construction - exposure situations subject to notification	F41 - Construction of buildings	2,399	2,381	99.25%	17	0.71%	1	0.04%
	F43 - Specialised construction activities	33,600	33,395	99.39%	186	0.55%	19	0.06%
	Potentially many sectors (e.g. D35 and E39; SCOLA database lists up to 24 sectors)	12,001	11,901	99.17%	68	0.57%	32	0.27%
Building and construction - exposure situations subject to Article 3(3) waiver, 'incidental' exposure	F41 - Construction of buildings	200,000	198,428	99.21%	1,454	0.73%	118	0.06%
	F43 - Specialised construction activities (selected sub-sectors)	1,000,001	993,907	99.39%	5,531	0.55%	563	0.06%
	Potentially many sectors (e.g. D35 and E39; SCOLA database lists up to 24 sectors)	300,000	297,517	99.17%	1,690	0.56%	793	0.26%
Building and construction - passive exposure in buildings	Many sectors	No data	No data	No data	No data	No data	No data	No data
Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other	C33 - Repair and installation of machinery and equipment (selected sub-sectors)	300	296	98.67%	3	1.00%	1	0.33%
	G45 - Wholesale and retail trade and repair of motor vehicles and motorcycles	50	50	100.00%	0	0.00%	0	0.00%
Waste management	E36 - Water collection, treatment and supply	300	279	93.00%	15	5.00%	6	2.00%
	E38 - Waste collection, treatment and disposal activities; materials recovery	2,200	2,027	92.14%	138	6.27%	35	1.59%
Mining and quarrying - naturally occurring asbestos	B08.11 - Quarrying of ornamental and building stone, limestone, gypsum, chalk and slate	251	242	96.41%	8	3.19%	1	0.40%

Exposure group	Main sectors	Total	Small	%	Medium	%	Large	%
Tunnel excavation	F42.12 - Construction of railways and underground railways	9	9	100.00%	0	0.00%	0	0.00%
	F42.13 - Construction of bridges and tunnel	40	38	95.00%	2	5.00%	0	0.00%
Road construction and maintenance	F42.11 - Construction of roads and motorways	1,100	1,042	94.73%	47	4.27%	11	1.00%
Sampling and analysis	M71.20 Technical testing and analysis	440	434	98.64%	5	1.14%	1	0.23%
Summary (rounded)		**1,550,500**	**1,540,000**	**99.32%**	**9,000**	**0.58%**	**1,500**	**0.10%**

Source: Eurostat and study team's calculation

Data on the costs as a proportion of turnover of companies are presented in Section 7.3, broken down by company size, sector and OEL. It is recognised that in some sectors, the costs of the lower two OEL options expressed as % of turnover shown in Section 7 are significant for companies in some sectors (>20%). Greater costs as % of turnover are especially the case for SMEs. When expressed as % of profits or investment, these costs would be even greater. Although these costs are likely, to a large extent, to be passed on to the customers, they may result in some companies abandoning the market and the transfer of the relevant activities to other companies. These issues may be greatest significance to small companies.

Where price rises result in consumers postponing or avoiding asbestos removal (reduction in the annual market), it is likely that the costs estimated in this report (which, as a proportion of turnover are more significant for SMEs), are likely to be more difficult for companies to absorb. SMEs involved in work with asbestos will find it more difficult to absorb the required cost increases and SME clients will find it more difficult to fund the costs of asbestos removal potentially impacting their activities.

8.3 Workers

Benefits to workers comprise of the avoided costs of ill-health, defined as the cost of ill health in the baseline scenario, less the cost of ill health following the introduction of an OEL.

Table 8.3 Benefits and costs to workers and their families

Sector	0.001 fibre/cm^3	0.002 fibre/cm^3	0.01 fibre/cm^3
Benefits (cost savings due to reduced ill health)	€220,000,000 - €420,000,000	€210,000,000 - €410,000,000	€170,000,000 - €320,000,000
Costs	-	-	-
Net benefit (benefits – costs)	€220,000,000 - €420,000,000	€210,000,000 - €410,000,000	€170,000,000 - €320,000,000

Source: study team's calculation

Family members may also benefit from reduced risk of illness resulting from asbestos fibres being brought into the home following improved and increased RMMs in the workplace. In addition, the wider public may benefit from reductions in the generation and spreading of dust in surrounding areas as a result of increase/improved RMMs.

8.4 Consumers

The ability of companies working with asbestos to pass on increases in costs arising from working under stricter OELs (due to the essential nature of the work being carried out) means that their customers will face higher prices as a result. These customers will include developers, public authorities, other companies further down the supply chain etc.

8.5 Taxpayers/public authorities

The benefits of the avoided costs of ill health relative to the baseline to the public sector are composed of cost of treatment and tax revenue, as summarised in the table below. These costs include healthcare treatment costs, which assume that the costs are borne by the public sector.

Costs to the public authorities will include transposing regulations to accommodate changes in OELs (including costs of any impact assessments required), changing guidelines (including recommended measures to ensure occupational exposure concentrations are well below the OEL) and enforcement, monitoring and adjudication costs.

Table 8.4 Costs and benefits to taxpayers/public authorities

Sector	0.001 fibre/cm^3	0.002 fibre/cm^3	0.01 fibre/cm^3
Benefits	**€4,500,000**	**€4,300,000**	**€3,400,000**
Costs: Transposition Guidelines Enforcement etc.	 **€1,350,000** **€1,350,000** **€4,200,000,000**	 **€1,300,000** **€1,300,000** **€2,800,000,000**	 **€750,000** **€750,000** **€1,400,000,000**
Net benefit (benefits – costs)	**-€ 4,198,200,000**	**-€ 2,798,300,000**	**-€ 1,398,100,000**

Source: study team's calculation

8.6 Specific Member States/regions

Companies working with asbestos are spread throughout the EU. Data limitations mean that it has not been possible to identify the spread of asbestos related activities or numbers of companies with exposed workers at Member State level. As such, it is difficult to determine any impacts that would likely occur in some Member States and not others.

However, it is noted that France and The Netherlands have current OELs of 0.01 fibres/cm^3 and 0.002 fibres/cm^3 respectively, and Germany has a binding OEL at 0.1 fibres/cm^3 and an "acceptance level" at 0.01 fibres/cm^3). With the current EU OEL being set at 0.1 fibres/cm^3, a move to any of the proposed EU OELs would mean that a large proportion of companies in France, The Netherlands and Germany would already be compliant, or close to complaint with the new EU OEL introduced. This is particularly the case at 0.01 fibres/cm^3 in all three Member States and companies in The Netherlands would already be compliant if an OEL of 0.002 fibres/cm^3 were introduced. As a result, these companies would incur lower costs than their counterparts in other Member States.

8.7 Different timeframes for costs and benefits

Exposure to asbestos does not immediately result in visible negative health impacts and there is a latency period for effects to emerge once workers are exposed. Consequently, introducing a stricter EU OEL which reduces exposure would not see benefits arising in terms of reduced incidence of lung cancer and mesothelioma until sometime in the future.

The latency period for lung cancer and mesothelioma arising from exposure to asbestos is estimated at 30 years. Cases arising from exposure in year 40 but which do not become visible until after the 30-year latency period are also included in the benefits modelling.

On the other hand, the introduction of lower EU OELs will require companies to implement measures immediately in order to comply with the regulations. This will incur costs for companies from the moment that the EU OELs are introduced and will consist of capital expenditures and operational expenditures, covering RMMs and RPE, training, monitoring, notification etc. It is noted that the cost model utilised for this study assumes an investment cycle of 20 years for the sectors with workers exposed to asbestos. Consequently, it is assumed that the capital expenditures required will be made at the start and then again after 20 years to update and improve equipment further. Operational expenditures will be carried out throughout the 40-year assessment period.

The following diagram provides a generic illustration of the timing of the costs and benefits.

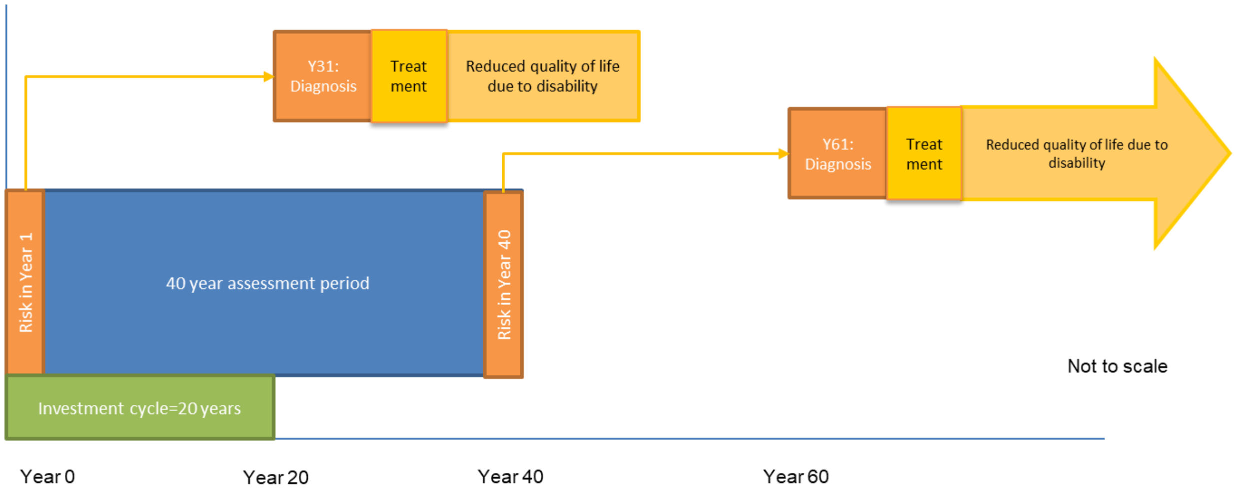

Figure 8.1 Assessment timeline

Source: developed by the study team

9. Environmental Impacts

This section considers the environmental impacts of new occupational exposure limits (OELs), for asbestos.

9.1 Persistent, bio-accumulative, and toxic (PBT) screening

The table below outlines the Persistent, Bio-accumulative, and Toxic (PBT) assessment status of asbestos fibres. To be classified as PBT, all three criteria must be fulfilled. The following table outlines the PBT status and harmonised classification for each selected asbestos, see table 9.1.

Table 9.1 PBT and harmonised classification status of asbestos

Asbestos	P	B	T	PBT	Harmonised classification
Crocidolite	Y	N	Y	N	Recognised carcinogen; Known to causes damage to organs through prolonged or repeated exposure
Amosite	Y	N	Y	N	Recognised carcinogen; Known to causes damage to organs through prolonged or repeated exposure
Anthophyllite	Y	N	Y	N	Recognised carcinogen; Known to causes damage to organs through prolonged or repeated exposure
Actinolite	Y	N	Y	N	Recognised carcinogen; Known to causes damage to organs through prolonged or repeated exposure
Tremolite	Y	N	Y	N	Recognised carcinogen; Known to causes damage to organs through prolonged or repeated exposure
Chrysotile	Y	N	Y	N	Recognised carcinogen; Known to causes damage to organs through prolonged or repeated exposure

Source: ECHA Substance Infocards

9.1.1 Persistent

Asbestos fibres do not biodegrade and as such are persistent in the environment. It should also be noted that asbestos fibres have relatively high biopersistance in the lungs which contributes to the overall risk to human health.

9.1.2 Bio-accumulative

Asbestos fibres are not able to be absorbed into the tissues of living organisms and as such are not bio-accumulative within food chains.

9.1.3 Toxicity

The toxicity of asbestos fibres is relatively consistent across the various substances. In general, asbestos fibres are classified under CLP Regulation (1272/2008) and harmonised classification as carcinogenic substances. In addition to this asbestos fibres are also classified as STOT RE 1 (toxic to humans or toxic effect in animal experiments after repeated exposures).

9.1.4 PBT conclusion

In conclusion, asbestos fibres do not meet the required thresholds to qualify as PBT (persistent, bio-accumulative and toxic) or vPvB (very persistent and very bio-accumulative).

9.2 Current environmental exposure

9.2.1 Sources

Natural sources of asbestos can result in releases of asbestos fibres to the environment via weathering processes of naturally occurring mineral deposits. Whilst asbestos is contained within the mineral deposit, no risk is posed from the substance.

Anthropogenic activities such as construction or mining often result in the disruption of naturally occurring asbestos resulting in releases of fibres. In addition to this, the dumping of asbestos wastes and demolition/maintenance work on buildings also relate to releases of asbestos fibres. Due to the persistence of asbestos, once released into the atmosphere these fibres have potential to be transported long distances from the original source which may result in risks to a wider area than just surrounding the point source.

9.2.2 Background exposure to asbestos

In rural areas background levels of asbestos (chrysolite) have been relatively consistent for the last ten thousand years. In these areas, far removed from the releases associated with anthropogenic activities, asbestos fibres are rarely found at levels in excess of 1 ng/m^3 with an average of around 0.00001 fibres/cm^3. In contrast a review of 20 studies published in 2003 found urban levels of asbestos were around 10fold higher with values generally below 10 ng/m^3 or 0.0001 fibres/cm^3 highlighting the impact of anthropogenic sources on background asbestos levels (INSPQ, 2011). A literature search was conducted for more up to date information regarding background levels of asbestos. This was unsuccessful due to the majority of recent papers addressing asbestos in regions not comparable to the EU or in specific workplace environments.

9.2.3 Environmental levels in relation to hazard data

As environmental releases of asbestos arise from different sources it is difficult to quantify the release to each environmental compartment (air, water, soil, sediment and biota). Table 9.2 below highlights the reported values for releases of asbestos to the environment from the European Pollutant Release and Transfer Register (E-PRTR). Due to the difficulties mentioned above the data provided are relatively incomplete and should not be seen as providing a thorough overview of asbestos releases to the environment.

*Table 9.2 Emission of asbestos in EU27 countries in kg**

Country	Air	Water
Germany	**2.0** (2008)	-
Ireland	-	**14.8** (2009)
Italy	**9.5** (2018)	-

** The unit of kg has been assumed as no units are stipulated in the E-PRTR summary table.*

Note: No data were found for releases to Soil, Sediment or Biota

Source: Source: E-PRTR Summary Table

9.2.4 Conclusions

In conclusion current environmental exposure to asbestos is thought to be relatively low, as releases only occur through specific anthropogenic activities or natural weathering. Currently there is limited data on the releases of asbestos to various environmental compartments, but it can be expected that once released, asbestos will remain in the environment for a relatively long timeframe.

9.3 Waste management and disposal

Waste which contains asbestos fibres is viewed as hazardous in the EU and is therefore disposed of as hazardous waste or as building waste for landfill. Particular issues with asbestos relate to the dismantling and demolition of buildings for which best practice varies between Member States.

Under article 6 of the asbestos at work directive it is stated that 'waste must be collected and removed from the place of work as soon as possible in suitable sealed packaging with labels indicating that it contains asbestos' (Directive 2009/148/EC). Suitable containers are defined as tear proof bags or metal/plastic containers which can be secured with locking rings. On receipt of the waste a two-chamber material lock should also be used where containers of asbestos waste are cleaned thoroughly and subject to a 30 times air change. In addition, only trusted couriers should be used and packaged waste should not be thrown or overturned (European Commission, 2012). In the event of the packaging breaking or being poorly sealed then potential releases to the environment may occur. Releases may also arise in the landfill process whilst disposing of building waste. However, if the above procedures are followed then the release of asbestos to the environment is likely to be minimal alongside the risks posed to human health.

9.4 Impact of introducing new risk management measures (RMMs) on environmental exposure

The new risk management measures proposed are an extension of the effective pre-existing measures and as such are unlikely to significantly reduce the overall environmental exposure of asbestos fibres. However, extension of these measures may still result in small improvements, for example the increased use of local ventilation equipped with high efficiency filters may result in the removal of an increased number of asbestos fibres reducing total environmental releases.

9.5 Conclusion

Releases of asbestos are believed to be relatively low, despite little measured data on this, due to the careful management of both asbestos waste and demolition/maintenance activities involving asbestos in buildings. Due to these low release levels the environmental impacts of asbestos are believed to be relatively low in spite of asbestos fibres persistence and toxicity. In addition, further RMMs (risk management measures) may help to marginally improve environmental exposure to asbestos however significant differences are unlikely to be recognised.

10. Limitations and sensitivity analysis

10.1 Overview of limitations and uncertainties

This section sets out the key limitations and uncertainties and considers their potential impact on the conclusions. The different types of uncertainties remain summarised below and their significance for the results of this study is assessed. A more detailed assessment of some of these limitations and uncertainties is provided in the second part of this section, where a number of sensitivity scenarios are presented.

Table 10.1 Overview of the key limitations and uncertainties and their significance

Limitation or uncertainty	Explanation	Uncertainty may have high (H) , low (L) or insignificant (I) impact on the estimates Estimates in this study are likely U (underestimates) or O (overestimates) (¥) : Uncertainties on costs and benefits are linked	
		Costs	Benefits
Included in the sensitivity analysis			
Exposed workforce, exposure group 2	The estimated workforce is subject to some uncertainty. Within this group, a significant part of the exposed workforce may be self-employed. Estimates on total number of workers within this group as reported in national surveys do in general not specify whether self-employed are included in the estimates. The total number will both influence the benefits and the costs and the uncertainly will have limited influence on the costs to benefits ratio. For exposure group 2, in addition to the uncertainty on the total number of exposed workers, a major uncertainty is linked to the fact that many of the workers are only exposed sporadically which influences both the benefits and costs estimated for this group. To take this into account a reduction factor of 50% was applied to both benefits and costs in the main analysis. The impacts of 25% and 75% reduction factors are explored in this section.	H ; O/U (¥)	H ; O/U (¥)
The latency period for the cancer endpoints	A common ERR is derived for lung cancer and mesothelioma. However, the latency period is different for the two endpoints with significantly longer latency period for mesothelioma than for lung cancer. The estimation is done so that all cases that will occur over the assessment period are included in the benefit estimation. However, the longer the latency the more heavily discounted are the benefits. A median 30-year latency has been assumed in this study. The sensitivity analysis explores the effect of a shorter latency, which is more characteristic for the lung cancer endpoint. Shorter latency will increase the benefits, costs will remain unaffected.	Not relevant	H ; U
Discount rate	The estimates in this report have all been modelled using a static discount rate. A declining discount rate has been assessed. The assessment below shows that a declining discount rate would increase both the costs and the benefits. The impacts of using a declining discount rate could be magnified when taking the shorter latency into account (see uncertainty above). The use of declining discount rate will increase the benefits. The costs will also increase as a result of declining discount rate, however, the increase will not be as noticeable as in case of benefits.	I ; U	H ; U

Limitation or uncertainty	Explanation	Uncertainty may have high (H) , low (L) or insignificant (I) impact on the estimates Estimates in this study are likely U (underestimates) or O (overestimates) (¥) : Uncertainties on costs and benefits are linked	
		Costs	Benefits
	In addition, it has been indicated that the revised better regulation guidelines will include a revised tool on the discount rates. The use of reduced discount rates is being discussed for the risk to life values. In order to explore the effects of the potential reduction of the discount rate, the effects of 1.5% declining discount rate applied to risk to life values (avoided costs of ill health) have been modelled.		
Not included in the sensitivity analysis			
Exposed workforce, other exposure groups	The estimated workforce is subject to some uncertainty. For the other exposure groups, the uncertainty is considered to go in various directions for the different sectors, and the total uncertainty is considered to be relatively low. The total number will both influence the benefits and the costs and the uncertainly will have limited influence on the costs to benefits ratio.	L ; O/U (¥)	L; O/U (¥)
Workforce exposure below the assessed level	The contribution of exposed workforce below the assessed level to the total occupational burden of disease and considered to have insignificant influence on the result	I; -	I; -
Workforce turnover	The workforce turnover rate does not have a significant impact on the estimated benefits because the maximum time required to develop the condition maxEX is set at 40 years. The impacts of monetised health impacts are limited and no specific scenario is assessed.	I; -	I; -
Additional cancer endpoints	Some cancer endpoints such as tracheal cancer have not been included in the exposure risk relationship (ERR.) The link between the cancer and exposure to asbestos is more uncertain for other cancers as compared to the cancers included in the ERR, and the underestimation of not including these other cancer endpoints is considered to be low.	Not relevant	L; U
Non-cancer endpoints	While the cancer endpoint is assessed to be the most important, there are other forms of health effects such as pleural plaques and pleural thickenings which are not quantified. Asbestos related cancer risks occur, and can be quantified, at lower levels than the non-malignant health effects and the health significance of non-cancer endpoints is not precisely defined. Asbestosis is not considered to be induced at exposure levels below the current EU OEL and is consequently not included in the estimate of future disease burden. The total benefits underestimate of not including the non-cancer endpoints is considered to be low.	Not relevant	L; U
RMMs in place	The assumptions about risk management measures (RMMs) in place impact on the costs since it is costlier for a company that already has RMMs in place to make improvements. Furthermore, it has been uncertain to what extent the RMMs in place may be used more efficiently in order to comply with the lower OELs without investment in new RMMs, but at higher staff costs. As each company undertake many different operations with different exposure levels and different use of RMMs it has proven difficult to undertake a detailed assessment of the need for new technical and organisational measures. The uncertainties may have high	H ; U/**O**	Not relevant

Limitation or uncertainty	**Explanation**	**Uncertainty may have high (H) , low (L) or insignificant (I) impact on the estimates Estimates in this study are likely U (underestimates) or O (overestimates) (¥) : Uncertainties on costs and benefits are linked**	
		Costs	**Benefits**
	influence on the costs estimates, and the costs of RMMs may both under or overestimate the actual costs.		
Slope of ERR	There are uncertainties in the evidence available to develop the ERR. The uncertainties are e.g. linked to the different analytical methods used (phase-contrast microscopy PCM vs electron microscopy EM) and to the derivation of ERR at relatively low concentrations from epidemiological data where workers were exposed to higher concentrations. The uncertainty could go in both directions, however, the applied ERR is relatively low compared the ERRs developed by other authorities. It is beyond the scope of this assessment to perform a sensitivity analysis of the applied ERR which has been derived by ECHA.	Not relevant	Not assessed; O/U
Exposure concentration distributions and compliance model	The applied exposure concentration distributions influence the ratio between P95 (used for compliance assessment) and the AM (major parameter for the benefits assessment). Very few data are available on the actual exposure distributions and exposure levels when RPE is taken into account. The exposure distributions have been determined under the assumption that the majority of companies are in compliance with the existing OELs in the Member States and that the P95 to AM ratio is lower for the distributions where RPE is taken into account as compared to the distributions where RPE is not taken into account (where the distributions are in accordance with the default distributions used in previous CMD projects)	H ; O/U (¥)	H ; O/U (¥)
Future trends	Exposed workforce is assumed to increase for the first ten years, then level of for a period and finely steeply decrease until the end of the 40-years assessment period. As the majority of the asbestos is likely to be removed within the 40-years period, the exact trends during the period will have an insignificant influence on the total benefits. It may have a small influence on total costs as the discounting will depend on when during the period the costs are incurred.	L; O/U	I; -
Positive bias in reported data	Data reported by companies for the stakeholder assessment has only been used to a limited extend to determine actual exposure concentrations and the use of RMMs. In the use of the data, the current national OELs in the Member States has been taken into account. Bias in the reported data for the stakeholder consultations is considered to have insignificant influence on the results.	I; -	I; -
Article 3 (3) waiver	For exposure group 2, it is uncertain to what extent lowering the OEL will require more works to be notified and more workers to be under health surveillance. Some of the activities may be taken over by companies where workers are already under health surveillance which may lower the estimated costs of health surveillance. For the notifications, the estimated costs will be the same independent of which companies undertake the works. The effect on the uncertainty on the total compliance costs of companies is considered to be low and the costs may be both under- and overestimated.	L; O/U	Not relevant

Limitation or uncertainty	Explanation	Uncertainty may have high (H) , low (L) or insignificant (I) impact on the estimates Estimates in this study are likely U (underestimates) or O (overestimates) (¥) : Uncertainties on costs and benefits are linked	
		Costs	Benefits
Monitoring costs	Uncertainty about the number of measurements used for monitoring compliance. Laboratories and companies providing sampling services may need to build up capacity. No data are available to demonstrate that the number of measurements actually increased when lower OELs were introduced in the Netherlands and France but it is noted that the number of measurements in France are relatively high compared with other Member States.	L ; U	Not relevant
Effects of establishing OELs for other substances under this study	For some demolition works and exposure by waste handling, workers may be exposed to both lead and asbestos. The RMMs established in order to comply with a lower OEL for lead and its compounds may in principle also have an effect on the exposure to asbestos. Typically, asbestos and lead and its compounds are not used in the same materials and consequently establishing a lower OEL for lead and its compounds is considered to have an insignificant effect on the exposure to asbestos and *vice versa.* Establishing an OEL for lead is considered not to have any significant influence on the costs or benefits of establishing a lower OEL for asbestos.	I; -	I; -
Assessment period	The reference period of 40 years for this study was selected to be consistent with previous Commission Impact Assessments. The estimation of costs and benefits take latency periods etc. into account. The length of the period does not affect the results.	No effect	No effect

Note: " - " means that the estimates could be both over- or underestimated but the uncertainty is insignificant.

Source: developed by the study team

10.2 Basis for sensitivity analysis

During the following analyses, the cost benefit ratios are the ratio of all costs divided by all benefits. All costs comprise the compliance, monitoring, transposition and social costs. The main scenario is the scenario developed throughout the report and presented in the previous sections. The compliance costs for the main scenario come from Table 6.23. The transposition costs and other costs for public authorities come from Table 6.26, see Section 6.

The benefits element (i.e. cost savings from avoided ill health) is based upon Method 1 and Method 2, shown in Table 5.16 and Table 5.18, respectively.

10.3 Key limitations and uncertainties

10.3.1 Declining discount rate and a shorter latency period

Exposure to asbestos does not immediately result in visible negative health impacts and there is a latency period for effects to emerge once workers are exposed. Consequently, introducing a stricter EU OEL which reduces exposure would not see benefits arising in terms of reduced incidence of lung cancer, mesothelioma, laryngeal cancer and ovarian cancer until sometime in the future. The latency period for lung cancer and mesothelioma arising from exposure to asbestos is estimated at 30 years. Cases arising from exposure in year 40 but which do not become visible until after the 30-year latency period are also included in the benefits modelling.

On the other hand, the introduction of lower EU OELs will require companies to implement measures immediately in order to comply with the regulations. The cost model utilised for this study assumes an investment cycle of 20 years for the sectors with workers exposed to asbestos. Consequently, it is assumed that the capital expenditures required will be made at the start and then again after 20 years to update and improve equipment further. Operational expenditures will be carried out throughout the 40-year assessment period. The effect of declining discount rate is considered to be less noticeable in case of costs as they are realised from the beginning of the assessment period and are therefore not as heavily discounted as benefits (resulting from costs savings of avoiding cases of mesothelioma, lung cancer, laryngeal cancer and ovarian cancer).

As described in Section 2, a common ERR is derived for lung cancer and mesothelioma. However, the latency period is different for the two endpoints with significantly longer latency period for mesothelioma than for lung cancer. The estimation is done so that all cases that will occur over the assessment period are included in the benefit estimation. However, the longer the latency the more heavily discounted are the benefits. A median 30-year latency has been assumed in this study. The sensitivity analysis explores the effect of a shorter latency, which is more characteristic for the lung cancer endpoint. Assuming a 10-year latency increases the benefits significantly. The impacts are shown in Table 10.2 below.

Table 10.2 Sensitivity of a shorter latency period on the cost, benefits relative to the baseline and CBR, for each OEL & benefit methods (€ million)

fibre/cm^3	0.001	0.002	0.01	0.1
Main				
Benefits M1	€ 420 million	€ 410 million	€ 330 million	€0 million
Benefits M2	€ 220 million	€ 210 million	€ 170 million	€0 million
Cost	€ 94,000 million	€ 76,000 million	€ 24,000 million	€0 million
CBR M1	220	190	70	0
CBR M2	430	360	140	0
Shorter latency				
Benefits M1	€ 1,000 million	€ 990 million	€ 790 million	€0 million
Benefits M2	€ 530 million	€ 520 million	€ 410 million	€0 million
Cost	€ 94,000 million	€ 76,000 million	€ 24,000 million	€0 million
CBR M1	90	80	30	0
CBR M2	180	150	60	0

Source: study team's calculation

The declining discount rate starts at 4% for the first 20 years; it then decreases to 3% for the remaining 20 years. The impacts of the declining discount rate are shown in Table 10.3 below.

Table 10.3 Sensitivity of declining discount rate on the cost, benefits relative to the baseline and CBR, for each OEL & benefit methods (€ million)

fibre/cm³	0.001	0.002	0.01	0.1
Main				
Benefits M1	€ 420 million	€ 410 million	€ 330 million	€0 million
Benefits M2	€ 220 million	€ 210 million	€ 170 million	€0 million
Cost	€ 94,000 million	€ 76,000 million	€ 24,000 million	€0 million
CBR M1	220	190	70	0
CBR M2	430	360	140	0
Declining discount rate				
Benefits M1	€ 630 million	€ 610 million	€ 490 million	€0 million
Benefits M2	€ 330 million	€ 320 million	€ 250 million	€0 million
Cost	€ 97,000 million	€ 78,000 million	€ 25,000 million	€0 million
CBR M1	150	130	50	0
CBR M2	290	240	100	0

Source: study team's calculation

The impacts of a 1.5% discount rate applied to risk to life values are shown in Table 10.4 below.

Table 10.4 Sensitivity of 1.5% discount rate applied to risk to life values relative to the baseline and CBR, for each OEL & benefit methods (€ million)

fibre/cm³	0.001	0.002	0.01	0.1
Main				
Benefits M1	€ 420 million	€ 410 million	€ 330 million	€0 million
Benefits M2	€ 220 million	€ 210 million	€ 170 million	€0 million
Cost	€ 94,000 million	€ 76,000 million	€ 24,000 million	€0 million
CBR M1	220	190	70	0
CBR M2	430	360	140	0
1.5% discount rate				
Benefits M1	€ 1,700 million	€ 1,600 million	€ 1,300 million	€0 million
Benefits M2	€ 850 million	€ 830 million	€ 660 million	€0 million
Cost	€ 94,000 million	€ 76,000 million	€ 24,000 million	€0 million
CBR M1	55	48	18	0
CBR M2	110	92	36	0

Source: study team's calculation

10.3.2 Exposed workforce – Exposure Group 2

As discussed in Section 4.4, the estimated exposed workforce is subject to some uncertainty. For exposure group 2, in addition to the uncertainty on the total number of exposed workers, a major uncertainty is linked to the fact that many of the workers are only exposed sporadically, which influences both the benefits and costs estimated for this group. To take this into account a 50% reduction factor has been applied for this group for both benefits and costs.

Costs and benefits estimated for Exposure Group 2 for a reduction factor of 75% and 25% are given below. It will not affect the cost benefit ratio significantly, but it will affect the total costs.

Table 10.5 Sensitivity of sporadic exposure (25% or 75%) on the cost, benefits relative to the baseline and CBR, for each OEL & benefit method (€ million)

fibre/cm^3	0.001	0.002	0.01	0.1
Low (75% reduction factor)				
Benefits M1	€ 260 million	€ 250 million	€ 200 million	€0 million
Benefits M2	€ 140 million	€ 130 million	€ 100 million	€0 million
Cost	€ 81,000 million	€ 64,000 million	€ 20,000 million	€0 million
CBR M1	310	260	100	0
CBR M2	580	490	200	0
Main (50% reduction factor)				
Benefits M1	€ 420 million	€ 410 million	€ 330 million	€0 million
Benefits M2	€ 220 million	€ 210 million	€ 170 million	€0 million
Cost	€ 94,000 million	€ 76,000 million	€ 24,000 million	€0 million
CBR M1	220	190	70	0
CBR M2	430	360	140	0
High (25% reduction factor)				
Benefits M1	€ 590 million	€ 570 million	€ 460 million	€0 million
Benefits M2	€ 310 million	€ 300 million	€ 240 million	€0 million
Cost	€ 113,000 million	€ 92,000 million	€ 30,000 million	€0 million
CBR M1	190	160	65	0
CBR M2	370	310	130	0

Source: study team's calculation

11. Comparing the options

The comparison of options entails the following sections:

- Section 11.1: Cost-benefit assessment (CBA)
- Section 11.2: Multi-criteria analysis (MCA)
- Section 11.3: Highlighted issues

11.1 Cost-benefit assessment (CBA)

The table below summarises the benefits (cost savings from reduced ill health) associated with the OEL options, as also assessed in section 5 above. The cost savings due to reduced ill health are for the present value (PV) over 40 years with a static discount rate of 4%.

11.1.1 Overview of the benefits for the reference OELs

Table 11.1 Overview of the benefits (cost savings due to reduced ill health) per OEL

Impact	Stakeholders affected	OEL options (fibres/cm^3)			
		0.001 fibres/cm^3	0.002 fibres/cm^3	0.01 fibres/cm^3	0.1 fibres/cm^3 (baseline)
Direct benefits – improved well-being - health					
Reduced cases of ill health (lung cancer, mesothelioma, laryngeal cancer and ovarian cancer)	Workers & families	860	830	660	0
Ill health avoided, incl. intangible costs (M2 to M1)	Workers & families	€215 – 418 million	€208 – 405 million	€166 – 323 million	€0
Avoided costs	Companies	€2.1 million	€2.0 million	€1.7 million	€0
Avoided costs	Public sector	€4.5 million	€4.3 million	€3.4 million	€0
Social policy agenda	All	Contribution to Green Deal: Chemicals Strategy towards a toxic-free environment			
Direct benefits – improved well-being - environmental					
Environmental releases	All	No impact/limited impact			
Direct benefits – market efficiency					
Level playing field	Companies	A harmonisation of the OEL leads to a level playing field, as all companies across all Member States follow a more symmetric requirement. The level-playing field increases slightly with the stringency of OEL.			
Indirect benefits					

Impact	Stakeholders affected	OEL options (fibres/cm³)			
		0.001 fibres/cm³	0.002 fibres/cm³	0.01 fibres/cm³	0.1 fibres/cm³ (baseline)
Administrative simplification	Companies	For large, and to a lesser extent medium-sized companies with facilities in different Member States will experience administrative simplification, owing to a more harmonious set of compliance requirements. As most asbestos-related activities are performed by companies working in one Member State only, the benefits will be limited.			
Collateral health benefits for the broader population	Workers & families	The measures to prevent the generation and spread of dust in demolition works can also be positive for people living or working in the surroundings. Moreover, increased prevention of the spread of asbestos and cleanliness of premises could help decrease the risk of developing mesothelioma for family members of workers heavily exposed to asbestos.			
Synergy	Companies	Synergies in terms of exposure reduction for other chemical substances used in production sectors may occur. The specific substances will vary between the sectors. The level of synergy to be harnessed will also depend on the RMMs applied in each enterprise.			
Corporate Social Responsibility	Companies	Activities with a risk of exposure to asbestos may be less perceived as a risky line of work associated with health issues. As a result of such an improvement in public image, companies may find it easier to recruit and retain staff, reducing the cost of recruitment and increasing the productivity of workers.			
No cost of setting OEL (savings for Member State for developing lower national OELs)	Public sector	Benefit (some MS might consider introducing a lower OEL)			No benefit

Source: study team's calculation

11.1.2 Overview of the costs for the OEL options

The table below summarises the incremental costs associated with complying with lower OEL options, as also assessed in section 6 above. The costs are for the present value (PV) over 40 years with a static discount rate of 4%.

Table 11.2 Overview of the incremental costs for 40 years per OEL

Impact	Stakeholders affected	OEL options (fibres/cm³)			
		0.001 fibres/cm³	0.002 fibres/cm³	0.01 fibres/cm³	0.1 fibres/cm³ (baseline)
Direct costs - compliance					
Risk management measures and discontinuation costs (one-off and recurrent)	Companies	€ 58,000 million	€ 52,000 million	€ 13,000 million	€0 million

Impact	Stakeholders affected	OEL options (fibres/cm³)			
		0.001 fibres/cm³	0.002 fibres/cm³	0.01 fibres/cm³	0.1 fibres/cm³ (baseline)
Costs of notification and health surveillance of activities currently subject to Article 3 waiver	Companies	€ 28,000 million	€ 19,000 million	€ 9,500 million	€0 million
Training costs	Companies	€ 2,000 million	€ 1,100 million	€ 530 million	€0 million
Monitoring (sampling and analysis)	Companies	€ 640 million	€ 560 million	€ 110 million	€0 million
Direct costs - administrative burdens					
Administrative burden	Companies	€ 60 million	€ 30 million	€ 15 million	€0 million
Direct costs - total					
Compliance – RMMs, notifications, health surveillance, training, monitoring and administrative burden costs <u>Average cost per company</u>	Companies	€ 57,000 (varies significantly by sector: € 39,000 - € 2,600,000)	€ 46,000 (varies significantly by sector: € 29,000 - € 2,300,000)	€ 15,000 (varies significantly by sector: € 12,000 - € 355,000)	€0
Direct costs - enforcement costs					
Transposition costs	Public sector	€ 1.4 million	€ 1.3 million	€ 0.75 million	€0
Costs of changing guidelines	Public sector	€ 1.4 million	€ 1.3 million	€ 0.75 million	€0
Enforcement, monitoring, adjudication costs	Public sector	€ 4,200 million	€ 2,800 million	€ 1,400 million	€0 million
Indirect costs - other					
Firms exiting the market - No. of company closures	Companies	A significant number of business closures is not expected. (Companies would be able to pass on the increased costs to their clients due to the fact that it is not an option to not treat/remove/deal with asbestos.) However, it is recognised that in some sectors, the costs of the lower two OEL options expressed as % of turnover shown in Section 7 are significant for companies in some sectors (>20%), especially SMEs. When expressed as % of profits or investment, these costs are even greater. Although these costs are likely to be, to a large extent, passed on to the customers, they may result in some companies abandoning the market and the transfer of the relevant activities to other companies. These issues may be greater for small companies. Where this is the case, it is more likely that the relevant companies in Exposure Group 2 that cease to accept asbestos-related work would carry on operating than shut down; this is because, on			

Impact	Stakeholders affected	OEL options (fibres/cm^3)			
		0.001 fibres/cm^3	0.002 fibres/cm^3	0.01 fibres/cm^3	0.1 fibres/cm^3 (baseline)
		average, asbestos-related work amounts to a small proportion of the activities of these companies (although there are some companies which could experience more significant impacts). However, significant price increases may result in consumers putting off asbestos work and as a result spread the demand over greater period of time, thus reducing the market available each year. This may result in a reduction of firms in the market.			
Employment – Jobs lost	Workers & families	No significant net loss of employment is being predicted at the OEL option of 0.01 fibres/cm^3. However, it is possible that some jobs may move between the different Exposure Groups identified, with companies that have concentrated on carrying out notified work taking up some of the work that might previously have been carried out by companies operating under Article 3(3) waiver. These companies may be able to carry out the work with greater economies of scale and the net impact on employment may thus be negative.			
Employment – Social cost	Workers & families				
International competitiveness	Companies	Limited negative impact Most of the activities involving exposure to asbestos will be required to be undertaken in-situ, with limited opportunities for third country companies to compete with EU ones from a base outside the EU. There are limited sectors where activities involving exposure to asbestos could be undertaken outside of the EU (potentially some under Exposure Group 4 "Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other").			
Consumers	Consumers	It is expected that enterprises working with asbestos will be able to pass on costs arising from having to comply with all of the stricter OELs (due to the essential nature of the work being carried out), although it cannot be ruled out that some clients may delay or abandon plans to remove asbestos. Customers of companies working with asbestos in each of the sectors (e.g. developers, public authorities, landowners, building owners, travel companies etc.) are therefore likely to face rises in prices at lower OELs. There is some risk of increase in unauthorised work.			
Internal market Level playing field: range of OELs in Member States (Lowest to Highest)	Companies	Lowest/ highest OEL from 0.001 to 0.001 fibres/cm^3	Lowest/ highest OEL from 0.002 to 0.002 fibres/cm^3	Lowest/ highest OEL from 0.002 to 0.01 fibres/cm^3	Lowest/ highest OEL from 0.002 to 0.1 fibres/cm^3
Specific Member States/regions – Member States that would have to change OELs	Public sector	All MS	All MS except the Netherlands	All MS except France and the Netherlands	Not applicable
Regulation	Companies	No impacts identified			

Source: study team's calculation

11.1.3 CBA for the OEL options

The table below provides a direct comparison of the costs and benefits.

Table 11.3 Cost-benefit of the OEL options

Impact	OEL options (fibres/cm^3)			
	0.001 fibres/cm^3	0.002 fibres/cm^3	0.01 fibres/cm^3	0.1 fibres/cm^3 (baseline)
Total benefits Method 1 (M1)	€ 420 million	€ 410 million	€ 330 million	€0 million
Total benefits Method 2 (M2)	€ 220 million	€ 210 million	€ 170 million	€0 million
Total costs	€ 94,000 million	€ 76,000 million	€ 24,000 million	€0 million
Cost benefit ratio M1	220	190	70	0
Cost benefit ratio M2	430	360	140	0

Source: study team's calculation

11.2 Multi-criteria analysis (MCA)

The table below summarises both the monetised and qualitative impacts.

Table 11.4 Multi-criteria analysis (all impacts over 40 years and additional to the baseline)

Impact	Stakeholders affected	OEL options (fibres/cm^3)			
		0.001 fibres/cm^3	0.002 fibres/cm^3	0.01 fibres/cm^3	0.1 fibres/cm^3 (baseline)
Direct costs - compliance					
Risk management measures and discontinuation costs (one-off and recurrent)	Companies	€ 58,000 million	€ 52,000 million	€ 13,000 million	€0 million
Costs of notification and health surveillance of activities currently subject to Article 3 waiver	Companies	€ 28,000 million	€ 19,000 million	€ 9,500 million	€0 million
Training costs	Companies	€ 2,000 million	€ 1,100 million	€ 530 million	€0 million
Monitoring (sampling and analysis)	Companies	€ 640 million	€ 560 million	€ 110 million	€0 million
Direct costs - administrative burdens					

Impact	Stakeholders affected	OEL options (fibres/cm^3)			
		0.001 fibres/cm^3	0.002 fibres/cm^3	0.01 fibres/cm^3	0.1 fibres/cm^3 (baseline)
Administrative burden	Companies	€ 60 million	€ 30 million	€ 15 million	€0 million
Direct costs - total					
Compliance – RMMs, notifications, health surveillance, training, monitoring and administrative burden costs <u>Average cost per company</u>	Companies	€ 57,000 (varies significantly by sector: € 39,000 - € 2,600,000)	€ 46,000 (varies significantly by sector: € 29,000 - € 2,300,000)	€ 15,000 (varies significantly by sector: € 12,000 - € 355,000)	€0
Direct costs - enforcement costs					
Transposition costs	Public sector	€ 1.4 million	€ 1.3 million	€ 0.75 million	€0
Costs of changing guidelines	Public sector	€ 1.4 million	€ 1.3 million	€ 0.75 million	€0
Enforcement, monitoring, adjudication costs	Public sector	€ 4,200 million	€ 2,800 million	€ 1,400 million	€0 million
Indirect costs - other					
Firms exiting the market - No. of company closures	Companies	A significant number of business closures is not expected. (Companies would be able to pass on the increased costs to their clients due to the fact that it is not an option to not treat/remove/deal with asbestos.) However, it is recognised that in some sectors, the costs of the lower two OEL options expressed as % of turnover shown in Section 7 are significant for companies in some sectors (>20%), especially SMEs. When expressed as % of profits or investment, these costs are even greater. Although these costs are likely to be, to a large extent, passed on to the customers, they may result in some companies abandoning the market and the transfer of the relevant activities to other companies. These issues may be greater for small companies. Where this is the case, it is more likely that the relevant companies in Exposure Group 2 that cease to accept asbestos-related work would carry on operating than shut down; this is because, on average, asbestos-related work amounts to a small proportion of the activities of these companies (although there are some companies which could experience more significant impacts). However, significant price increases may result in consumers putting off asbestos work and as a result spread the demand over greater period of time, thus reducing the market available each year. This may result in a reduction of firms in the market.			
Employment – Jobs lost	Workers & families	No significant net loss of employment is being predicted at the OEL option of 0.01 fibres/cm^3. However, it is possible that some jobs may move between the different Exposure Groups identified, with companies that have concentrated on carrying out notified work taking up some of the work that might previously have been			
Employment – Social cost	Workers & families				

Impact	Stakeholders affected	OEL options (fibres/cm^3)			
		0.001 fibres/cm^3	0.002 fibres/cm^3	0.01 fibres/cm^3	0.1 fibres/cm^3 (baseline)
		carried out by companies operating under Article 3(3) waiver. These companies may be able to carry out the work with greater economies of scale and the net impact on employment may thus be negative.			
International competitiveness	Companies	Limited negative impact Most of the activities involving exposure to asbestos will be required to be undertaken in-situ, with limited opportunities for third country companies to compete with EU ones from a base outside the EU. There are limited sectors where activities involving exposure to asbestos could be undertaken outside of the EU (potentially some under Exposure Group 4 “Exposure to asbestos in articles: Trains, vehicles, vessels, aircraft and other”).			
Consumers	Consumers	It is expected that enterprises working with asbestos will be able to pass on costs arising from having to comply with all of the stricter OELs (due to the essential nature of the work being carried out), although it cannot be ruled out that some clients may delay or abandon plans to remove asbestos. Customers of companies working with asbestos in each of the sectors (e.g. developers, public authorities, landowners, building owners, travel companies etc.) are therefore likely to face rises in prices at lower OELs. There is some risk of increase in unauthorised work.			
Internal market Level playing field: range of OELs in Member States (Lowest to Highest)	Companies	Lowest/ highest OEL from 0.001 to 0.001 fibres/cm^3	Lowest/ highest OEL from 0.002 to 0.002 fibres/cm^3	Lowest/ highest OEL from 0.002 to 0.01 fibres/cm^3	Lowest/ highest OEL from 0.002 to 0.1 fibres/cm^3
Specific Member States/regions – Member States that would have to change OELs	Public sector	All MS	All MS except the Netherlands	All MS except France and the Netherlands	Not applicable
Regulation	Companies	No impacts identified			
Direct benefits – improved well-being - health					
Reduced cases of ill health (lung cancer, mesothelioma, laryngeal cancer and ovarian cancer)	Workers & families	860	830	660	0
Ill health avoided, incl. intangible costs (M2 to M1)	Workers & families	€215 – 418 million	€208 – 405 million	€166 – 323 million	€0
Avoided costs	Companies	€2.1 million	€2.0 million	€1.7 million	€0
Avoided costs	Public sector	€4.5 million	€4.3 million	€3.4 million	€0

Impact	Stakeholders affected	OEL options (fibres/cm^3)			
		0.001 fibres/cm^3	0.002 fibres/cm^3	0.01 fibres/cm^3	0.1 fibres/cm^3 (baseline)
Social policy agenda	All	Contribution to Green Deal: Chemicals Strategy towards a toxic-free environment			
Direct benefits – improved well-being - environmental					
Environmental releases	All	No impact/limited impact			
Direct benefits – market efficiency					
Level playing field	Companies	A harmonisation of the OEL leads to a level playing field, as all companies across all Member States follow a more symmetric requirement. The level-playing field increases slightly with the stringency of OEL.			
Indirect benefits					
Administrative simplification	Companies	For large, and to lesser extent medium-sized companies with facilities in different Member States will experience administrative simplification, owing to a more harmonious set of compliance requirements. As most asbestos-related activities are performed by companies working in one Member State only, the benefits will be limited.			
Collateral health benefits for the broader population	Workers & families	The measures to prevent the generation and spread of dust in demolition works can also be positive for people living or working in the surroundings. Moreover, increased prevention of the spread of asbestos and cleanliness of premises could help decrease the risk of developing mesothelioma for family members of workers heavily exposed to asbestos.			
Synergy	Companies	Synergies in terms of exposure reduction for other chemical substances used in production sectors may occur. The specific substances will vary between the sectors. The level of synergy to be harnessed will also depend on the RMMs applied in each enterprise.			
Corporate Social Responsibility	Companies	Activities with risk of exposure to asbestos may be less perceived as a risky line of work associated with health issues. As a result of such an improvement in public image, companies may find it easier to recruit and retain staff, reducing the cost of recruitment and increasing the productivity of workers.			
No cost of setting OEL (savings for Member State for developing lower national OELs)	Public sector	Benefit (some MS might consider introducing a lower OEL)			No benefit

Notes: All costs/benefits are incremental to the baseline (PV over 40 years)

Internal market shows the ratio of highest OEL to lowest OEL before and after implementing the OEL option.

Source: study team's calculation

11.3 Highlighted issues

Other issues to be considered in the decision-making process include:

- Although the costs are estimated to significantly outweigh the benefits for all of the policy options considered, it should be noted that the actual exposure concentrations when RPE has been taken into account are uncertain. This is because the available data mainly concern the workplace concentrations, and the use of RPE had to be modelled as part of this study. It is therefore possible that the cost savings from reduced ill health modelled in this study are underestimates and the cost-benefit ratio is thus overestimated.
- It should be noted that the total workforce exposed to asbestos is expected to increase over the coming decade.
- Companies in three Member States (France, Germany[61] and the Netherlands who collectively account for 37% of the EU-27 population) work to a limit that is lower than the current OEL in the Asbestos at Work Directive (AWD).
- A key uncertainty relates to the implications for workers with passive exposure in buildings (Exposure Group 3) at the option of 0.001 fibres/cm^3. The costs and benefits for this group are highly uncertain and the costs for this group could significantly increase the total costs estimated in this study at this option, because employees may need to take action to reduce passive exposure in buildings.
- It is expected that a large proportion of enterprises in Exposure Group 2 (exposure situation subject to Article 3 (3) waiver and incidental exposure) will opt to no longer accept asbestos related contracts and specialised asbestos removal companies in Exposure Group 1 will see their business increase. These income losses or gains can thus be seen as transfer costs with a low net impact overall, although some impacts may occur due to companies in Exposure Group 1 benefiting from greater economies of scale.
- When the costs of specialised asbestos removal companies in the construction sector increase, they are likely to pass them on to their clients without suffering any losses themselves (this is due to the relatively inelastic demand for asbestos removal). Whilst this may not always be the case where asbestos is contained in movable objects such as trains and ships, it is also unlikely that train refurbishment activities will shift outside the EU because of a lower OEL. It cannot, however, be ruled out that significant price increases would result in clients delaying or abandoning plans to remove asbestos thus resulting in a reduction in asbestos removal revenues and delays in removing passive exposure to asbestos.
- In the current directive, the likelihood of not exceeding the OEL is a key criterion for the waiver in Article 3(3) to apply. The waiver in Article 3(3) has the potential to reduce the costs of notification estimated in this study.
- Major concern has been raised about the applicability of the existing EM methods for compliance monitoring at the two lowest OEL options in settings with high dust levels and small asbestos fibre to dust ratios, e.g. by working with building materials with low asbestos concentrations or by exposure to naturally occurring asbestos.
- Monitoring compliance with the current OEL is complex and the requirements for monitoring will depend on the initial risk assessments undertaken. If the OEL is lowered, more often it will be uncertain if the exposure concentration is below the OEL, and more measurements will be needed to confirm the results of the risk assessment

[61] The current binding OEL in Germany is 0.1 fibres/cm^3 while the 'acceptance level' is 0.01 fibres/cm^3. The mandatory guidelines require measures that are considered in practice to bring the exposure concentration below the 'acceptance level'.

or to adjust the working procedures. However, the estimated increase in monitoring costs is highly uncertain.

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Appendix A Summary of the consultation

The number of consultation responses for asbestos is summarised below.

Table A1.1 Number of responses relevant to asbestos @ 12 July 2021

Response type	Number of responses
Questionnaire responses	130
Interviews and conference calls	61
Site visits	1
Total	192

The study team has among others conducted conference calls with the following industry associations and HSE institutions:

- FIEC - European Construction Industry Federation
- Confederation of Danish Industry
- INRS, France
- EDA – European Demolition Association
- EMA - Industrial Minerals Association – Europe
- BAuA, Germany
- BG BAU - Berufsgenossenschaft der Bauwirtschaft, Germany
- DGUV, Germany
- TNO, the Netherlands
- The Polish Chamber of Chemical Industry (PIPC)
- Chamber of Construction and Building Materials Industry of Slovenia

Conference calls were conducted with the following employees organisations:

- EFBWW - European Federation of Building and Woodworkers
- Latvian Building Sector Trade Union (LBNA)
- National and Gdansk region Sections of the Shipbuilding Industry NSZZ „Solidarność” (”Solidarity”), Poland
- Services Industrial Professional and Technical Union, Ireland

Site visits

One site visit was conducted at power plant in which asbestos-containing materials were removed by a medium-sized asbestos removal firm based in Spain. During this site visit, first-hand information was collected on processes, the risk management measures currently in place and costs of reaching reference exposure levels. This site visit was identified via contact to a Spanish industry association.

A planned site visit in Denmark was cancelled due to corona restrictions

Appendix B Asbestos questionnaire

Questionnaire for Companies: Asbestos

A consortium comprising RPA Risk & Policy Analysts (United Kingdom), COWI (Denmark), and FoBiG Forschungs- und Beratungsinstitut Gefahrstoffe (Germany) has been contracted by the European Commission's Directorate-General for Employment, Social Affairs and Inclusion to assess the impacts of establishing Occupational Exposure Limit values (OELs) for a number of substances.

As part of the study, a baseline study is carried out for **“Asbestos”.** The collected information and subsequent analyses shall support the European Commission's work in the area of possible amendments of Directive 2009/148/EC on the protection of workers from the risks related to exposure to asbestos at work (Asbestos at Work Directive, **AWD**). This part of the study is being carried out by COWI.

The purpose of this questionnaire is to collect data and information that will underpin the assessment. This questionnaire is intended for **all companies where exposure to asbestos may take place**.

All responses to this questionnaire will be treated in the **strictest confidence** and will only be used for the purposes of this study. In preparing our reports for the Commission (which, subsequently, may be published), care will be taken to ensure that specific responses cannot be linked to individual companies.

This questionnaire is intended for a **typical work situation**, if you operate in many different work situations, please contact the study team. If you work in **more than one Member State**, please complete a questionnaire for each Member State.

The deadline for completion of the questionnaire is 26 March 2021.

This questionnaire is available in English, French, German, Italian, Polish and Spanish. However, you are welcome to **answer the questions in an official language of the European Union of your choice**.

If you have any questions about the survey, please contact: Frans Christensen
fmch@cowi.com

Abbreviations used in the questionnaire:

AIB	Asbestos insulating board
AWD	Asbestos at Work Directive 2009/148/EC
NACE	NACE Revision 2, statistical classification of economic activities in the European Community https://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF , page 61 ff.
OEL	The term Occupational Exposure Limit value (OEL) refers to the limit of the time-weighted average (TWA) of the concentration in the air within the breathing zone of a worker, measured or calculated in relation to a reference period of eight hours.
RAC	The Committee for Risk Assessment (RAC) is a scientific committee of ECHA that prepares the opinions related to the risks of substances to human health and the environment.
RMM	Risk Management Measure
RPE	Respiratory protective equipment
8 hour TWA	8 hour Time-Weighted Average, measured in parts per million (ppm) or milligrams per cubic metre (mg/m^3). The 8 hour TWA is an expression for the average exposure for a typical working day. It is calculated by summing up the concentrations (in ppm or mg/m^3) during different periods of a day (usually 8 hours). Each concentration is multiplied by its relevant duration and the total is divided by the entire length of the working day (usually 8 hours) such as in this example:

	8h-TWA = (2 hours * 500 ppm + 5 hours * 100 ppm + 1 hours * 700 ppm) / (2 + 5 + 1 hours).

Publication privacy settings

By checking this box, I confirm that I have read the Privacy Statement and agree with the processing of my personal data for the purposes stated therein. I acknowledge that my views could be shared with the European Commission and published with information concerning the name and type of the organisation that I represent, to which I hereby give my consent.	☐

A) About your company

A1) Please provide the following details about your company	
Name of contact person	
Company	
Email address of contact person	
Telephone number of contact person	
Country	Picklist of Member States and option to add “Other”

A2) Please define the sector in which your company is active (if possible, using a NACE code(s))	
A3) How many workers are employed in your company?	
A4) How many of the workers currently employed in your company are/have some risk of being exposed to asbestos?	
A5) Have you any experience of workers having health issues resulting from occupational exposure to asbestos at the workplace? (e.g., mesothelioma, or lung cancer)	
A6) Have any workers left the company or been eligible for compensation due to health issues associated with exposure to asbestos?	
A6) What is the annual turnover for 2019 in EUR for the type of work/activities which can lead to asbestos exposure?	☐ < €2 million ☐ €2 – 10 million ☐ €10 – 50 million ☐ €50 – 100 million ☐ > €100 million

A7) If possible, please specify the specific asbestos fibrous silicates that are usually present in your activities. You may tick more than one. If unknown, please leave blank. Note: This information will often appear in the pre-investigation analysis report. Please tick all that apply.		
Asbestos	**CAS No**	
Asbestos actinolite	77536-66-4	☐
Asbestos grunerite (amosite) (brown asbestos)	12172-73-5	☐
Asbestos anthophyllite	77536-67-5	☐
Chrysotile (white asbestos)	12001-29-5	☐
Crocidolite (blue asbestos)	12001-28-4	☐
Asbestos tremolite	77536-68-6	☐

A8) Please describe the types of structures/parts/buildings that you/your company works with that present a risk of exposure to asbestos. (Please tick all that apply.)	
Industrial - inside	
Sprayed coatings on ceilings, walls, beams and columns	☐
Asbestos cement water tank	☐
Loose fill insulation	☐
Lagging on boilers and pipes	☐
Asbestos insulating board (AIB) ceiling tiles	☐
Toilet seat and cistern	☐
AIB partition walls	☒
AIB panels in fire doors	☐
Asbestos rope seals, gaskets and paper	☐
Vinyl floor tiles	☐
AIB around boilers	☐
Textiles e.g., fire blankets	☐
Textured decorating coatings on walls and ceilings e.g. Artex	☐
Industrial - outside	
Asbestos cement roof	☐
Asbestos cement panels	☐
Asbestos cement gutters and downpipes	☐
Soffits – AIB or asbestos cement	☐
Asbestos cement flue	☐
Residential - inside	
Asbestos cement Water tank	☐
Pipe insulation	☐
Loose fill insulation	☐
Textured decorative coating e.g., Artex	☐
AIB ceiling tiles	☐
AIB bath panel	☐

Toilet seat and cistern	☐
AIB behind fuse box	☐
AIB airing cupboard and/or sprayed insulation coating boiler	☐
AIB partition wall	☐
AIB interior window panel	☐
AIB around boiler	☐
Vinyl floor tiles	☐
AIB behind fire	☐
Residential - outside	
Gutters and Asbestos cement downpipes	☐
Soffits – AIB or asbestos cement	☐
AIB exterior window panel	☐
Asbestos cement roof	☐
Asbestos cement panels	☐
Roofing felt	☐
Other locations	☐
Ships	☐
Trains	☐
Road building	☐
Mining	☐
Waste disposal	☐
Other – please specify	

A9) Have you or your workers encountered asbestos unexpectedly after commencing work activities? E.g., during repair work, renovation or demolition? **Or if you are an asbestos removal company, has your company been contracted as a consequence of another company having encountered asbestos after starting work activities?**	
Yes	☐
No	☐

A10) If you answered 'yes' to the previous question, please indicate how often this has occurred in the last five years.	
Once	☐
Twice	☐
Several times	☐
Frequently	☐
Please describe these situations	

B) Information about airborne concentrations encountered in activities

If you would like to report on more than four activities, please complete additional questionnaires.

	Activity 1	***Activity 2***	***Activity 3***	***Activity 4***
B1) Please specify the most important activities/locations* during which exposure to asbestos can occur.				
B2) Please provide the number of workers exposed during a typical working day				

**The most important activities in this context are those for which exposure to asbestos gives you the most concern. This could be because the activity has low levels of exposure but affects many people. Or because the activity has high levels of exposure but for short periods. Or alternatively, an activity where it is very difficult or expensive to reduce exposure at all.*

Please include the location of the asbestos related activity, as well as the type of work carried out. (Pop-up list of locations from A8)

B3) Please provide data for airborne concentrations (without RPE – respiratory protective equipment) from your most recent measurements (8-hour Time Weighted Averages). The 8-hour TWA should ideally be expressed in fibres/m^3' or fibres/cm^3

	Activity *1*	Activity *2*	Activity *3*	Activity *4*
Lowest concentration (value)				
Highest concentration (value)				
Mean concentration (arithmetic mean; value)				
Median concentration (value)				
95th percentile concentration (value)				
Number of samples (n)				
Year of monitoring				
B4) Please confirm the unit for the data you have just entered	*PICK LIST fibres/m^3, fibres/litre or fibres/cm^3*	*PICK LIST fibres/m^3, fibres/litre or fibres/cm^3*	*PICK LIST fibres/m^3, fibres/litre or fibres/cm^3*	*PICK LIST fibres/m^3, fibres/litre or fibres/cm^3*
B5) Please confirm the sampling and analytical methods followed	*PICK LIST - Phase contrast microscopy (PCM)*			

	- Scanning Electron Microscopy (SEM) *- Transmission Electron Microscopy (TEM)* *- EM electron microscopy (SEM or TEM)*			
B6) Are the workers wearing RPE (respiratory protective equipment) during the activity?	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
B7) If you have airborne concentration data (without RPE) other than 8-hour Time Weighted Averages, please specify type of value and air exposure concentration. Please, for example, provide any short-term exposure data here.				
Type of value (value):				
B8) Please confirm the unit for the data you have just entered	*PICK LIST Fibres/m³, fibres/litre or fibres/cm³*	*PICK LIST Fibres/m³, fibres/litre or fibres/cm³*	*PICK LIST Fibres/m³, fibres/litre or fibres/cm³*	*PICK LIST Fibres/m³, fibres/litre or fibres/cm³*
B9) Please confirm the sampling and analytical methods followed	*PICK LIST* *- EM electron microscopy* *- PCM phase contrast microscopy*			

B10) Do you have any other information on exposure to asbestos in your typical work situations? **Please describe. For example, this could be using gel tape measurements before, during or after the asbestos work carried out.**
If you are happy to provide more detailed information about numbers of workers exposed, exposure levels and/or further activities, please email this to Sophie Garrett, sophie.garrett@rpaltd.co.uk, directly.

B11) Which Risk Management Measures are in place to control exposure to asbestos in the different activities at this workplace? Please tick all that you use.				
	Activity 1	***Activity 2***	***Activity 3***	***Activity 4***

Organisational and hygiene measures				
Reduced number of workers exposed	☐	☐	☐	☐
Rotation of the workers exposed	☐	☐	☐	☐
Redesign of work processes	☐	☐	☐	☐
Formal/external RPE (respiratory protective equipment) cleaning and filter changing regime	☐	☐	☐	☐
Segregating asbestos work area from other work and the surroundings	☐	☐	☐	☐
Enclosure with negative pressure	☐	☐	☐	☐
Airlock(s) for personnel entering and leaving the enclosure	☐	☐	☐	☐
Three chamber decontamination unit with vacuum cleaner	☐	☐	☐	☐
Work permission from authorities agreeing to the risk management needed	☐	☐	☐	☐
Displaying of warning signs	☐	☐	☐	☐
Creation of separate areas for eating and drinking	☐	☐	☐	☐
Creation of demarcated no-smoking zones	☐	☐	☐	☐
Provision of separate storage facilities for work clothes	☐	☐	☐	☐
Dedicated shower/bathing facilities	☐	☐	☐	☐
Training and education	☐	☐	☐	☐
Cleaning	☐	☐	☐	☐
Continuous measurement to detect unusual exposures	☐	☐	☐	☐
Identifying asbestos type	☐	☐	☐	☐
Health surveillance	☐	☐	☐	☐
Technical measures				
Open hoods over equipment or local extraction ventilation	☐	☐	☐	☐
General ventilation	☐	☐	☐	☐
Using low pressurised work area	☐	☐	☐	☐
Pressurised or sealed control cabin	☐	☐	☐	☐
Simple enclosed control cabins	☐	☐	☐	☐
Dust suppression techniques (e.g. wet stripping or controlled dry removal)	☐	☐	☐	☐

Please specify type of dust suppression techniques used:				
Automated/robotic removal	☐	☐	☐	☐
Respiratory protective equipment (RPE)				
Filtering half mask EN 149	☐	☐	☐	☐
Valved filtering half mask EN 405	☐	☐	☐	☐
Filtering half mask without inhalation valves EN 1827	☐	☐	☐	☐
Half mask EN 140 and filter EN 143	☐	☐	☐	☐
Full face mask EN 136 and filter EN 143	☐	☐	☐	☐
Powered hoods and filter EN 12941	☐	☐	☐	☐
Power assisted masks and filter EN 12942	☐	☐	☐	☐
Breathing apparatus				
Fresh air hose breathing apparatus EN 138/269	☐	☐	☐	☐
Light duty compressed airline breathing apparatus masks EN 12419	☐	☐	☐	☐
Light duty compressed airline breathing apparatus hoods, helmets, visors EN 1835	☐	☐	☐	☐
Constant flow compressed airline breathing apparatus hood EN 270/271 Mask, EN 14593-1, EN 14593-2, EN 14594	☐	☐	☐	☐
Demand flow compressed airline breathing apparatus mask EN 14593-1, EN 14593-2, EN 14594	☐	☐	☐	☐
Self-contained breathing apparatus EN 137	☐	☐	☐	☐
General personal protective equipment (PPE)				
Safety spectacles, goggles	☐	☐	☐	☐
Gloves, gloves with a cuff, gauntlets and sleeving that covers part or all of the arm	☐	☐	☐	☐
Coveralls/hazardous materials suits with hood	☐	☐	☐	☐
Safety boots and shoes, rubber boots	☐	☐	☐	☐
Waste disposal				
Storage and transport of asbestos in suitable sealed packaging	☐	☐	☐	☐
Lockable container with asbestos waste	☐	☐	☐	☐

Labelling of waste containing asbestos	☐	☐	☐	☐
Other measures				
Other: Please specify	☐	☐	☐	☐

C) What are the lowest exposure levels that you could achieve

	Value	Unit
C1) What do you think is the lowest *technically possible* 8-hour TWA air concentration that can be achieved?		☐ Fibres/m³ ☐ Fibres/litre ☐ Fibres/cm³
C2) What do you think is the lowest *economically feasible* 8-hour TWA air concentration that can be achieved?		☐ Fibres/m³ ☐ Fibres/litre ☐ Fibres/cm³
C3) Any comments on above answer?		

D) Compliance with a potential new OEL under the AWD

This section considers the Risk Management Measures (RMMs) that would have to be put in place to comply with a new OEL under the AWD.
Please fill out the section for the **activity with the highest exposure concentration.**

The following limit values and air concentrations given below are used as reference points for this questionnaire. Note: the current EU occupational exposure limit is 0.1 fibres/cm³ (100,000 fibres/m³).	
	Reference values
OEL reference value 1 **(Equal to the French and German OELs)**	0.01 fibres/cm³ (10,000 fibres/m³)
OEL reference value 2 **(Half of the current Dutch OEL which is the lowest national OEL)**	0.001 fibres/cm³ (1000 fibres/m³)

D1) Please indicate which *additional* RMMs would be the most important in helping you to achieve the OEL reference values?		
	0.01 fibres/cm³	**0.001 fibres/cm³**
No action required as OEL already achieved	☐	☐
Discontinuation of activity	☐	☐
Organisational Measures		

Reduced number of workers exposed	☐	☐
Rotation of the workers exposed	☐	☐
Redesign of work processes	☐	☐
Formal/external RPE (respiratory protective equipment) cleaning and filter changing regime	☐	☐
Segregating asbestos work area from other work and the surroundings	☐	☐
Enclosure with negative pressure	☐	☐
Airlock(s) for personnel entering and leaving the enclosure	☐	☐
Three chamber decontamination unit with vacuum cleaner	☐	☐
Work permission from authorities agreeing to the risk management needed	☐	☐
Displaying of warning signs	☐	☐
Creation of separate areas for eating and drinking	☐	☐
Creation of demarcated no-smoking zones	☐	☐
Provision of separate storage facilities for work clothes	☐	☐
Dedicated shower/bathing facilities	☐	☐
Training and education	☐	☐
Cleaning	☐	☐
Continuous measurement to detect unusual exposures	☐	☐
Identifying asbestos type	☐	☐
Health surveillance	☐	☐
Technical measures		
Open hoods over equipment or local extraction ventilation	☐	☐
General ventilation	☐	☐
Low pressurised work area	☐	☐
Pressurised or sealed control cabin	☐	☐
Simple enclosed control cabins	☐	☐
Dust suppression techniques (e.g., wet stripping or controlled dry removal)	☐	☐
Please specify type of dust suppression techniques used:		
Automated/robotic removal	☐	☐
Respiratory protective equipment (RPE)		
Filtering half mask EN 149	☐	☐
Valved filtering half mask EN 405	☐	☐
Filtering half mask without inhalation valves EN 1827	☐	☐

Half mask EN 140 and filter EN 143	☐	☐
Full face mask EN 136 and filter EN 143	☐	☐
Powered hoods and filter EN 12941	☐	☐
Power assisted masks and filter EN 12942	☐	☐
Breathing apparatus		
Fresh air hose breathing apparatus EN 138/269	☐	☐
Light duty compressed airline breathing apparatus masks EN 12419	☐	☐
Light duty compressed airline breathing apparatus hoods, helmets, visors EN 1835	☐	☐
Constant flow compressed airline breathing apparatus hood EN 270/271 Mask, EN 14593-1, EN 14593-2, EN 14594	☐	☐
Demand flow compressed airline breathing apparatus mask EN 14593-1, EN 14593-2, EN 14594	☐	☐
Self-contained breathing apparatus EN 137	☐	☐
General personal protective equipment (PPE)		
Safety spectacles, goggles	☐	☐
Gloves, gloves with a cuff, gauntlets and sleeving that covers part or all of the arm	☐	☐
Coveralls/hazardous materials suits with hood	☐	☐
Safety boots and shoes, rubber boots	☐	☐
Waste disposal		
Storage and transport of asbestos in suitable sealed packaging	☐	☐
Lockable container with asbestos waste	☐	☐
Labelling of waste containing asbestos	☐	☐
Other Measures		
Other: Please specify	☐	☐

D2) What is your estimated range of total <u>initial investment</u> likely to be incurred in your company to achieve the following OEL reference values?		
	0.01 fibres/cm³	**0.001 fibres/cm³**
< €10,000	☐	☐
€10,000 - €100,000	☐	☐
€100,000 - €1 million	☐	☐
€1 - 10 million	☐	☐
€10 - 100 million	☐	☐
€100 - 1 billion	☐	☐

Over € 1 billion	☐	☐
Don't know	☐	☐

D3) What is your estimated range of total annual *recurrent costs* likely to be incurred in your company to achieve the following OEL reference values?		
	0.01 fibres/cm^3	**0.001 fibres/cm^3**
< €10,000	☐	☐
€10,000 - €100,000	☐	☐
€100,000 - €1 million	☐	☐
€1 - 10 million	☐	☐
€10 - 100 million	☐	☐
€100 - 1 billion	☐	☐
Over € 1 billion	☐	☐
Don't know	☐	☐

D4) How would the OEL reference values impact the competitiveness of your company…		
	0.01 fibres/cm^3	**0.001 fibres/cm^3**
versus competitors in EU	☐ Significant positive impact ☐ Moderate positive impact ☐ Limited/no impact ☐ Moderate negative impact ☐ Significant negative impact	☐ Significant positive impact ☐ Moderate positive impact ☐ Limited/no impact ☐ Moderate negative impact ☐ Significant negative impact
versus competitors outside of EU (moveable items such as ships, trains, waste, plant could be taken outside the EU)	☐ Significant positive impact ☐ Moderate positive impact ☐ Limited/no impact ☐ Moderate negative impact ☐ Significant negative impact	☐ Significant positive impact ☐ Moderate positive impact ☐ Limited/no impact ☐ Moderate negative impact ☐ Significant negative impact

D5) Are you aware of any voluntary industry initiatives to reduce exposure to asbestos (e.g., Product Stewardships or Social Partner Agreements)?	☐ Yes ☐ No
If yes, please specify name of the initiative and to which sectors it applies.	

E) Impacts of COVID-19

E1) Has COVID-19 had any impact on exposure levels of asbestos or the numbers of workers exposed to asbestos at this facility? (Examples could include: COVID-19 preventative measures have reduced your exposure levels or on the number of workers exposed has reduce/increased, or some of your operations have had to close due to COVID-19)

F) Any other comments

F1) Do you have any other comments relevant to this study that you would like to make?

G) Further communication

G1) Please tick if you are happy for the study team to contact you for further clarification or discussion about your responses?	☐
G2) If you prefer this contact to be via a different email or phone number from those you provided at the start of the questionnaire, please provide the details here.	

Thank you for your answers!

Appendix C Additional exposure data

Table C1.1 Summary of personal measurements in the TNO database based on nominal asbestos fibre concentrations (in fibres/cm^3). (Translated from Spaan et al., 2019). Data apparently from the period where the OEL was 0.01 fibres/cm^3.

Main pro-duct group	Product group	Removal method / control measures *	N	N<BG	AM	SD	GM	Min.	P10	P50	P75	P90	Max.
Bound in plastic / imitation marble	Window sill	Total	33	21	0.00028	0.00021	0.00021	0.00023	0.00009	0.00010	0.00022	0.00044	0.00052
		V: Disassembling with moderate / much damage	11	7	0.00037	0.00037	0.00025	0.00030	0.00010	0.00012	0.00030	0.00044	0.00061
		V Disassembling with little / no dam-age	22	14	0.00024	0.00024	0.00017	0.00019	0.00009	0.00010	0.00019	0.00044	0.00049
		B: Moisturising	8	8	0.00015	0.00015	0.00006	0.00014	0.00010	0.00010	0.00011	0.00022	0.00023
		B: No control measures	25	13	0.00033	0.00033	0.00022	0.00026	0.00009	0.00010	0.00028	0.00045	0.00061
Elastic	Bitumen	Total	33	20	0.00144	0.00144	0.00076	0.00121	0.00032	0.00050	0.00145	0.00185	0.00230
		V: Fine manual processing	2	2	0.0005	0.00050	0.00000	0.00050	0.00050	0.00000	0.00000	0.00000	0.00000
		V: Fine machined processing	6	2	0.0006	0.00060	0.00037	0.00053	0.00032	0.00032	0.00049	0.00064	0.00130
		V: Coarse machined processing	9	8	0.00193	0.00193	0.00059	0.00184	0.00082	0.00082	0.00185	0.00185	0.00280
		V: Manual parting	16	8	0.00159	0.00159	0.00065	0.00146	0.00065	0.00065	0.00145	0.00220	0.00230
		B: No control measures	27	16	0.00165	0.00165	0.00067	0.00149	0.00033	0.00065	0.00180	0.00220	0.00280
		B: Local Exhaust Ventilation	6	4	0.00049	0.00049	0.00010	0.00048	0.00032	0.00032	0.00050	0.00050	0.00064

Main pro-duct group	Product group	Removal method / control measures *	N	N<BG	AM	SD	GM	Min.	P10	P50	P75	P90	Max.
	Glue	Total	56	47	0.00055	0.00055	0.00115	0.00025	0.00009	0.00010	0.00025	0.00050	0.00090
		V: Electric parting	14	8	0.00128	0.00128	0.00215	0.00040	0.00009	0.00010	0.00036	0.00120	0.00580
		V: Manual parting	42	39	0.00031	0.00031	0.00027	0.00021	0.00009	0.00010	0.00016	0.00047	0.00080
		B: Moisturising	8	5	0.00205	0.00205	0.00258	0.00110	0.00033	0.00033	0.00088	0.00335	0.00660
		B: No control measures	11	11	0.00021	0.00021	0.00011	0.00018	0.00010	0.00010	0.00028	0.00031	0.00031
		B: Local Exhaust Ventilation	37	31	0.00033	0.00033	0.00038	0.00020	0.00009	0.00010	0.00010	0.00044	0.00080
Asbestos cement	Asbestos ce-ment	Total	85	58	0.0008	0.00080	0.00359	0.00023	0.00003	0.00009	0.00014	0.00049	0.00114
		V: Disassembling with moderate / much damage	12	9	0.00304	0.00304	0.00944	0.00043	0.00019	0.00019	0.00029	0.00049	0.00060
		V Disassembling with little / no dam-age	62	45	0.00041	0.00041	0.00067	0.00019	0.00003	0.00009	0.00010	0.00049	0.00097
		V: Fine manual processing	4	0	0.0009	0.00090	0.00061	0.00055	0.00006	0.00006	0.00101	0.00132	0.00151
		V: Fine machined processing	1	0	0.00014	0.00014	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		V: Normal handling	5	3	0.00045	0.00045	0.00057	0.00024	0.00010	0.00010	0.00010	0.00057	0.00140
		V: Handling with care	1	1	0.00025	0.00025	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		B: Moisturising	76	57	0.00077	0.00077	0.00379	0.00020	0.00003	0.00009	0.00010	0.00042	0.00088
		B: No control measures	9	1	0.00107	0.00107	0.00075	0.00087	0.00033	0.00033	0.00095	0.00140	0.00260
Woven / pressed	Asbestos	Total	4	0	0.31575	0.31575	0.43604	0.15807	0.04200	0.04200	0.12750	0.56150	0.96600

Main pro-duct group	Product group	Removal method / control measures *	N	N<BG	AM	SD	GM	Min.	P10	P50	P75	P90	Max.
	cloth	V: Fine manual processing	1	0	0.157	0.15700	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		V: Normal handling	1	0	0.042	0.04200	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		V: Rough handling	2	0	0.532	0.53200	0.61377	0.30768	0.09800	0.00000	0.00000	0.00000	0.00000
		B: No control measures	4	0	0.31575	0.31575	0.43604	0.15807	0.04200	0.04200	0.12750	0.56150	0.96600
	Asbestos chord	Total	33	17	0.00531	0.00531	0.01244	0.00081	0.00009	0.00010	0.00068	0.00270	0.01900
		Fine manual processing	11	6	0.0015	0.00150	0.00140	0.00086	0.00011	0.00015	0.00122	0.00225	0.00270
		Normal handling	7	1	0.01224	0.01224	0.01145	0.00513	0.00035	0.00035	0.01000	0.02400	0.02800
		Handling with care	15	10	0.00487	0.00487	0.01614	0.00033	0.00009	0.00009	0.00010	0.00068	0.00510
		Moisturising	22	11	0.00237	0.00237	0.00507	0.00071	0.00009	0.00010	0.00077	0.00225	0.00480
		No control measures	6	1	0.02044	0.02044	0.02329	0.00708	0.00015	0.00015	0.01450	0.02800	0.06300
		Local Exhaust Ventilation	5	5	0.00011	0.00011	0.00002	0.00011	0.00009	0.00009	0.00010	0.00011	0.00015
	Gasket **	Total	13	6	0.0003	0.00030	0.00020	0.00026	0.00012	0.00018	0.00024	0.00032	0.00048
		V: Rough manual processing	3	1	0.00052	0.00052	0.00031	0.00046	0.00027	0.00000	0.00042	0.00000	0.00000
		V: Manual parting	9	5	0.00022	0.00022	0.00010	0.00021	0.00012	0.00012	0.00019	0.00024	0.00048
		V: Handling with care	1	0	0.00032	0.00032	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		B: Moisturising	12	6	0.0003	0.00030	0.00021	0.00025	0.00012	0.00018	0.00021	0.00035	0.00048
		B: No control measures	1	0	0.00032	0.00032	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Main pro-duct group	Product group	Removal method / control measures *	N	N<BG	AM	SD	GM	Min.	P10	P50	P75	P90	Max.
Moderately friable asbes-tos (moderately bound)	Board	Total	96	17	5.0628	5.06280	17.85918	0.02789	0.00003	0.00020	0.03390	0.30537	17.02000
		V: High-pressure Moisturising	1	0	0.754	0.75400	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		V: Low-pressure Moisturising	15	6	0.02463	0.02463	0.05262	0.00212	0.00020	0.00020	0.00100	0.02067	0.11716
		V: Disassembling with moderate / much damage	48	3	10.03123	10.03123	24.37682	0.16190	0.00010	0.00130	0.11175	3.42279	31.24000
		V Disassembling with little / no dam-age	12	8	0.00047	0.00047	0.00058	0.00024	0.00003	0.00005	0.00027	0.00049	0.00120
		V: Fine manual processing	3	0	0.02879	0.02879	0.00749	0.02811	0.02101	0.02941	0.00000	0.00000	0.03594
		V: Fine machined processing	2	0	0.59919	0.59919	0.33270	0.55108	0.36394	0.00000	0.00000	0.00000	0.83445
		V: Rough machined processing	1	0	0.0025	0.00250	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		V: Normal handling	3	0	0.00116	0.00116	0.00117	0.00083	0.00040	0.00057	0.00000	0.00250	0.00000
		V: Rough handling	11	0	0.19186	0.19186	0.17425	0.11031	0.02030	0.02310	0.15580	0.31860	0.41320
		B: Moisturising	52	10	0.29475	0.29475	1.18274	0.01169	0.00003	0.00020	0.02565	0.11175	0.29000
		B: No control measures	34	7	13.68867	13.68867	28.23370	0.09158	0.00020	0.00033	0.08798	18.60000	37.12000
		B: Local Exhaust Ventilation	10	0	0.52875	0.52875	0.79620	0.04502	0.00040	0.00049	0.21297	0.83445	1.74407
	Stucco	Total	7	4	0.00108	0.00108	0.00053	0.00094	0.00028	0.00028	0.00105	0.00170	0.00180
		V: Rough machined processing	4	2	0.00141	0.00141	0.00039	0.00137	0.00105	0.00105	0.00140	0.00175	0.00180
		V: Manual parting	3	2	0.00063	0.00063	0.00030	0.00056	0.00028	0.00000	0.00075	0.00000	0.00000

Main pro-duct group	Product group	Removal method / control measures *	N	N<BG	AM	SD	GM	Min.	P10	P50	P75	P90	Max.
		B: Moisturising	3	2	0.00063	0.00063	0.00030	0.00056	0.00028	0.00000	0.00075	0.00000	0.00000
		B: No control measures	4	2	0.00141	0.00141	0.00039	0.00137	0.00105	0.00105	0.00140	0.00175	0.00180
Friable asbestos (non-bound)	Spray asbes-tos	Total	5	0	11.0388	11.03880	22.22225	2.17261	0.52000	0.52000	0.98400	1.95900	50.78000
		V: Manual parting	5	0	11.0388	11.03880	22.22225	2.17261	0.52000	0.52000	0.98400	1.95900	50.78000
		B: Moisturising	5	0	11.0388	11.03880	22.22225	2.17261	0.52000	0.52000	0.98400	1.95900	50.78000

Descriptive statistics of the available personal task-oriented measurements in the TNO database that have been used for the calibration of the exposure model, subdivided by main product group, product group, removal method or type of control measure applied. The descriptive statistics are based on the nominal concentrations (in fibers / m^3)

* V: removal method *(verwijderingsmethode)*; B: control measure *(beheersmaatregel)*.

**: Of the 13 personal measurements available for the product group gasket, 1 of the measurements concerns work with knife fuse(s) instead of gaskets (measurements of both product groups have been combined).

N = number of available measurements, N<BG = number of measurements in which no fibres were found on the filters (below detection level *(onder bepalingsgrens = BG)*), AM = mathematical average, SD = mathematical standard deviation, GM = geometric average, GSD = geometric standard deviation, Min. = minimum, P10 = 10th percentile of the distribution, P50 = 50th percentile (median), P75 = 75th percentile, P90 = 90th percentile, Max. = maximum.

When interpreting exposure data, for example for comparing the measured concentrations of different sets of measurements, it is common to use GM in combination with the 90th percentile of the distribution of the relevant set of measurements. The GM can be accurately estimated with a relatively limited number of measurements. The difference between the GM and the 90th percentile is an indication of the spread in exposure levels within the relevant dataset. In addition, the 90th percentile is often used as a test value for comparison with the limit value, because this value applies to the majority (90%) of the situations within the relevant dataset. However, in the case of a dataset with a relatively small number of measurements, the 90th percentile is difficult to estimate and often corresponds with the maximum value.

Table C1.2 Measured concentration by roofing work - sub-section 4 in SCOLA database, activities (combination of techniques) with more than 10 reported measurements (based on INRS, 2020). Analysed with TEM according to NFX 43-050. In fibres/cm^3.

Activity	Wet-work	Local ventilation	n	AM	GM	P50	P95
Brushing - Manual scraping	Combined types of wet work	No	11	0.179	0.041	0.038	0.820
Lining - Enclosure - Covering - Recapping	No	No	15	0.027	0.010	0.006	0.130
Cutting with manual tool	Combined types of wet work	Combination of types of ventilation	21	0.094	0.030	0.037	0.554
Pneumatic cutting - Cutting - Drilling - Sawing - Thermal cutting	Combined types of wet work	Combination of types of ventilation	11	0.698	0.028	0.014	3.772
Removal from below - Disassembly - Deconstruction	No	No	16	0.020	0.011	0.014	0.060
	Combined types of wet work	Ventilation system with THE filter	14	0.082	0.039	0.046	0.236
	Spraying the materials alone	No	14	0.094	0.039	0.050	0.266
	Spraying the materials alone	No	58	0.069	0.029	0.034	0.258
	No	No	44	0.132	0.037	0.039	0.417
	Spraying the materials alone	Ventilation system with THE filter	20	0.040	0.014	0.009	0.220
	Combined types of wet work	Yes	12	0.217	0.059	0.086	0.560
	Spraying the materials and misting or nebulization	No	12	0.057	0.026	0.028	0.196
Cleaning - Collection - Handling - Packaging	No	No	39	0.136	0.035	0.025	0.585

Activity	Wet-work	Local ventilation	n	AM	GM	P50	P95
	Spraying the materials and misting or nebulization	No	31	0.131	0.032	0.032	0.366
	Combined types of wet work	Ventilation system with THE filter	23	0.644	0.103	0.082	1.684
	Spraying the materials alone	No	23	0.016	0.009	0.007	0.037
	Combined types of wet work	Combination of types of ventilation	13	0.572	0.081	0.052	1.785
	No	Combination of types of ventilation	11	0.289	0.077	0.048	1.040
	No	Ventilation system with THE filter	10	0.436	0.040	0.116	1.519
Screwing - Cable pulling - Adjustment	Combined types of wet work	Combination of types of ventilation	11	0.028	0.009	0.006	0.126

Appendix D Number of companies and employees by NACE code

Table D1.1 Number of companies and employees by NACE code for activities with main risk of exposure as demonstrated by data from national databases (Source: Eurostat Structural business statistics)

Exposure group	2-digit NACE category	4-digit NACE category	Indicator	Total in the EU27	Micro		Small		Medium		Large	
					No.	%	No.	%	No.	%	No.	%
Asbestos in building and construction	F41 Construction of buildings	F41.20 Construction of residential and non-residential buildings	No. of enterprises	677,446	627,766	92.7%	44,355	6.5%	4,926	0.7%	400	0.1%
			No. of employees	2,325,033	976,821	42.0%	683,954	29.4%	370,736	15.9%	293,522	12.6%
	F43 Specialised construction activities	F43.11 Demolition	No. of enterprises	24,004	22,869	95.3%	1,040	4.3%	91	0.4%	4	0.0%
			No. of employees	74,036	40,804	55.1%	21,278	28.7%	8,897	12.0%	3,057	4.1%
		F43.12 Site preparation	No. of enterprises	157,756	150,298	95.3%	6,834	4.3%	598	0.4%	26	0.0%
			No. of employees	271,822	149,810	55.1%	78,123	28.7%	32,665	12.0%	11,225	4.1%
		F43.21 Electrical installation	No. of enterprises	344,137	317,572	92.3%	24,468	7.1%	1,903	0.6%	194	0.1%
			No. of employees	1,209,416	527,905	43.6%	377,085	31.2%	144,454	11.9%	159,973	13.2%
		F43.22 Plumbing, heat and air conditioning installation	No. of enterprises	348,954	322,017	92.3%	24,810	7.1%	1,930	0.6%	196	0.1%
			No. of employees	1,063,606	464,259	43.6%	331,622	31.2%	127,038	11.9%	140,686	13.2%
		F43.29 Other construction installation	No. of enterprises	99,570	95,995	96.4%	3,387	3.4%	151	0.2%	37	0.04%
			No. of employees	382,713	263,311	68.8%	96,774	25.3%	20,608	5.4%	2,019	0.5%
		F43.33 Floor and wall covering	No. of enterprises	170,130	164,021	96.4%	5,788	3.4%	258	0.2%	64	0.04%
			No. of employees	276,082	189,948	68.8%	69,811	25.3%	14,866	5.4%	1,457	0.5%

Exposure group	2-digit NACE category	4-digit NACE category	Indicator	Total in the EU27	Micro		Small		Medium		Large	
					No.	%	No.	%	No.	%	No.	%
		F43.34 Painting and glazing	No. of enterprises	240,214	231,589	96.4%	8,172	3.4%	364	0.2%	90	0.04%
			No. of employees	410,306	282,296	68.8%	103,751	25.3%	22,094	5.4%	2,165	0.5%
		F43.39 Other building completion and finishing	No. of enterprises	244,028	235,266	96.4%	8,302	3.4%	370	0.2%	91	0.04%
			No. of employees	225,896	155,419	68.8%	57,121	25.3%	12,164	5.4%	1,192	0.5%
		F43.91 Roofing activities	No. of enterprises	116,843	108,794	93.1%	7,432	6.4%	576	0.5%	41	0.04%
			No. of employees	338,190	168,283	49.8%	109,741	32.4%	40,148	11.9%	20,018	5.9%
		F43.99 Other specialised construction activities n.e.c.	No. of enterprises	256,390	238,727	93.1%	16,309	6.4%	1,264	0.5%	90	0.04%
			No. of employees	775,515	385,895	49.8%	251,652	32.4%	92,064	11.9%	45,904	5.9%
	E39 Remediation activities and other waste management services	E39.00 Remediation activities and other waste management services (includes asbestos, lead paint, and other toxic material abatement)	No. of enterprises	4,080	3,434	84.2%	524	12.8%	108	2.6%	14	0.3%
			No. of employees	31,000	6,621	21.4%	10,093	32.6%	8,601	27.7%	5,685	18.3%
	D35 Electricity, gas, steam and air conditioning supply	D35.11 Production of electricity	No. of enterprises	144,783	141,693	97.9%	1,975	1.4%	735	0.5%	380	0.3%
			No. of employees	501,965	78,764	15.7%	21,114	4.2%	39,502	7.9%	362,585	72.2%
Asbestos in articles	C33 Repair and installation of machinery and equipment	C33.14 Repair of electrical equipment	No. of enterprises	15,299	14,132	92.4%	987	6.5%	154	1.0%	26	0.2%
			No. of employees	50,754	16,330	32.2%	11,464	22.6%	9,873	19.5%	13,086	25.8%

Exposure group	2-digit NACE category	4-digit NACE category	Indicator	Total in the EU27	Micro		Small		Medium		Large	
					No.	%	No.	%	No.	%	No.	%
		C33.15 Repair and maintenance of ships and boats	No. of enterprises	16,408	15,157	92.4%	1,059	6.5%	165	1.0%	28	0.2%
			No. of employees	79,094	25,449	32.2%	17,865	22.6%	15,387	19.5%	20,394	25.8%
		C33.16 Repair and maintenance of aircraft and spacecraft	No. of enterprises	2,196	2,029	92.4%	142	6.5%	22	1.0%	4	0.2%
			No. of employees	66,940	21,538	32.2%	15,120	22.6%	13,022	19.5%	17,260	25.8%
		C33.17 Repair and maintenance of other transport equipment	No. of enterprises	3,400	3,141	92.4%	219	6.5%	34	1.0%	6	0.2%
			No. of employees	53,940	17,356	32.2%	12,183	22.6%	10,493	19.5%	13,908	25.8%
	G45 Wholesale and retail trade and repair of motor vehicles and motorcycles	G45.2 Maintenance and repair of motor vehicles	No. of enterprises	452,830	433,279	95.7%	18,454	4.1%	886	0.2%	211	0.05%
			No. of employees	994,874	674,808	67.8%	228,335	23.0%	55,478	5.6%	36,253	3.64%
Naturally occurring asbestos	B08 Other mining and quarrying	B08.11 Quarrying of ornamental and building stone, limestone, gypsum, chalk and slate	No. of enterprises	5,000	3,876	77.5%	959	19.2%	155	3.1%	11	0.2%
			No. of employees	47,116	8,922	18.9%	17,551	37.2%	13,298	28.2%	7,345	15.6%
	F42 Civil engineering	F42.11 Construction of roads and motorways	No. of enterprises	33,569	26,305	78.4%	5,489	16.4%	1,449	4.30%	326	1.0%
			No. of employees	630,759	56,814	9.0%	107,193	17.0%	134,117	21.3%	332,635	52.7%
		F42.12 Construction of railways and underground railways	No. of enterprises	2,136	1,674	78.4%	349	16.4%	92	4.3%	21	1.0%
			No. of employees	79,751	7,183	9.0%	13,553	17.0%	16,957	21.3%	42,057	52.7%
		F42.13 Construction of bridges and tunnel	No. of enterprises	1,900	1,489	78.4%	311	16.4%	82	4.3%	18	1.0%
			No. of employees	36,994	3,332	9.0%	6,287	17.0%	7,866	21.3%	19,509	52.7%

Exposure group	2-digit NACE category	4-digit NACE category	Indicator	Total in the EU27	Micro		Small		Medium		Large	
					No.	%	No.	%	No.	%	No.	%
Waste treatment of asbestos-containing	E36 Water collection, treatment and supply	E36.00 Water collection, treatment and supply	No. of enterprises	15,000	12,239	81.6%	1,691	11.3%	749	5.0%	321	2.1%
			No. of employees	348,937	21,582	6.2%	37,053	10.6%	75,918	21.8%	214,384	61.4%
	E38 Waste collection, treatment and disposal activities; materials recovery	E38.11 Collection of non-hazardous waste	No. of enterprises	17,989	13,922	77.4%	2,654	14.8%	1,128	6.3%	285	1.6%
			No. of employees	533,581	31,066	5.8%	60,087	11.3%	122,401	22.9%	320,027	60.0%
		E38.12 Collection of hazardous waste	No. of enterprises	1,323	1,024	77.4%	195	14.8%	83	6.3%	21	1.6%
			No. of employees	17,803	1,037	5.8%	2,005	11.3%	4,084	22.9%	10,678	60.0%
		E38.22 Treatment and disposal of hazardous waste	No. of enterprises	1,000	736	73.6%	179	17.9%	71	7.1%	15	1.5%
			No. of employees	28,660	1,622	5.7%	3,940	13.7%	7,170	25.0%	15,929	55.6%
		E38.31 Dismantling of wrecks	No. of enterprises	3,097	2,549	82.3%	458	14.8%	79	2.6%	10	0.3%
			No. of employees	15,798	2,737	17.3%	4,521	28.6%	3,662	23.2%	4,878	30.9%
		E38.32 Recovery of sorted materials	No. of enterprises	16,126	13,273	82.3%	2,387	14.8%	414	2.6%	52	0.3%
			No. of employees	177,712	30,793	17.3%	50,861	28.6%	41,190	23.2%	54,868	30.9%
Remediation	E39 Remediation activities and other waste management services	E39.00 Remediation activities and other waste management services (includes asbestos, lead paint, and other toxic material abatement)	No. of enterprises	4,080	3,434	84.2%	524	12.8%	108	2.6%	14	0.3%
			No. of employees	31,000	6,621	21.4%	10,093	32.6%	8,601	27.7%	5,685	18.3%

Exposure group	2-digit NACE category	4-digit NACE category	Indicator	Total in the EU27	Micro		Small		Medium		Large	
					No.	%	No.	%	No.	%	No.	%
Testing	M71 Architectural and engineering activities; technical testing and analysis	M71.20 Technical testing and analysis	No. of enterprises	68,984	63,717	92.4%	4,291	6.2%	791	1.1%	185	0.27%
			No. of employees	410,396	100,501	24.5%	76,669	18.7%	72,261	17.6%	160,965	39.22%

Source: Data were retrieved from Eurostat's Structural Business Statistics database.

Notes: All data are for year 2018. Data on the number of micro, small, and medium enterprises are not available at 4-digit level and hence all data regarding the number of SMEs presented in table above are based on information available at 3-digit level.

Appendix E Summary of costs retrieved from the HSE (2017) report

The costs have been assessed for the following types of work:

Licensable work, which refers to work where the concentrations of asbestos fibres in the air during the work activity are likely to exceed specified limits or involve specific asbestos-containing materials (ACMs). This includes most large-scale asbestos removal and building refurbishment/demolition work. This work can only be undertaken by licensed contractors.

Notifiable non-licensed work (NNLW), which refers to work where concentrations of asbestos fibres in the air during the work activity are unlikely to exceed specified limits and the activity is sporadic and of low intensity. This work does not need to be carried out by licensed contractors, however, must be notified prior to its commencement.
There is a lot of overlap between licensable and NNLW work. A large proportion of licence holders also undertake NNLW work, hence the cost estimates for licensable work often cover the NNLW as well.
Many of the costs reported in tables below are overestimates. The reason is that the main businesses that participated in the HSE research were much larger than the average for the sector (those who responded employed an average of 47 workers, while the average for all licensed firms is 5 workers).

Non-notifiable work, which refers to work where the concentrations of asbestos fibres in the air during the work activity undertaken are likely to be low, and covers such activity as maintenance and small scale asbestos work. This includes work done by workers such as plumbers, electricians, etc. who may disturb asbestos as a consequence of carrying out their jobs.

Duty to manage asbestos relates to owners of non-domestic buildings (schools, local authorities, hospitals, industrial buildings, etc.) and those in charge of common areas of domestic buildings. This involves identifying, risk assessing, and recording the location and condition of asbestos; and putting in place a plan to manage the risks from any asbestos in the building that they own or manage. Information must be passed on to any contractors or workers who may disturb asbestos while they are working on the building, so that they can put in place appropriate control measures.

Assumptions made for the calculation of unit costs

Licensable work and NNLW:

- The total <u>number of licences</u> as of September 2016 is 434.
- The estimated <u>number of licensed jobs</u> a year is around 37,500. Using this data, the average number of jobs per licensee is around 86 jobs.
- The estimated <u>number of NNLW jobs</u> a year is around 28,400 (based on the number of notifications for NNLW jobs).
- The <u>number of employees</u> working with asbestos in licensed firms is 2,100, an average of approximately 5 per firm.

Non-notifiable work:

- Approximately 50% of businesses active in the construction sector will be undertaking non-notifiable work occasionally, so around 480,000 in the UK.
- The number of non-notifiable projects (jobs) a year is around 1.3million (estimated based on the number of construction projects involving non-notifiable work with asbestos a year).
- It is estimated that there are 2.2 million workers in the construction sector who could come across asbestos in their work. Each year approximately half, or 1.1 million of these will undergo refresher training.
- New entrants to the workforce each year have been estimated to be around 320,000.

Duty to manage asbestos

- For several of the estimates, the numbers of buildings have been adjusted by the proportion of buildings estimated to contain asbestos, estimated as 37%.
- Three are 28 thousand school buildings in GB, in total. Using the estimate of 37% of buildings likely to contain asbestos leads to an estimate of approximately 11 thousand schools with asbestos.
- There are 380 Local Authorities (LAs) in GB. 98% of LA respondents stated asbestos was present in the buildings they manage.
- There are approximately 460 hospitals in GB,19 37% of which have been assumed to contain asbestos (a total of 172).
- Industrial and commercial buildings: There are 9,300 large industrial buildings in GB, majority of them are estimated to contain asbestos. There are 52,000 medium sized industrial buildings in GB, 37% of them are likely to contain asbestos (a total of 19,240). There are 5.2 million small industrial buildings in GB, majority of them are estimated to contain asbestos. This includes approximately 4.7m self-employed, some 20% of whom are home-workers, and therefore do not have a duty to manage asbestos. This leaves 4.3m businesses, of which HSE assumed 37% (or 1.6m) have asbestos on their property.
- Domestic buildings which are likely to have common areas are those dwellings which include 2 or more household spaces. There are 22,000 of such buildings in GB, 37% of which are estimated to contain asbestos (a total of 8,140).

Main costs identified by work type are summarized in Table 10.1. The individual cost categories as well as the relevant estimated costs are described in more detail in Tables 10.2 (Costs for licensable and NNLW work), 10.3 (Costs for non-notifiable work), and 10.4 (Costs of duty to manage asbestos).

Table E1.1 Main costs assessed by duty holder group retrieved from the HSE report (costs are reported per annum)

Duty holder groups / Cost description	Licensable work	Notifiable non-licensed work	Non-notifiable work	Duty to manage asbestos
Dutyholders are required to find out if there is asbestos in the premises, its location and **what condition it is in**. If there is asbestos present, they must make a record of the location and condition of the asbestos, assess the risk from it, and prepare a plan that sets out in detail how they are going to manage the risk from this material – **one off cost** (no buildings that are new will contain asbestos. So the one-off costs are **negligible**) **Most costs would arise from ongoing duties** (keep up to date the record of the location and condition of the asbestos in the premises and to verify every 12 months the information in the management plan)	-	-	-	✓ **€ 138 million** *Ongoing costs for duties of owners of non-domestic buildings and those who manage common areas of domestic buildings*
Employers are required to **identify the presence of asbestos** and its type and condition before any building, maintenance, demolition or other work, liable to disturb asbestos, begins Employers are required to **carry out a risk assessment** to identify the risks of exposure to asbestos	✓ **€ 18.3 million (€ 14.4 million – € 21.3 million)** *Note: covers both licensable and notifiable non-licensed work* *The costs are calculated as 65,900 licensed and NNLW jobs * € 505 (€ 401 – € 586) per job*	✓ **See the estimate for licensable work**	✓ **€ 10.6 million** *The costs are calculated as 1.3 million non-notifiable projects * €8 per 1 risk assessment per project*	-
Employers are required to **prepare a written plan** before work on asbestos is carried out	✓	✓	-	-

Duty holder groups / Cost description	Licensable work	Notifiable non-licensed work	Non-notifiable work	Duty to manage asbestos
Employers are required to make sure that **areas where asbestos work is being carried out are separated, clearly marked, and restricted** to those required to work in the area; and to **provide suitable facilities for employees to eat and drink**	**€ 75.3 million (€ 65.3 million – € 84.9 million)** *Note: covers both licensable and notifiable non-licensed work* *The costs are calculated as 65,900 licensed and NNLW jobs * € 2,012 (€ 1,745 – € 2,268) per job*	**See the estimate for licensable work**		
Employers are required to **obtain a licence** before they can carry out any licensable work with asbestos	✓ **€ 0.53 million** *Note: Assuming that 145 licences are applied for and/or renewed each year* *The costs are calculated as 145 applications * (€ 7,394 one -off cost for a first application + € 3,485 for a renewal)*	-	-	-
Notification of work with asbestos	✓ **€ 1.5 million (€ 0.9 million – € 2.2 million)** *The costs are calculated as 37,500 licensed jobs * € 41 (€ 23 – € 58) per job*	✓ **€1.2 million (€ 0.7 million – € 1.6 million)** *The costs are calculated as 28,400 licensed jobs * € 41 (€ 23 – € 58) per job*	-	-
Provision of information, instruction and training	✓ **€ 3.3 million (€ 3.1 million – € 3.5 million)** *Note: covers both licensable and notifiable non-licensed work*	✓ **See the estimate for licensable work**	✓ **€ 112 million** *The costs are calculated as follows: 50% of 2,200,000 employees in the construction sector that*	-

Duty holder groups / Cost description	Licensable work	Notifiable non-licensed work	Non-notifiable work	Duty to manage asbestos
	*The costs are calculated as 2,072 employees * € 1,603 (€ 1,504 – € 1,708) per employee*		*may come into contact with asbestos must take a refresher course every year, i.e. 1,100,000 employees * € 46 per course per employee* + *50% of 320,000 new entrants that may come into contact with asbestos must take an awareness raising course every year, i.e. 160,000 employees * € 29 per course per employee* + *50% of 320,000 new entrants that may come into contact with asbestos must take a full-day course every year, i.e. 160,000 employees * € 349 per course per employee*	
Prevention or reduction of exposure to asbestos, use of control measures, maintenance of control measures and provision and cleaning of protective equipment	✓ **€ 42 million (€ 6 million – € 77.7 million)** *Note: covers both licensable and notifiable non-licensed work* *The costs are calculated as 434 licences * € 87,393 (€ 13,912 – € 160,730) per licence; except for the costs of PPE, which are calculated on*	✓ **See the estimate for licensable work**	✓ **€ 72 million** *The costs are calculated as follows: 1 employee per project (the projects are assumed to be small-scale and will involve only 1 employee/project) will require a full asbestos protection kit priced at €*	-

Duty holder groups / Cost description	Licensable work	Notifiable non-licensed work	Non-notifiable work	Duty to manage asbestos
	*per employee basis: 2,072 employees * € 2,788 (€ 232– € 5,228) per employee*		*55, i.e. 1,300,000 projects * € 55 per kit per employee*	
Duty to **prevent the spread or reduce the spread of asbestos**, **cleanliness of premises and plan** (possible overlap with the above category)	✓ **€ 0.9 million on average (min and max estimate are not available)** *Note: covers both licensable and notifiable non-licensed work* *The costs are calculated as 434 licences * € 2,091 per licence*	✓ **See the estimate for licensable work**	✓ **Relevant, but not quantified**	-
Air monitoring and standards for testing and site clearance certification	✓ **€ 22.2 million (€ 14.6 million – € 30.2 million)** *Note: covers both licensable and notifiable non-licensed work* *The costs of arranging regular monitoring of airborne asbestos fibres are calculated as 434 licences * € 9,235 (€ 6,796– € 11,559) per licence* + *The costs of engaging someone to test the air are calculated on per job basis: 37,500 licensed jobs * € 484 (€310– € 671) per job*	✓ **See the estimate for licensable work (minimal costs for NNLW as this type of cost does not generally apply to NNLW)**	-	-

Duty holder groups / **Cost description**	**Licensable work**	**Notifiable non-licensed work**	**Non-notifiable work**	**Duty to manage asbestos**
Standards for analysis (check that meets the criteria set out in ISO 17025)	✓ **€ 4.7 million (€ 4.4 million– € 5 million)** *The costs are calculated as 37,500 licensed jobs * € 125 (€ 116 – € 134) per job*	✓ **€ 3.1 million (€ 2.8 million– € 3.3 million)** *The costs are calculated as 28,400 NNLW jobs * € 125 (€ 116 – € 134) per job*	-	-
Health records and medical surveillance	✓ **€ 3.6 million (€ 1.5 million– € 5.8 million)** *Note: covers both licensable and notifiable non-licensed work* *The costs are calculated as 2,072 employees * € 1,719 (€ 714 – €2,788) per employee*	✓ **See the estimate for licensable work**	-	-
Employers are required to **provide suitable and sufficient washing, changing and storage facilities** for employees	✓ **€ 0.4 million (€ 0.1 million– € 0.6 million)** *Note: covers both licensable and notifiable non-licensed work* *The costs are calculated as 434 licences * € 848 (€ 290 – € 1,394) per licence*	✓ **See the estimate for licensable work**	-	-
Storage, distribution and labelling of raw asbestos and asbestos waste	✓ **€ 57.6 million (€ 48.2 million– € 67.1 million)**	✓ **See the estimate for licensable work**	✓ **Relevant, but not quantified**	-

Duty holder groups / Cost description	Licensable work	Notifiable non-licensed work	Non-notifiable work	Duty to manage asbestos
	Note: covers both licensable and notifiable non-licensed work *The cash costs are calculated as 65,900 licensed and NNLW jobs * € 1,394 (€1,162– € 1,626) per job* + *the staff costs are calculated on per licence basis: 434 licences * € 4,531 (€2,881– € 6,273) per licence*			
TOTAL estimated costs	**€236 million (€158 million – €300 million)** ***Note: covers both licensable and notifiable non-licensed work*** *! There is a discrepancy between the total cost given in the HSE report €272 million (€182 million – €344 million) and the total calculated by aggregating the individual cost categories, also available in the HSE report, which are described in more detail in table below*	**See the estimate for licensable work**	**€ 194 million** ***Note: This is likely to be a slight underestimate, it is expected that the potential scale of the costs would be at most in the low hundreds of millions of pounds per annum.***	**€ 138 million** ***Note: This is likely to be a slight underestimate, it is expected that the potential scale of the costs would be at most in the low hundreds of millions of pounds per annum.***

The costs summarised above are described in more detail in the following tables.

Table E1.2 Costs identified for licensable work and notifiable non-licensed work (NNLW) in the UK (Source: HSE, 2017)

		Costs for licensed companies (whole of UK) In million EUR			Costs of notifiable non-licensed work (NNLW) (whole of UK) In million EUR			Cost per unit Licensed work In EUR				Cost per unit NNLW work In EUR			
Cost description	**Cash/Staff cost?**	**Best estimate**	**Min**	**Max**	**Best estimate**	**Min**	**Max**	**Best estimate**	**Min**	**Max**	**Unit**	**Best estimate**	**Min**	**Max**	**Unit**
RPE costs															
Not available – the estimate is included in the costs of control measures provided below															
Technical/organisational measures															
Employers are required to identify asbestos and its type and condition before any building, maintenance, demolition, or other work, liable to disturb asbestos, begins	n/a (but presumably it is a staff cost)	**4.1**	**2.2**	**5.2**	**0.20**	**n/a**	**n/a**	110	58	139	Per job per annum	7	n/a	n/a	Per job per annum
Employers are required to carry out a risk assessment to identify the risks of exposure to asbestos	n/a (but presumably it is a staff cost)	**7.6**	**6.1**	**9.1**	**0.29**	**n/a**	**n/a**	203	163	244	Per job per annum	10	n/a	n/a	Per job per annum
Other costs associated with the two categories above (no specific description of cost given)	n/a (but presumably it is a staff cost)	**6.5**	**6.1**	**7.0**	**0.00**	**0**	**0**	174	163	186	Per job per annum	0	0	0	Per job per annum

Cost description	Cash/Staff cost?	Costs for licensed companies (whole of UK) In million EUR			Costs of notifiable non-licensed work (NNLW) (whole of UK) In million EUR			Cost per unit Licensed work In EUR				Cost per unit NNLW work In EUR			
		Best estimate	Min	Max	Best estimate	Min	Max	Best estimate	Min	Max	Unit	Best estimate	Min	Max	Unit
Employers are required to prepare a written plan before work on asbestos is carried out	Cash cost	**8.3**	**5.2**	**10.9**	**0.00**	**n/a**	**n/a**	221	139	290	Per job per annum	0	n/a	n/a	Per job per annum
	Staff cost	**17.4**	**15.2**	**19.6**	**0.20**	**n/a**	**n/a**	465	407	523	Per job per annum	7	n/a	n/a	Per job per annum
Employers are required to make sure that areas where asbestos work is being carried out are separated, clearly marked, and restricted to those required to work in the area, and to provide suitable facilities for employees to eat and drink	n/a (but presumably it is a staff cost)	**5.7**	**0.9**	**10.5**	**0.20**	**n/a**	**n/a**	151	23	279	Per job per annum	7	n/a	n/a	Per job per annum
Costs of putting up barriers and fencing	Cash and staff costs	**43.6**	**n/a**	**n/a**	**<- also covers NNLW estimate**	**n/a**	**n/a**	1,162	n/a	n/a	Per job per annum	<- also covers NNLW estimate	n/a	n/a	n/a
Employers are required to obtain a licence from HSE before they can carry out any licensable work with asbestos	One-off cash cost of applying for the licence for the first time	**0.57**	**n/a**	**n/a**	**0 (no licence required)**	**0**	**0**	3,909	n/a	n/a	Per licence per annum	0 (no licence required)	0	0	n/a

Cost description	Cash/Staff cost?	Costs for licensed companies (whole of UK) In million EUR			Costs of notifiable non-licensed work (NNLW) (whole of UK) In million EUR			Cost per unit Licensed work In EUR				Cost per unit NNLW work In EUR			
		Best estimate	**Min**	**Max**	**Best estimate**	**Min**	**Max**	**Best estimate**	**Min**	**Max**	**Unit**	**Best estimate**	**Min**	**Max**	**Unit**
	One-off staff cost of applying for the licence for the first time	**0.51**	**n/a**	**n/a**	**0 (no licence required)**	**0**	**0**	3,485	2,323	4,647	Per licence per annum	0 (no licence required)	0	0	n/a
	Staff cost for licence renewal (annual cost). A renewal is required every 3 years on average	**0.51**	**n/a**	**n/a**	**0 (no licence required)**	**0**	**0**	3,485	2,091	4,879	Per licence per annum	0 (no licence required)	0	0	n/a
Employers are required to notify the appropriate enforcing authority of proposed work which is either licensable (always notifiable) or NNLW	Cash cost	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	0	0	0	Per job per annum	0	0	0	Per job
	Staff cost	**1.5**	**0.9**	**2.2**	**1.2**	**0.7**	**1.6**	41	23	58	Per job per annum	41	23	58	Per job

Cost description	Cash/Staff cost?	Costs for licensed companies (whole of UK) In million EUR			Costs of notifiable non-licensed work (NNLW) (whole of UK) In million EUR			Cost per unit Licensed work In EUR				Cost per unit NNLW work In EUR			
		Best estimate	Min	Max	Best estimate	Min	Max	Best estimate	Min	Max	Unit	Best estimate	Min	Max	Unit
Costs of control measures Control measures can include dust suppression techniques, extraction equipment, using enclosures, hygiene facilities (showers to decontaminate), using respiratory protective equipment (RPE) and protective clothing, the use of 'H' vacuum cleaners and eating, drinking and smoking in designated areas only	One-off cash cost	**0.5**	**0.2**	**0.8**	**<- also covers NNLW estimate**	**n/a**	**n/a**	3,659	1,510	5,808	Per licence	<- also covers NNLW estimate	n/a	n/a	n/a
	One-off staff cost	**0.3**	**0.03**	**0.6**	**<- also covers NNLW estimate**	**n/a**	**n/a**	2,230	232	4,229	Per licence	<- also covers NNLW estimate	n/a	n/a	n/a
	Ongoing cash costs	**11.6**	**0.5**	**22.7**	**<- also covers NNLW estimate**	**n/a**	**n/a**	26,719	1,104	52,276	Per licence per annum	<- also covers NNLW estimate	n/a	n/a	n/a
	Ongoing staff costs	**1.5**	**1.0**	**2.0**	**<- also covers NNLW estimate**	**n/a**	**n/a**	3,485	2,323	4,647	Per licence per annum	<- also covers NNLW estimate	n/a	n/a	n/a
Employers are required to carry out regular inspection and maintenance of control measures	Cash cost	**2.5**	**n/a**	**n/a**	**<- also covers NNLW estimate**	**n/a**	**n/a**	5,808	n/a	n/a	Per licence per annum	<- also covers NNLW estimate	n/a	n/a	n/a
	Staff cost	**12**	**0.08**	**24**	**<- also covers**	**n/a**	**n/a**	27,183	186	54,251	Per licence	<- also covers	n/a	n/a	n/a

Cost description	Cash/Staff cost?	Costs for licensed companies (whole of UK) In million EUR			Costs of notifiable non-licensed work (NNLW) (whole of UK) In million EUR			Cost per unit Licensed work In EUR				Cost per unit NNLW work In EUR			
		Best estimate	Min	Max	Best estimate	Min	Max	Best estimate	Min	Max	Unit	Best estimate	Min	Max	Unit
					NNLW estimate						per annum	NNLW estimate			
Costs of a competent person examining exhausts	Cash cost	**0.8**	**0.10**	**1.5**	**<- also covers NNLW estimate**	**n/a**	**n/a**	1,859	232	2,485	Per licence per annum	<- also covers NNLW estimate	n/a	n/a	n/a
	Staff cost	**0.9**	**0.06**	**1.7**	**<- also covers NNLW estimate**	**n/a**	**n/a**	2,091	139	3,950	Per licence per annum	<- also covers NNLW estimate	n/a	n/a	n/a
Costs of record keeping of examinations (for 5 years)	Cash cost	**0.5**	**n/a**	**n/a**	**<- also covers NNLW estimate**	**n/a**	**n/a**	1,115	n/a	n/a	Per licence per annum	<- also covers NNLW estimate	n/a	n/a	n/a
	Staff cost	**0.3**	**0.04**	**0.5**	**<- also covers NNLW estimate**	**n/a**	**n/a**	627	93	1,162	Per licence per annum	<- also covers NNLW estimate	n/a	n/a	n/a

Cost description	Cash/Staff cost?	Costs for licensed companies (whole of UK) In million EUR			Costs of notifiable non-licensed work (NNLW) (whole of UK) In million EUR			Cost per unit Licensed work In EUR				Cost per unit NNLW work In EUR			
		Best estimate	Min	Max	Best estimate	Min	Max	Best estimate	Min	Max	Unit	Best estimate	Min	Max	Unit
Costs of PPE (e.g. disposable tyvex type full hooded overall (at least 4 overalls per worker per day), rubber boots, gloves, disposable half-masks for set up and dismantling, for enclosure work would have a power assisted full face respirator **! it is possible that a part of this estimate is already included in the costs of control measures**	Cash cost	**5.8**	**0.5**	**10.8**	**<- also covers NNLW estimate**	**n/a**	**n/a**	2,788	232	5,228	!Per employee! per annum	<- also covers NNLW estimate	n/a	n/a	n/a
	Staff cost	**1.6**	**0.4**	**2.8**	**<- also covers NNLW estimate**	**n/a**	**n/a**	3,717	987	6,389	Per licence per annum	<- also covers NNLW estimate	n/a	n/a	n/a
Costs of cleaning of PPE	Cash cost	**3.8**	**0.0**	**7.6**	**<- also covers NNLW estimate**	**n/a**	**n/a**	8,713	0	17,425	Per licence per annum	<- also covers NNLW estimate	n/a	n/a	n/a
	Staff cost	**0.08**	**n/a**	**n/a**	**<- also covers NNLW estimate**	**n/a**	**n/a**	186	n/a	n/a	Per licence per annum	<- also covers NNLW estimate	n/a	n/a	n/a

Cost description	Cash/Staff cost?	Costs for licensed companies (whole of UK) In million EUR			Costs of notifiable non-licensed work (NNLW) (whole of UK) In million EUR			Cost per unit Licensed work In EUR				Cost per unit NNLW work In EUR			
		Best estimate	Min	Max	Best estimate	Min	Max	Best estimate	Min	Max	Unit	Best estimate	Min	Max	Unit
Prevention of the spread or reduction of the spread of asbestos, cleanliness of premises and plant and washing and changing machines **! it is possible that a part of this estimate is already included in the costs of cleaning of PPE**	Cash cost	**0.4**	**n/a**	**n/a**	**<- also covers NNLW estimate**	**n/a**	**n/a**	813	n/a	n/a	Per licence per annum	<- also covers NNLW estimate	n/a	n/a	n/a
	Staff cost	**0.6**	**n/a**	**n/a**	**<- also covers NNLW estimate**	**n/a**	**n/a**	1,278	n/a	n/a	Per licence per annum	<- also covers NNLW estimate	n/a	n/a	n/a
Provision of washing and changing facilities	Cash cost	**0.4**	**0.1**	**0.6**	**<- also covers NNLW estimate**	**n/a**	**n/a**	848	290	1,394	Per licence per annum	<- also covers NNLW estimate	n/a	n/a	n/a
Training															
Employers are required to conduct a training needs analysis	n/a (but presumably it is a staff cost)	**0.4**	**0.2**	**0.6**	**<- also covers NNLW estimate**	**n/a**	**n/a**	186	87	290	Per employee per annum	<- also covers NNLW estimate	n/a	n/a	Per employee per annum
External training	Both cash and staff cost	**0.9**	**n/a**	**n/a**	**<- also covers NNLW estimate**	**n/a**	**n/a**	418	n/a	n/a	Per employee per annum	<- also covers NNLW estimate	n/a	n/a	Per employee per annum

Cost description	Cash/Staff cost?	Costs for licensed companies (whole of UK) In million EUR			Costs of notifiable non-licensed work (NNLW) (whole of UK) In million EUR			Cost per unit Licensed work In EUR				Cost per unit NNLW work In EUR			
		Best estimate	Min	Max	Best estimate	Min	Max	Best estimate	Min	Max	Unit	Best estimate	Min	Max	Unit
In house training	Both cash and staff cost	**2.1**	**n/a**	**n/a**	**<- also covers NNLW estimate**	**n/a**	**n/a**	999	n/a	n/a	Per employee per annum	<- also covers NNLW estimate	n/a	n/a	Per employee per annum
Employees providing information to other employees about asbestos	Staff cost	**0.07**	**0.04**	**0.10**	**<- also covers NNLW estimate**	**n/a**	**n/a**	157	81	232	Per licence per annum	<- also covers NNLW estimate	n/a	n/a	n/a
Cost of ensuring asbestos is properly packed, labelled, stored and transported	Cash cost	**52**	**44**	**61**	**3.4**	**n/a**	**n/a**	1,394	1,162	1,626	Per job per annum	120	n/a	n/a	Per job per annum
	Staff cost	**1**	**n/a**	**n/a**	**<- also covers NNLW estimate**	**n/a**	**n/a**	2,788	n/a	n/a	Per licence per annum	<- also covers NNLW estimate	n/a	n/a	n/a
Any other costs	Cash costs and staff costs	**0.8**	**0.04**	**1.5**	**<- also covers NNLW estimate**	**n/a**	**n/a**	1,743	93	3,485	Per licence per annum	<- also covers NNLW estimate	n/a	n/a	n/a
Monitoring															

Cost description	Cash/Staff cost?	Costs for licensed companies (whole of UK) In million EUR			Costs of notifiable non-licensed work (NNLW) (whole of UK) In million EUR			Cost per unit Licensed work In EUR				Cost per unit NNLW work In EUR			
		Best estimate	Min	Max	Best estimate	Min	Max	Best estimate	Min	Max	Unit	Best estimate	Min	Max	Unit
Employers are required to arrange regular monitoring of airborne asbestos fibres	Cash cost	**0.5**	**n/a**	**n/a**	**Not relevant for NNLW**	**n/a**	**n/a**	1,104	n/a	n/a	Per licence per annum	Not relevant for NNLW	n/a	n/a	n/a
	Staff cost	**3.5**	**2.5**	**4.5**	**Not relevant for NNLW**	**n/a**	**n/a**	8,132	5,692	10,455	Per licence per annum	Not relevant for NNLW	n/a	n/a	n/a
Costs of engaging someone to test the air	Cash cost	**17**	**11**	**24**	**Not relevant for NNLW**	**n/a**	**n/a**	465	290	651	Per job per annum	Not relevant for NNLW	n/a	n/a	n/a
	Staff cost	**0.74**	**n/a**	**n/a**	**Not relevant for NNLW**	**n/a**	**n/a**	20	n/a	n/a	Per job per annum	Not relevant for NNLW	n/a	n/a	n/a
Employers are required to perform their own analysis of material to check for asbestos in a way that meets the criteria set out in ISO 17025	Cash cost	**0.8**	**0.4**	**1.1**	**0.6**	**0.3**	**0.8**	21	12	29	Per job per annum	21	12	29	Per job per annum
	Staff cost	**3.9**	**n/a**	**n/a**	**2.5**	**n/a**	**n/a**	105	n/a	n/a	Per job per annum	105	n/a	n/a	Per job per annum
	Cash cost	**0.7**	**0.6**	**0.7**	**<- also covers**	**n/a**	**n/a**	325	290	349	Per employee	<- also covers	n/a	n/a	Per employee

Cost description	Cash/Staff cost?	Costs for licensed companies (whole of UK) In million EUR			Costs of notifiable non-licensed work (NNLW) (whole of UK) In million EUR			Cost per unit Licensed work In EUR				Cost per unit NNLW work In EUR			
		Best estimate	Min	Max	Best estimate	Min	Max	Best estimate	Min	Max	Unit	Best estimate	Min	Max	Unit
Costs of maintaining a health record for each employee					**NNLW estimate**						per annum	NNLW estimate			per annum
	Staff cost	**2.4**	**0.6**	**4.4**	**<- also covers NNLW estimate**	**n/a**	**n/a**	1,162	279	2,114	Per employee per annum	<- also covers NNLW estimate	n/a	n/a	Per employee per annum
Cost of a medical examination per employee	Cash cost	**0.3**	**0.2**	**0.4**	**<- also covers NNLW estimate**	**n/a**	**n/a**	151	99	209	Per employee per annum	<- also covers NNLW estimate	n/a	n/a	Per employee per annum
	Staff cost	**0.2**	**0.1**	**0.2**	**<- also covers NNLW estimate**	**n/a**	**n/a**	81	46	116	Per employee per annum	<- also covers NNLW estimate	n/a	n/a	Per employee per annum
Further notification/surveillance															
Not available															

Note: Prices were converted from British Pounds to Euros using the following exchange rate: 1.00 British Pound = 1.1616819 Euros [as of 04/06/2021], available at: https://www.xe.com/currencyconverter/convert/?Amount=1&From=GBP&To=EUR

Source of data: HSE, 2017, "Post Implementation Review of the Control of Asbestos Regulations 2012", available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/598574/post-implementation-review-of-the-control-of-asbestos-regulations-2012.pdf

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