



**Expert forecast on emerging chemical risks related to occupational safety and health**





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## FOREWORD



Each year 167,000 workers die in the EU-27 of the consequences of their work, according to estimates from the International Labour Office. As many as 159,500 of these fatalities can be attributed to work-related diseases, of which 74,000 are attributable to exposure to dangerous substances. The number of work-related diseases is considerably higher than the number of accidents. In particular, work-related cancers are among the main causes – if not the main one – of deaths in Europe related to working conditions.

A lot is going on at EU level in relation to dangerous substances in the workplace which will hopefully help to better protect workers from exposure to dangerous substances. The implementation of the REACH Regulation should encourage the industry to develop safer substances as well as generate information on the hazards of chemicals and the means of managing the risks related to their uses, and hence contributing to the improvement of workers' protection. In addition, the tripartite Advisory Committee on Safety and Health at Work (ACSHW) approved a proposal in May 2007 for a Directive establishing a third list of indicative occupational exposure limit values (IOELVs). The new list establishes IOELVs for 20 more hazardous chemicals used in workplaces, bringing the number of IOELVs up to 116 with the two previous lists already adopted. At the request of the European Commission, the European Agency for Safety and Health at Work has investigated both existing Occupational Exposure Levels (OELs) for carcinogens and methodologies for setting OELs. This, together with the results of the second consultation on Directive 2004/37/EC (the carcinogens directive) in spring 2007, could help the Commission to define possible options for revising the Directive.

The previous Community strategy on health and safety at work 2002-2006 called on the Agency to 'set up a risk observatory' and to 'anticipate new and emerging risks' in order to tackle the continuously changing world of work and the new risks and challenges it brings. The new Community strategy for the period 2007-2012 reinforces the European Risk Observatory's role and explicitly mentions the identification of new risks and dangerous substances as a research priority.



Between 2002 and 2006, the Agency took the first step towards establishing a European Risk Observatory (ERO). Four expert forecasts have been carried out through questionnaire-based surveys following the Delphi method on emerging risks related to occupational safety and health on physical, psychosocial, biological and chemical risks. This division into four themes was not meant to indicate fixed boundaries between the areas or to exclude combinations of them. On the contrary, many occupational safety and health issues are multi-factorial and have been mentioned in several of the surveys. In total, 520 experts from 27 countries and one international organisation were invited to participate in the surveys. Answers were received from 188 experts from 24 countries and the international organisation, giving a response rate of 35%.

This report, the last of the series of four European Risk Observatory reports dedicated to expert forecasts of emerging risks, sets out the forecast on emerging chemical risks. The results of this expert survey on emerging chemical risks – like the results of the forecasts on physical, biological and psychosocial risks carried out by the European Risk Observatory – are based on scientific expertise and should be seen as a basis for discussion among stakeholders to set priorities for further research and actions. As for the three previous expert forecasts, the Agency will organise a workshop involving high-level representatives from the occupational safety and health (OSH) community – and possibly from other disciplines concerned with the issue of dangerous substances – as well as EU policy-makers and social partners in order to consolidate the forecast and to explore concrete ways to tackle the emerging risks identified in this forecast. This workshop will take place in March 2009.

Last, but not least, the Agency is also setting up a follow-up, larger-scale foresight study. This will start in 2009 and look, as a first step, at emerging OSH risks arising from technological innovations.

The Agency would like to thank the members of the Topic Centre Risk Observatory for carrying out this survey and for their contributions to the drafting of this report. Most of all, it would like to thank all the safety and health experts from around Europe who took the time to reply to the survey; their participation was essential to the project. The Agency would also like to thank its focal points, Expert Group and Advisory Group for their valuable comments and suggestions.

Jukka Takala  
Director  
European Agency for Safety and Health at Work  
July 2008



## EXECUTIVE SUMMARY

The Community strategy on health and safety at work 2002-2006 called on the European Agency for Safety and Health at Work to 'set up a risk observatory' to 'anticipate new and emerging risks'. Within this context, a series of four expert forecasts were formulated with the aim of providing as comprehensive as possible a picture of the potential emerging risks in the world of work. Three reports on emerging physical risks, biological risks and psychosocial risks have already been published. This publication (the last one of the series) presents the results of the forecast on emerging chemical risks related to occupational safety and health based on an expert survey and a literature review.

### Method

Within the scope of this project, an 'emerging occupational safety and health (OSH) risk' has been defined as any occupational risk that is both new and increasing.

By new it means that:

- the risk was previously unknown and is caused by new processes, new technologies, new types of workplace, or social or organisational change; or
- a longstanding issue is newly considered as a risk due to a change in social or public perceptions; or
- new scientific knowledge allows a longstanding issue to be identified as a risk.

The risk is increasing if:

- the number of hazards leading to the risk is growing; or
- the likelihood of exposure to the hazard leading to the risk is increasing (exposure level and/or the number of people exposed); or
- the effect of the hazard on workers' health is getting worse (seriousness of health effects and/or the number of people affected).

To formulate this expert forecast, a questionnaire-based survey was run in three consecutive rounds following the Delphi method. This method was chosen to avoid individual, non-scientifically founded opinions and to verify whether a consensus was reached among the respondents; 174 experts in the first survey round and 152 experts from each of the second and third rounds were invited to participate in the survey following their nomination by the Agency's Focal Points and Topic Centre Research. Thirty-one valid questionnaires from the first round, 35 from the second round and 49 from the third were returned from 64 organisations covering 19 European Member States as well as Iceland and Switzerland. The response rates were 31% (first survey round), 35% (second round) and 32% (third round). Participating experts were required to have at least five years' experience in the field of OSH and chemical risks. The majority of respondents were managers in an OSH organisation, or OSH researchers.

*An 'emerging OSH risk' is any occupational risk that is both new and increasing.*

*174 experts were approached. The forecast is based on 49 questionnaires returned from 21 European countries.*

### 'Top' emerging risks

#### Particles

Among the 'top ten' emerging risks, three (nanoparticles and ultrafine particles, diesel exhaust and man-made mineral fibres) have in common their physico-chemical state





as particles. According to the Fourth European Working Conditions Survey <sup>(1)</sup> 19.1% of the EU-27 workforce reported in 2005 that they 'breathe in smoke, fumes, powders or dust'.

The risks posed by '**nanoparticles and ultrafine particles**' are by far the strongest agreed as emerging by the experts. Applications of nanotechnology are mainly found in:

- information and communication technologies;
- environmental and energy technologies;
- transport, aviation and space;
- agriculture and nutrition;
- medical applications;
- cosmetics;
- military technologies.

*Very little research has been performed on the health and safety effects of nanoparticles (NPs). Once in the body, NPs can translocate to organs or tissues distant from the portal of entry. There is considerable evidence that some NPs are toxic to human health.*

The nanotechnology industry is expected to grow rapidly into a global, multi-billion-euro market and to employ 10 million workers worldwide by 2014. However, very little research has been performed on the health and safety effects of nanoparticles (NPs). NPs can have very different properties from the same materials at the macro scale. There are indications that the toxicity of particles increases with decreasing diameter and increasing surface area, thus challenging current mass-based risk evaluation approaches. Several studies indicate that, once in the body, NPs can translocate to organs or tissues distant from the portal of entry. Durable, biopersistent NPs may bioaccumulate in the body – in particular in the lungs, the brain and the liver. Ultrafine particles have been found to act as an important environmental risk factor for cardiopulmonary mortality and there is considerable evidence that some NPs are toxic to human health. The basis of toxicity is not fully established, but appears to be primarily expressed through an ability to cause inflammation. NPs could also act like haptens to modify protein structures, hence raising the potential for autoimmune effects. Damage to the cells through oxidative stress, believed to induce many diseases such as cancers, is also suggested. However, decisive scientific information is still lacking.

Although the quantitative data needed for satisfactory risk assessment are still missing, sufficient information is available to begin preliminary assessment and to develop interim working practices to reduce workplace exposure. The manufacturing phase of nanomaterials as well as maintenance and clean-up of equipment used to produce NPs are known to be a source of exposure. Further research should concentrate on the complete life-cycle of a given nanomaterial in order to identify all exposure situations and the workplaces concerned. In parallel, further research should be undertaken to guarantee the development of 'responsible' nanotechnology which integrates health and safety considerations.

*Diesel exhaust is the fourth most common carcinogen found in the workplace.*

Exposure to **diesel exhaust** is the second most emerging risk highlighted in the forecast. According to the CAREX (CARcinogen EXposure) database <sup>(2)</sup>, at the beginning of the 1990s, 3.1 million workers in the EU-15 were exposed for at least 75% of their

<sup>(1)</sup> Parent-Thirion, A., Fernández Macías, E., Hurley, J., Vermeylen, G., *Fourth European Working Conditions Survey*, European Foundation for the Improvement of Living and Working Conditions, Luxembourg, 2007. <http://eurofound.europa.eu/pubdocs/2006/98/en/2/ef0698en.pdf>

<sup>(2)</sup> Kauppinen, T. et al., *CAREX – International Information System on Occupational Exposure to Carcinogens. Occupational exposures to carcinogens in the European Union in 1990-1993*, Finnish Institute of Occupational Health, Helsinki 1998. [http://www.ttl.fi/NR/rdonlyres/4444380F-B1FB-4D01-A974-0B6A9E663CFA/0/1\\_description\\_and\\_summary\\_of\\_results.pdf](http://www.ttl.fi/NR/rdonlyres/4444380F-B1FB-4D01-A974-0B6A9E663CFA/0/1_description_and_summary_of_results.pdf)



working time to diesel exhaust, making it the fourth most common carcinogen found in the workplace after solar radiation, tobacco smoke and crystalline silica.

Hazardous levels of diesel exhaust can be found in occupations ranging from mining to driving diesel-fuelled trucks or forklifts. Diesel exhaust is made up of a complex mixture of thousands of fine particles, gases and vapours. The major components are carbon dioxide, carbon monoxide, nitrogen dioxide, nitric oxide, particulate matter and sulphur dioxide. Diesel engine exhaust is classified as 'probably carcinogenic to humans' (Group 2A) in the International Agency for Research on Cancer's classification <sup>(3)</sup>. More specifically with regard to lung cancer, a positive association between diesel exhaust emissions and lung cancer is suspected but is still controversial. A link between emissions from diesel-fuelled engines and non-cancer damage to the lung has also been found. More research is needed on the health effects of such particulates.

**Man-made mineral fibres** are divided into siliceous and non-siliceous. Fibres with a geometric diameter less than 3 µm may reach the alveolar zone of the lungs. While the size of the fibres is acknowledged to be linked to their harmful toxic effects (the longer and thinner the fibres, the more dangerous they are), standard air sampling methods do not allow precise measurement of fibre size. Specific fibre dimensions hypothesised to have a biological activity have been proposed but need to be evaluated in epidemiologic studies. In general, fibrous structure increases inflammatory, cytotoxic and carcinogenic potential. Oxidising stress of the cells can also occur, especially in the case of repetitive exposure.

Manufacturers continuously strive to reduce the biopersistence of siliceous fibres by modifying their compositions – a process favourable to occupational health. However, the compositional changes make it more difficult to obtain comparable data from epidemiological studies. As a consequence, very few toxicological data are available for these new products. Aluminium silicate wool (ASW) – more commonly called refractory ceramic fibres (RCFs) – is carcinogenic category 2 in the EU classification.

ASW/RCF products put on the market are labelled according to Directive 67/548 for substance and preparations. According to the European Ceramic Fibres Industry Association (ECFIA), the manufacturing industry also labels articles containing ASW/RCFs (though not required by the regulations). However, a study by the French agency Afsset found:

- there is no specific code or labelling clearly indicating their presence in items and equipment;
- RCFs cannot be reliably differentiated from other fibres by simple visual examination.

The Afsset survey also found that some companies claim to be unaware of the exact nature of the fibre-containing components they order from their providers and most of them do not carry out any measurements to evaluate the level of workers' exposure to RCFs. The results of many exposure measurements carried out by producers and prevention organisations are available and could be a help to these companies.

Continuous filament fibres, which are unclassified in the EU classification of carcinogens, have been little studied and there is a need to acquire knowledge on their toxicity. There is also a particular lack of information on special purpose glass fibres. As for carbon fibres, some information inclines towards caution because of their capacity to break and to create ultrafine particles. There are few toxicological data on tungsten oxide and magnesium sulphate whiskers, or on alumina fibres, while silicon carbide whiskers appear carcinogenic in animals. Potassium titanate fibres are suspected to be

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*The longer and thinner the fibres, the more dangerous they are, but standard air sampling methods do not allow precise measurement of their size.*

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*Manufacturers strive to reduce the biopersistence of siliceous fibres by modifying their compositions, which is favourable to OSH. But toxicological data are lacking for these new products.*

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<sup>(3)</sup> <http://monographs.iarc.fr/ENG/Classification/crthgr02a.php>



*Epoxy resins have become one of the main causes of occupational allergic contact dermatitis.*

carcinogenic. The toxicity of other non-siliceous man-made mineral fibres has been little investigated, but they seem to be biopersistent.

Although some man-made mineral fibres contain up to 25% additives, studies rarely take their presence into account. Workers handling fibre-based products, especially during laying, maintenance or removal operations, may be highly exposed.

### *Allergenic and sensitising agents*

Another three risks identified as emerging were mentioned by the respondents with a view to allergies and sensitising effects. These are epoxy resins, isocyanates and dermal exposure.

**Epoxy resins** are one of the most important and widely used polymeric systems. They are used in adhesives, sealants, inks, varnishes and reinforced polymer composite structures with glass fibre, carbon fibre or metal substrates, paints and coatings, including protective coatings of canned food. The continuous demand for always newer generations of epoxy resins and derived products with enhanced properties may introduce new, unknown adverse health effects. These effects may be caused by uncured epoxy resins or by the variety of curing agents, diluents or other constituents used in epoxy formulations. Epichlorohydrin, used to obtain epoxy resins, is classified as 'carcinogenic category 2' in the EU classification. Bisphenol A, the other coupling constituent, was found to induce allergic contact dermatitis (ACD) and to be a weakly estrogenic monomer.

Epoxy resins themselves have become one of the main causes of occupational ACD. Skin sensitisation of the hands, arms, face and throat as well as photosensitisation has also been reported. Some of the components can also cause irritation of the eyes and respiratory tract, contact urticaria, rhinitis and asthma. Workers in the production of epoxy resins and workers in the manufacture of composite products, in the electrical and electronics industry, and painters may be at risk. Epoxy skin sensitisation is particularly problematic in the construction industry where a safe and healthy working environment (e.g. clean room) and the use of protective clothing (e.g. gloves) is less common and/or less practical. Wherever possible, one-part instead of two-part epoxies should be used to reduce the risk of dermal contact during hand mixing. Contact with incompletely cured epoxy resins should be avoided. The proper identification of the epoxy system involved in the process is essential for the selection of appropriate prevention measures.

A further emerging chemical risk identified in the survey is the increasing use of **isocyanates**. Again exposure to isocyanates does not only occur at the production stage but also when polyurethane products containing isocyanates are used (e.g. when spraying), are processed (e.g. grinding or welding), or when they undergo thermal or chemical degradation. Isocyanates are widely used in the manufacture of flexible and rigid foams, fibres, elastomers, building insulation materials, paints and varnishes. Workers in car body repair shops may, for example, be exposed during the abrasive process of a car body, as isocyanates may be released into the air as a consequence of thermal degradation of the isocyanate-containing car paint induced by the heat generated in the abrasion.

Isocyanates are powerful irritants to the mucous membranes of the eyes and of the gastrointestinal and respiratory tracts. Direct skin contact can cause serious inflammation and dermatitis. They are also powerful asthmatic sensitising agents. Death from severe asthma in some sensitised subjects has been reported. Early recognition of sensitisation,



coupled with prompt and strict elimination of the source of exposure, is essential to reduce the risk of long-term or permanent respiratory problems in sensitised workers.

**Dermal exposure** is a major route of occupational exposure to dangerous substances. In EU Member States, skin diseases are the second most common occupational diseases after musculoskeletal disorders (MSDs); contact dermatitis being the most common. Other work-related skin diseases include chemical burns, contact urticaria, photodermatitis, contact leukoderma (Vitiligo), infectious dermatitis and skin cancer.

Chemicals are responsible for 80–90% of skin diseases. The skin of the hands and other body parts can be affected by indirect exposure to airborne substances (e.g. face, neck) or when contaminated hands touch other body parts (e.g. hand-to-face contact). In the construction industry, chromate is the most important allergen followed by epoxy resins and cobalt. Natural rubber protein (latex) is another major occupational allergen, in particular in the healthcare sector. Soaps, detergents and solvents can cause dermatitis as they remove the surface lipids and dissolve the natural protective barrier of the skin. Allergies from exposure to fragrances have been observed among masseurs, physiotherapists and geriatric nurses. The use of protective gloves is controversial due to other influencing factors such as the wet atmosphere inside the glove.

There are no 'dermal OELs'. Two reasons are the uncertainties in the quantification of the dermal exposure level and the meagre toxicological data available on health effects from dermal exposure – especially for repeated exposure, exposure to diluted preparations, and combined exposures to various chemicals or to other factors such as humidity. Within the European project RISKOFDERM, determinants of dermal exposure, exposure control measures and default dermal exposure values particularly useful to small and medium enterprises (SMEs) have been defined and integrated into a risk assessment toolkit.

*There are no 'dermal OELs' due to uncertainties in quantifying dermal exposure levels and a lack of toxicological data on health effects from dermal exposure.*

### **Sector-specific chemical risks**

Other major emerging risks identified are specific to certain workplaces; for example the exposure to dangerous substances during waste treatment activities and in the construction industry. It is interesting to note that these jobs are neither in the chemical industry nor in industries where chemicals are used intentionally in the work process, but rather where dangerous substances are incidental products of the work.

**Dangerous substances in waste treatment** activities were also agreed as emerging risks in another expert survey on emerging biological risks <sup>(4)</sup>. Waste management is considered one of the most hazardous occupations with an illness rate 50% higher and an infectious diseases rate six times higher than in other workers. European and national waste regulations were adopted in the 1990s primarily for environmental purposes (i.e. to reduce the volume of waste sent to landfill) and, as a consequence, do not integrate OSH aspects enough. The amount of waste generated in the EU is growing. Municipal solid waste (MSW) accounts for a relatively small proportion of total waste, with the largest volume of waste being generated by mining, manufacturing, construction and demolition activities.

Up to 110 different volatile organic compounds (VOCs) have been found during waste collection and at compost plants, landfills and resource recovery plants. Landfill

<sup>(4)</sup> European Agency for Safety and Health at Work, *Expert forecast on emerging biological risks related to occupational safety and health*, Office for Official Publications of the European Communities, Luxembourg, 2007. [http://riskobservatory.osha.europa.eu/risks/forecasts/biological\\_risks/](http://riskobservatory.osha.europa.eu/risks/forecasts/biological_risks/)



*While the recycling of car components, plastics and electronic products is increasing, there are concerns about workers' exposure to the hazardous materials that they contain.*

workers, compost workers and waste collectors are also exposed to high levels of dust. While an increase in the recycling of car components, plastics and electronic products is expected, there are concerns that waste electrical and electronic equipment (WEEE) and end-of-life vehicles (ELVs) contain hazardous materials such as lead, cadmium, mercury and polychlorinated biphenyls (PCBs). In incineration processes, the pollutants most often detected are dioxins, furans and PCBs. The handling of medical waste presents extra challenges such as the risk of contamination with sharps.

The health effects depend on the type of waste and substances. While it is not possible to completely eliminate the chemical risks inherent to waste-related activities, the most efficient prevention measure is to reduce the generation of dust, bioaerosols and VOCs in the workplace. Technical collective prevention measures and hygiene plans also contribute greatly to reducing workers' exposure. In any case, prevention should be adapted to the specific characteristics of each branch of the waste sector and its activities.

The **construction sector** is one of Europe's largest industries. Construction workers are exposed to a variety of dangerous substances in addition to noise, vibrations, falls from height and musculoskeletal disorders. Respiratory problems are widespread, not least due to asbestos – although its use is now virtually banned in the European Union. If inhaled, asbestos fibres can have serious health effects including asbestosis, lung cancer and mesothelioma. There is no known safe exposure level to asbestos. The more one is exposed, the greater the risk of developing an asbestos-related disease. As the time between exposure to asbestos and the first signs of disease can be as much as 30 years, the effects of past exposure are only now apparent and are still expected to rise <sup>(5)</sup>.

Construction workers may also be exposed to dust generated from cutting or handling **crystalline silica-based products**. A major effect in humans of the inhalation of respirable crystalline silica is silicosis. Crystalline silica is also classified as 'Group 1 human lung carcinogen' in the International Agency for Research on Cancer's classification. There is currently no Occupational Exposure Limit (OEL) for respirable crystalline silica at an EU level and existing national OELs vary. A European multi-sector agreement aims to reduce workers' exposure to crystalline silica dust through good practice in the workplace.

Carpenters, in particular, are exposed to **wood dust** and thus have an elevated risk of contracting nasal cancer. Workers in the construction industry are also exposed to **solvents, oils, resins and cement-based products containing chromium (VI)** which exacerbate the likelihood of skin problems. Important contact with **lead** may also occur when working with old lead piping or removing lead-based paints.

### *Chemical risks combined with organisational factors*

Last, but not least, some of the main emerging risks identified are a consequence of the combination of chemical hazards and poor organisational factors as demonstrated by the selection by respondents of the items 'poor control of chemical risks in small and medium enterprises' and 'outsourced activities performed by subcontracted workers with poor knowledge of chemical risks'.

**Micro-, small and medium-size enterprises (SMEs)** are socially and economically important, representing 99.8% of all enterprises in the EU-25 in 2003. SMEs employ 66%

*SMEs represent 99.8% of all enterprises in the EU-25 and employ 66% of the workforce in the private sector (in 2003).*

<sup>(5)</sup> European Agency for Safety and Health at Work, *Asbestos in construction. Factsheet 51*, Office for Official Publications of the European Communities, Luxembourg, 2004. <http://osha.europa.eu/en/publications/factsheets/51/view>



of the workforce in the private sector. They often experience difficulties in complying with their obligation to assess and control chemical risks in the workplace as laid down by EU Framework Directive 89/391/EEC and Directive 98/24/EC on chemical agents.

In some cases, underlying factors are the limited technical expertise of SMEs and the absence of a dedicated OSH professional. Most SMEs are aware of the hazards associated with the hazardous substances they use but often only in very general terms. Moreover, there is generally a high level of acceptance of the risks as being part of the job. Even when hazardous substances are monitored, the results are not always representative of the actual exposure in the workplace. Despite being feasible in many cases, the possibility of eliminating or substituting the hazardous substance is generally not given enough consideration. While appropriate effective local ventilation is often lacking, there is an excessive tendency in SMEs to rely on personal protective equipment (PPE). In general, workers are not consulted enough about the implementation of controls on hazardous substances.

As the cost of implementing controls is also one of the main barriers cited, one of the challenges is to make OSH a benefit for SMEs. It is essential to target awareness-raising interventions at SME managers as they play a key role in determining the priority for implementing controls. Although SMEs see the distinctions between health, safety and environment as irrelevant to them, they do want to know exactly how to control chemicals in order to meet all regulatory requirements. A number of easy-to-use tools are available but they need to be better shared among the Member States and to be made available to SMEs in their national language.

The item '**outsourced activities performed by subcontracted workers with poor knowledge of chemical risks**' – such as cleaning and maintenance activities – reflects the increasing concern for multiple occupational risk factors and the importance of taking a holistic approach when managing OSH risks. In particular, outsourcing and subcontracting practices have increased during the last 15 years. Subcontracted workers increasingly perform high-risk work across many industries. They generally have less control over working times, often work in less skilled jobs, have fewer opportunities for training and life-long learning, and subsequently less insight into their work environment. All this contributes to making outsourced workers more vulnerable to OSH risks. Outsourcing practices are also often associated with an unclear repartition of legal responsibilities between the host company and the contractor. There is evidence that these new forms of employment have serious negative effects on workers' health and safety.

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*Despite being feasible in many cases, the possibility of eliminating or substituting the hazardous substance is generally not given enough consideration. There is an excessive tendency in SMEs to rely on personal protective equipment.*

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*Subcontracted workers increasingly perform high-risk work across many industries.*

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European Agency for Safety and Health at Work

*EUROPEAN RISK OBSERVATORY REPORT*

# 1.

**INTRODUCTION**



The chemical industry is Europe's third largest manufacturing industry. It employs 1.7 million people directly and up to 3 million indirectly who further process or use chemicals – for instance using pesticides in agriculture, additives in the food industry, or detergents in cleaning activities <sup>(6)</sup>. Global production of chemicals worldwide has increased from 1 million tonnes in 1930 to 400 million tonnes today. Of the chemicals that are marketed 5–10% are considered hazardous; 150–200 of these chemicals are known carcinogens <sup>(7)</sup>. In the EU alone, about 100,000 different substances were registered in 2001 and about 30,000 chemicals are commonly in use.

In addition to the production, processing and use of chemicals, exposure to hazardous substances may also occur in many workplaces where they arise as by-products; examples include wood dust in the construction industry and volatile organic compounds (VOCs) in waste treatment activities. According to the 4th European Survey on Working Conditions, about 15% of workers handle or are exposed to dangerous substances at least a quarter of their working time and one in five workers (19.1%) breathes in smoke, powder or fumes <sup>(8)</sup>.



Exposure to dangerous substances in the workplace can cause many different types of harm: cancers, reproductive disorders, damage to the nervous system, respiratory disorders, skin diseases and infectious diseases. The harm done by dangerous substances can occur from a single short exposure or by the long-term accumulation of substances in the body. For example, a latency period of as much as 30 years has been observed between exposure to asbestos and incidence of lung cancer. According to the collection of harmonised data on recognised occupational diseases by Eurostat (EU-15 except Germany, Greece and Ireland) <sup>(9)</sup>:

- about half (47%) of recognised occupational diseases are related to dangerous substances;
- every fifth recognised occupational disease (20%) is a neurological disease;
- almost 15% are respiratory diseases;
- the proportion of skin diseases fell from 11% in 2002 to 7% in 2005;
- about 5% are cancers, with an increase from 3,148 recognised occupational cancers in 2002 to 4,210 in 2005.

*Of the estimated 167,000 work-related fatalities occurring annually in the EU-27, about 74,000 can be attributed to dangerous substances at work.*

Of the estimated 167,000 work-related fatalities occurring annually in the EU-27, 159,000 are attributed to work-related diseases with nearly 100,000 being cancers. Almost half

<sup>(6)</sup> Commission of the European Communities, *White Paper – Strategy for a Future Chemicals Policy*, COM/2001/0088 final, Commission of the European Communities, Brussels, 2001. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2001:0088:FIN:EN:PDF>

<sup>(7)</sup> Watfa, N.T., Awan, S., Goodson, R., *Chemical risk assessment and occupational hygiene preventive measures in small and medium-sized enterprises (SMEs)*, International Labour Office (ILO), Geneva, 1998. <http://www.ilo.org/public/english/protection/safework/papers/smechem/index.htm>

<sup>(8)</sup> Parent-Thirion, A., Fernández Macías, E., Hurley, J., Vermeylen, G., *Fourth European Working Conditions Survey*, European Foundation for the Improvement of Living and Working Conditions, Luxembourg, 2007. <http://eurofound.europa.eu/pubdocs/2006/98/en/2/ef0698en.pdf>

<sup>(9)</sup> Extracted from Eurostat database under the category *Population and social conditions – Health – Health and Safety at Work* available at: [http://epp.eurostat.ec.europa.eu/portal/page?\\_pageid=1996,45323734&\\_dad=portal&\\_schema=PORTAL&screen=welcomeref&open=/data/popul/health/hsw/hsw\\_occ\\_dis&language=en&product=EU\\_MAIN\\_TREE&root=EU\\_MAIN\\_TREE&scrollto=403](http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1996,45323734&_dad=portal&_schema=PORTAL&screen=welcomeref&open=/data/popul/health/hsw/hsw_occ_dis&language=en&product=EU_MAIN_TREE&root=EU_MAIN_TREE&scrollto=403)





of these work-related diseases (74,000) are estimated to be due to exposure to hazardous substances at work <sup>(10)</sup>.

According to Directive 98/24/EC <sup>(11)</sup>, the employer must determine whether any hazardous chemical agents are present at the workplace, assess any risk to safety and health arising from their presence and take the necessary prevention measures. Other important pieces of European legislation in this field are Directive 90/394/EEC <sup>(12)</sup> – later replaced by Directive 2004/37/EC <sup>(13)</sup> related to exposure to carcinogens at work – and Directive 2006/15/EC <sup>(14)</sup> establishing a second list of indicative occupational exposure limit values.

Regulation of classification and labelling <sup>(15)</sup> are equally important as they also determine important information (e.g. safety labels, symbols and safety data sheets) available to workers as users of these substances. The Registration, Evaluation and Authorisation of CHemicals (REACH) Regulation <sup>(16)</sup>, which came into force on 1 June 2007, requires producers and importers to assess – before their commercialisation – the potential adverse health effects of chemicals being produced or imported in quantities above one tonne a year. The Regulation strengthens the requirement for the risk assessment which manufacturers, importers and downstream users have to carry out for intended uses and then propose risk management measures to control the risks. Practical guidance to identify, assess and control the risks of dangerous substances in the workplace can be found on the website of the European Agency for Safety and Health at Work in the sections dedicated to good practice examples <sup>(17)</sup> and on the page entitled 'European Week 2003: 'Dangerous substances, handle with care' <sup>(18)</sup>.



<sup>(10)</sup> A study by Hämäläinen P., Takala J. of Tampere University of Technology (Finland) for the International Labour Office available in: J. Takala, ILO, Introductory Report – Decent work, Safe work. XVIIth World Congress on Safety and Health at Work, Orlando, 18-22 Sep. 2005, <http://www.ilo.org/public/english/protection/safework/wdcongrs17/intrep.pdf>; European Agency for Safety and Health at Work, Work-related cancers, [http://osha.europa.eu/OSH\\_world\\_day/occupational\\_cancer](http://osha.europa.eu/OSH_world_day/occupational_cancer)

<sup>(11)</sup> 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 (fourteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC), Official Journal, L131, 5 May 1998, pp. 11-23. [http://europa.eu/eur-lex/pri/en/oj/dat/1998/L\\_131/L\\_13119980505en00110023.pdf](http://europa.eu/eur-lex/pri/en/oj/dat/1998/L_131/L_13119980505en00110023.pdf)

<sup>(12)</sup> Council Directive 90/394/EEC of 28 June 1990 on the protection of workers from the risks related to exposure to carcinogens at work, Official Journal, L196, 26 July 1990, pp. 1-7. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31990L0394:EN:HTML>

<sup>(13)</sup> Directive 2004/37/EC on the protection of workers from the risks related to exposure to carcinogens or mutagens at work, Official Journal, L158, 30 April 2004, p. 50 plus correction in Official Journal, L229, 29 June 2004, pp.23-34. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:229:0023:0034:EN:PDF>

<sup>(14)</sup> Commission Directive 2006/15/EC of 7 February 2006 establishing a second list of indicative occupational exposure limit values in implementation of Council Directive 98/24/EC and amending Directives 91/322/EEC and 2000/39/EC, Official Journal, L38, 9 February 2006, pp. 36-39. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:038:0036:01:EN:HTML>

<sup>(15)</sup> For example, Directives 67/548/EEC and 1999/45/EC.

<sup>(16)</sup> <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:396:0001:0849:EN:PDF>

<sup>(17)</sup> [http://osha.europa.eu/good\\_practice/topics/dangerous\\_substances/](http://osha.europa.eu/good_practice/topics/dangerous_substances/)

<sup>(18)</sup> <http://ew2003.osha.europa.eu/>



New and emerging risks for workers and employers arise from:

- the development of new substances or materials with modified composition, such as epoxy resins with enhanced properties;
- the development of new technologies such as nanotechnologies and conversion technologies;
- continuously changing workplaces, work practices and work processes.

This report presents the results of the Agency's expert forecast on emerging chemical OSH risks. The risks identified in the forecast are grouped by themes into the following seven categories:

- particles, dusts and aerosols;
- risks due to carcinogenic, mutagenic and reprotoxic substances;
- risks of allergies and sensitisation;
- flammable and explosive substances;
- substances and mixtures with unknown or newly recognised health effects;
- chemical risks specific to work processes and workplaces;
- multi-factorial risks related to dangerous substances.

Six literature reviews explore in more depth the main emerging risks singled out in the forecast in terms of context, workers at risk, health and safety outcomes and prevention:

- nanoparticles;
- epoxy resins;
- man-made mineral fibres;
- dermal exposure to dangerous substances;
- dangerous substances in waste treatment activities;
- poor control of chemical risks in small and medium enterprises (SMEs).

Information on the Agency's work relating not only to chemical but also to biological, physical and psychosocial emerging risks is regularly updated and made available on the Agency's European Risk Observatory website <sup>(19)</sup>.

### *What are emerging risks?*

An 'emerging OSH risk' is defined as any occupational risk that is both new and increasing.

By 'new' it means that:

- the risk was previously unknown and is caused by new processes, new technologies, new types of workplace, or social or organisational change; or
- a longstanding issue is newly considered as a risk due to a change in social or public perceptions; or
- new scientific knowledge allows a longstanding issue to be identified as a risk.

The risk is 'increasing' if:

- the number of hazards leading to the risk is growing; or
- the likelihood of exposure to the hazard leading to the risk is increasing (exposure level and/ or the number of people exposed); or
- the effect of the hazard on workers' health is getting worse (seriousness of health effects and/or the number of people affected).

<sup>(19)</sup> <http://osha.europa.eu/en/riskobservatory/>



# 2.

## METHODOLOGY



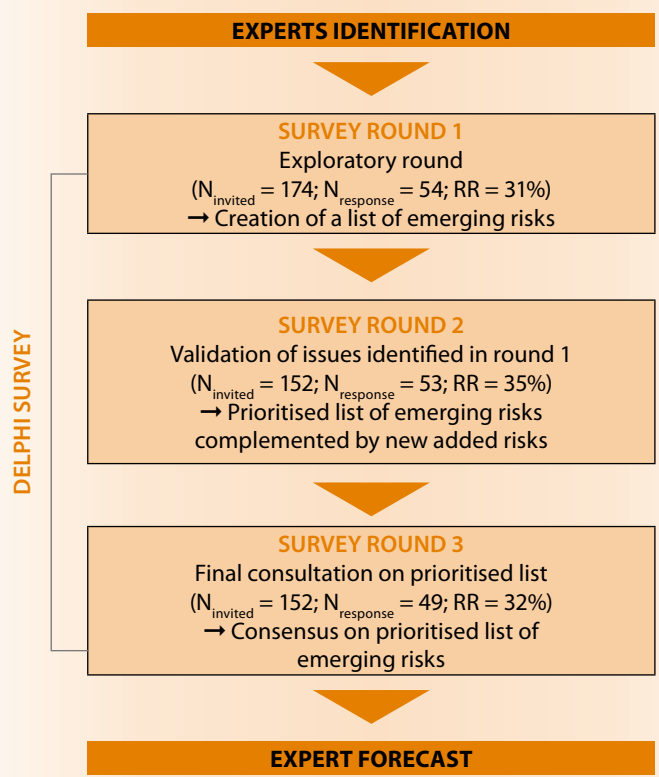
# 2.1. IMPLEMENTATION OF THE EXPERT SURVEY

A survey of European experts was undertaken to identify emerging occupational safety and health chemical risks. The Delphi method was used in order to reach a broad consensus and to avoid non-scientifically founded opinions.

### Delphi method <sup>(20)</sup>

The Delphi method is a methodology used widely to create foresight information on topics for which only uncertain or incomplete knowledge is available. There are several variations of the Delphi method, but all of them are based on an iteration process with at least two survey rounds in which the results of the previous rounds are fed back and submitted again to the experts for new evaluation. The feedback process ensures that the experts are aware of the views of other experts and gives them the opportunity to revise their first evaluation. At the same time, it avoids group pressure, which could lead to experts not daring to give their real opinion and lead to distorted results.

Figure 1: Delphi process implemented for the expert forecast on emerging OSH chemical risks



<sup>(20)</sup> Cuhls, K., *Technikvorausschau in Japan – Ein Rückblick auf 30 Jahre Delphi-Expertenbefragungen*, *Technik, Wirtschaft und Politik*, Volume 29, Schriftenreihe des Fraunhofer-Instituts für Systemtechnik und Innovationsforschung (ISI), Physica, Heidelberg, 1998.



The Delphi method adopted for formulating the expert forecast on emerging risks in this project consisted in three survey rounds (Figure 1). Only the answers from experts eligible for participation were analysed (see Section 3.1.).

### First survey round

A first exploratory survey round carried out in 2004 aimed to identify the risks which the experts reckoned to be emerging. A questionnaire with open-ended questions was developed to help the experts formulate their views as to the emerging OSH chemical risks of the next 10 years. The experts were invited to fill in the questionnaire electronically or on paper.

Based on all the issues identified in the questionnaires filled in and returned, a list was drawn up in which the risks were sorted into seven categories:

- particles, dusts and aerosols;
- carcinogenic, mutagenic and reprotoxic substances;
- allergens and sensitising substances;
- flammable and explosive substances;
- substances and mixtures with newly recognised or unknown health effects;
- chemical risks specific to work processes and workplaces;
- multi-factorial risks related to dangerous substances.

### Second survey round

A second questionnaire-based survey round was carried out in 2005 which aimed to validate and complement the results of the first round. The questionnaire presented a list, drafted from the first round responses and with an indication of the number of times each item was suggested. **The questionnaire invited participants to rate each item, independently from the others, on a five-point Likert scale (non-comparative scaling process). The scale ranged from 'strongly disagree that the issue is an emerging risk', through 'undecided' to 'strongly agree that the issue is an emerging risk'.** The experts could add new risks to the list.

As a result of the second survey round, a prioritised list of risks was drawn up based on the mean values of the item ratings and the standard deviations (see box on next page for more details).

### Third survey round

As the last step towards reaching a consensus, a third consolidation round was carried out in 2005.

The third questionnaire also consisted of a non-comparative scaling process whereby **the respondents were asked to rate each issue independently from the others on the same five-point Likert scale used in the second round.**

The prioritised list of emerging risks established at the end of the third survey round formed the expert forecast on emerging OSH chemical risks.



### *How to interpret the ratings*

For each risk, the mean value of the ratings and the standard deviation were calculated. While the mean values help to prioritise the risks, the standard deviations reflect the level of consensus on one item among the respondents.

The following areas have been defined for the interpretation of the mean values, based on the definition of the five-point Likert scale used in the survey (see above), and in order to have a reasonable balance of items between the different areas:

- the risk is strongly agreed to be emerging if the mean value (MV) of the ratings is above four ( $MV > 4$ );
- a mean value between 3.25 and 4 means that the item is considered to be an emerging risk ( $3.25 < MV \leq 4$ );
- as a mean value is unlikely to be exactly equal to 3, the 'undecided' area was extended from 2.75 to 3.25, which means that the status of a risk is regarded as undecided if its mean value is within this interval ( $2.75 \leq MV \leq 3.25$ );
- there is agreement that the risk is not emerging if the mean value is between 2 and 2.75 ( $2 \leq MV < 2.75$ );
- there is strong agreement that the risk is not emerging if the mean value is below 2 ( $MV < 2$ ).

## 2.2. RELIABILITY OF THE DATA

For each item, the response data sets were checked for statistical anomalies (ratings deviating significantly from the median of the data). No specific respondent profile could be associated to the few exceptional ratings found. As the anomalies had no significant influence on the mean value (MV), they were not removed from the data sets.

Kolmogorov–Smirnow tests were also run to verify the standard distribution of the data.

Delphi studies usually end after two to four survey rounds <sup>(21)</sup>. With regard to the present Delphi survey, a consensus among participants was reached in the third round for the majority of the items. Indeed when considering only the answers from the 32 experts who responded to both the second and the third survey rounds, a comparison of the standard deviations of round two with round three shows that most were smaller from one round to the next; out of the 80 items rated in both rounds, 46 standard deviations decreased. Given this positive development together with the limited financial resources and time allocated to the project, it was decided to end the Delphi survey at the third round.

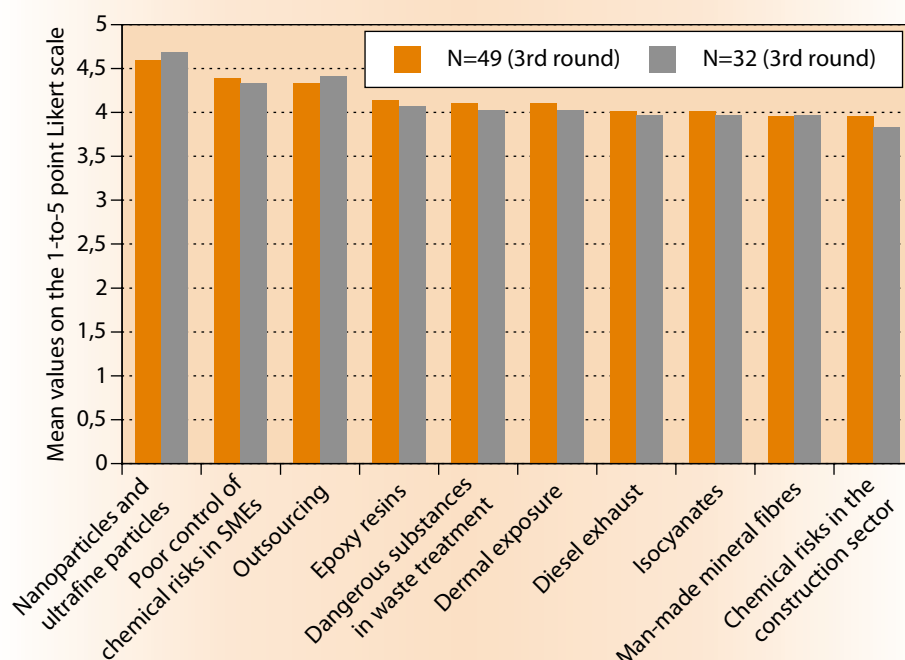
<sup>(21)</sup> Cuhls, K. et al., Fraunhofer-Institut für Systemtechnik und Innovationsforschung (ISI), *Delphi 98 – Umfrage. Studie zur globalen Entwicklung von Wissenschaft und Technik. Zusammenfassung der Ergebnisse. Methoden- und Datenband*, ISI, Karlsruhe, Germany, 1998. <http://publica.fraunhofer.de/starweb/servlet.starweb?path=pub.web&search=PX-45392>



Although the same experts were invited to participate in the second and third rounds, different people actually responded to one or other round. To decide whether to base the forecast only on the answers of the participants in round three who also responded to round two (N=32), or on all answers from all participants in the third round (N=49) including those who did not participate in the second round, the mean values were calculated for both population samples separately and compared.

Globally, the mean values did not vary significantly between the two groups. When looking at the 'top' ten items, the differences lay between 0.01 points (for 'man-made mineral fibres') and 0.15 points (for 'dust mixtures in the recycling sector') (Diagram 1). Therefore, the ratings from all the experts who participated in the third survey round were taken into consideration so as to have a forecast based on more participants.

**Diagram 1: Comparison between the mean values of the top 10 items of the third survey round for the following two population samples: all respondents to the third survey round (N=49) and respondents to both round 2 and round 3 (N=32)**



## LIMITATIONS OF THE METHODOLOGY

# 2.3.

The study relied on the goodwill of the experts to complete the questionnaires with no financial reward for their contribution. In addition, as the questionnaires were not translated, the respondents had to understand written English and be able to formulate their answers in English. This certainly had an impact on the response rate and may be one of the report's major limitations. The higher the number of participants, the better the reliability and representative nature of the forecast.



It also means that some countries may be over-represented in terms of the origin of the experts willing to participate – as was the case for Germany in this survey. This may affect the representativeness of the forecast in terms of the European view. This is all the more true in the case of a survey on chemical risks as the chemical industry in Germany is stronger and more developed than in many other European countries. It also produces different products, which means that the use of, and exposure to chemicals in the working environment may be different in Germany. Considering that Germany was over-represented in this survey, this may have biased the results towards a German picture of the issue.

Independently of the fact that some countries are over- or under-represented, for some issues there may well be no consensual European view but diverging views depending on the national context of the Member States. This may lead to some items being rated as undecided or having a low consensus between the respondents.

There are also limitations concerning the initial phase when risks are defined. Analysing and compiling the free text answers to the open-ended questions raised in the first, 'brainstorming' survey round was a difficult exercise. The answers received were variable in terms of:

- the amount of information and detail provided;
- the level of specificity of the issues brought up – while some issues mentioned were, for example, substance-oriented, others had been formulated with a view to health outcomes, or overlapped with several other items but addressed only one specific workplace or one specific health outcome;
- the quality of the written English.

Unlike a workshop, there is no opportunity in such a questionnaire-based process for a moderator to:

- ask the participants for clarification;
- ask participants to re-focus their answers on OSH when they have moved beyond the scope of the study;
- provide participants with the information they might need to answer the question adequately.

These factors impede the setting of clear risk descriptions, which is essential to avoid misunderstanding of the items to be rated in the further rounds.

A further issue is the difficulty of finding the right participants. On the one hand, respondents with a deep but specific expertise may be too focused on their own area of work and mention only their own topics and activities in the survey. Conversely, generalists with broader knowledge may lack the expertise to judge whether an issue is actually emerging and may be influenced by more political views.

Furthermore, most of the items identified in the survey are longstanding, well-identified issues requiring action (i.e. priorities rather than new or potential emerging risks). Although the definition was clearly stated at the beginning of the questionnaire, the experts may have had different interpretations of 'emerging risk' in mind when rating the items 'priority risk' versus 'new and increasing risk'. Some items in the survey seem to have been mentioned because they were seen as a 'priority' or 'major risk' rather than a 'new and increasing risk'.

These different possible interpretations may explain the sometimes high standard deviations of some items: while some respondents may have given a low score to an item they did not consider as 'new and increasing' even if they believed it to be a





priority, others may have been influenced by the fact that they considered it a priority and hence may have given it a high rate – and vice-versa.

For example, the negotiations on the multi-sectoral social dialogue agreement on crystalline silica <sup>(22)</sup>, which started in September 2005, probably had an impact on the evaluation of the item 'crystalline silica' which was rated in this survey as an emerging risk (MV=3.51) but with a low level of consensus between the respondents (SD=1.272). This may reflect the conflicting 'priority' versus 'new and increasing' rating patterns. Conversely, passive smoking at work was not rated as emerging risk but instead given a lower score and rated as undecided (MV=3.20), although there is sufficient evidence that passive smoking at work is a major risk to workers' health. The fact that it was rated as undecided does not mean that the respondents did not consider it as a major risk and a high priority, but rather that they reckoned it is not emerging according to our definition, i.e. not 'new and increasing'. The poor consensus between the respondents (SD=1.254) probably reflects the divergence in rating patterns between those experts who gave higher scores because they considered it a priority, and those who gave lower scores because they acknowledged it as not emerging according to our definition.

However, in other cases, even if something has been known for some time, it can still be considered as an emerging risk because the scientific knowledge that enables us to understand that something is a risk is often deferred – hence our definition of 'emerging'. Still, it seems that the point 'the risk was previously unknown and is caused by new processes, new technologies, new types of workplace, or social or organisational change' of the emerging risks definition referring to **genuinely new** risks was poorly addressed in this exercise. Questionnaire-based surveys may not be suitable for the forecast and anticipation of issues that are genuinely new or do not yet exist.

Last, but not least, because of the nature of forecasting activities, the evidence may still be inconclusive for some of the emerging risks mentioned in the survey. However, this does not mean that such issues should be avoided as this would mean the European Risk Observatory had failed to accomplish its main objective. Rather, particular care should be taken to discuss the findings with the relevant stakeholders in order to validate any conclusions and to decide on the need for any further work on the topic. In this way, the European Risk Observatory will fulfil its mission to stimulate debate and assist policy-makers in identifying priorities for action and research.

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<sup>(22)</sup> European Network on Silica, *Agreement on workers health protection through the good handling and use of crystalline silica and products containing it*. <http://www.nepsi.eu/agreement.aspx>



# 3.

## EXPERT PARTICIPATION



## 3.1. SELECTION OF PARTICIPANTS

*Participating experts were required to have at least five years' experience in the field.*

The experts were proposed by members of the Topic Centre Research on Work and Health (TCWH) and the focal points of the Agency to ensure a broad coverage of qualified expertise across the EU. For their answers to be taken into consideration, the respondents had to have at least five years' experience in the field of dangerous substances and related risks.

The expertise was collected and used with full awareness of the principles and guidelines of the European Commission <sup>(23)</sup>.

## 3.2. RESPONSES

*174 experts were approached. The forecast is based on 49 questionnaires returned from 21 European countries.*

For the first round, 174 experts were approached by the TCWH and invited to participate in the survey. Fifty-four experts returned completed questionnaires (response rate: 31%).

In the second phase, 152 experts were invited of which 53 returned completed questionnaires (response rate: 35%).

The same number of experts (N=152) was invited to take part in the third and last survey round. Forty-nine questionnaires were returned (response rate: 32%).

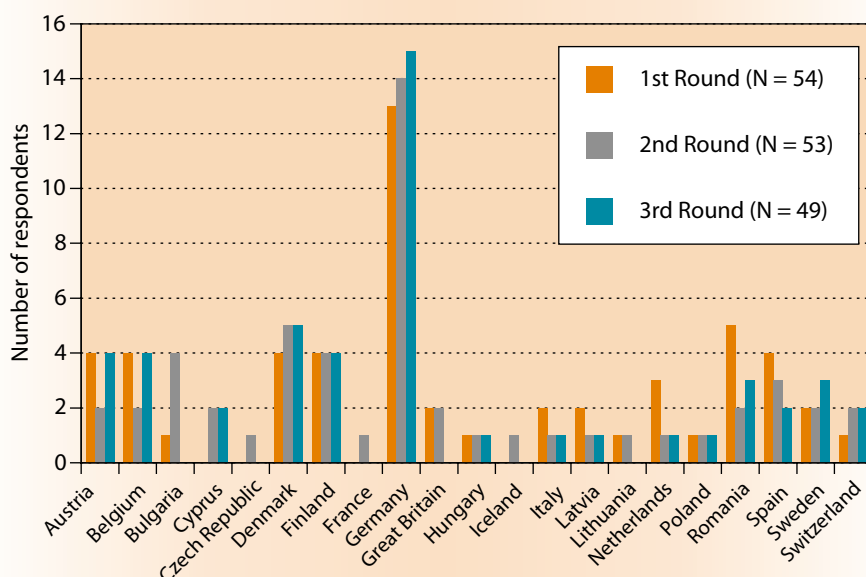
All the questionnaires received in the three rounds were returned from experts meeting the selection criteria of 'at least five years of experience' in the field of chemical risks.

Over the three survey rounds, experts from 21 European countries participated in the formulation of the forecast on emerging OSH chemical risks (Diagram 2).

It should be noted that almost a third (30%) of the answers were received from Germany, which is therefore over-represented in the survey. This may have biased the results towards the German position on emerging OSH chemical risks. Thus, the forecast may not be representative of a European consensus.

<sup>(23)</sup> European Commission, *Collection and use of expertise by the Commission – principles and guidelines*, Office for Official Publications of the European Communities, Luxembourg, 2004. [http://ec.europa.eu/research/science-society/pdf/guidelines\\_ss\\_en.pdf](http://ec.europa.eu/research/science-society/pdf/guidelines_ss_en.pdf)



**Diagram 2: Number of respondents from different countries of origin to the first, second and third rounds of the survey**

## CHARACTERISTICS OF THE RESPONDENTS

# 3.3.

### 3.3.1. Functions of the respondents

In the third survey round, which forms the forecast, the majority of the respondents were either 'heads of department' (N=17) or 'researchers' (N=16), i.e. over a third respectively (Diagram 3).

More than one out of four experts (N=14) ticked – in some cases, additionally – 'other function'. In nine cases, these 'other functions' were specified:

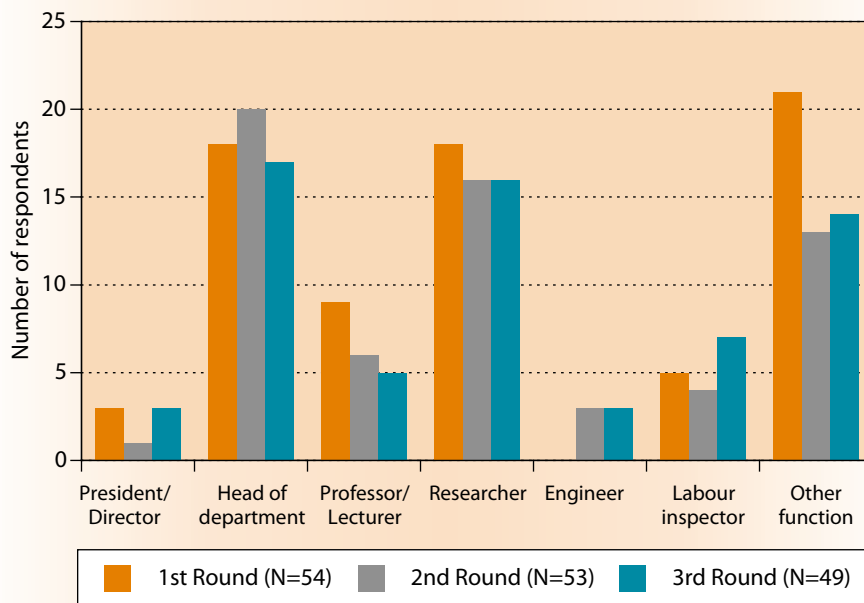
- 'ministerial counsellor' (N=1);
- 'principal administrative officer' (N=1);
- 'consultant' (N=2);
- 'head of department dealing with hazardous substances and measurement' (N=1);
- 'chemist and safety engineer' (N=1);
- 'head of laboratory' (N=1);
- 'executive officer' (N=1);
- 'toxicologist' (N=1).

Five experts did not specify their 'other function' but indicated, in the field 'Main fields of activity' of the questionnaire (see Section 3.3.2.) that they were involved in the following activities:

- 'consulting';
- 'consulting and other functions concerning health and hygiene';
- 'law'.



Diagram 3: Number of respondents to the first, second and third survey rounds, by function



### 3.3.2. Fields of activity of the respondents

Most of the respondents to the third survey round were involved in ‘research’ (N=18). About a third were active in ‘policies/ standards development’ (N=15) and ‘consulting’ (N=14) respectively (Diagram 4).

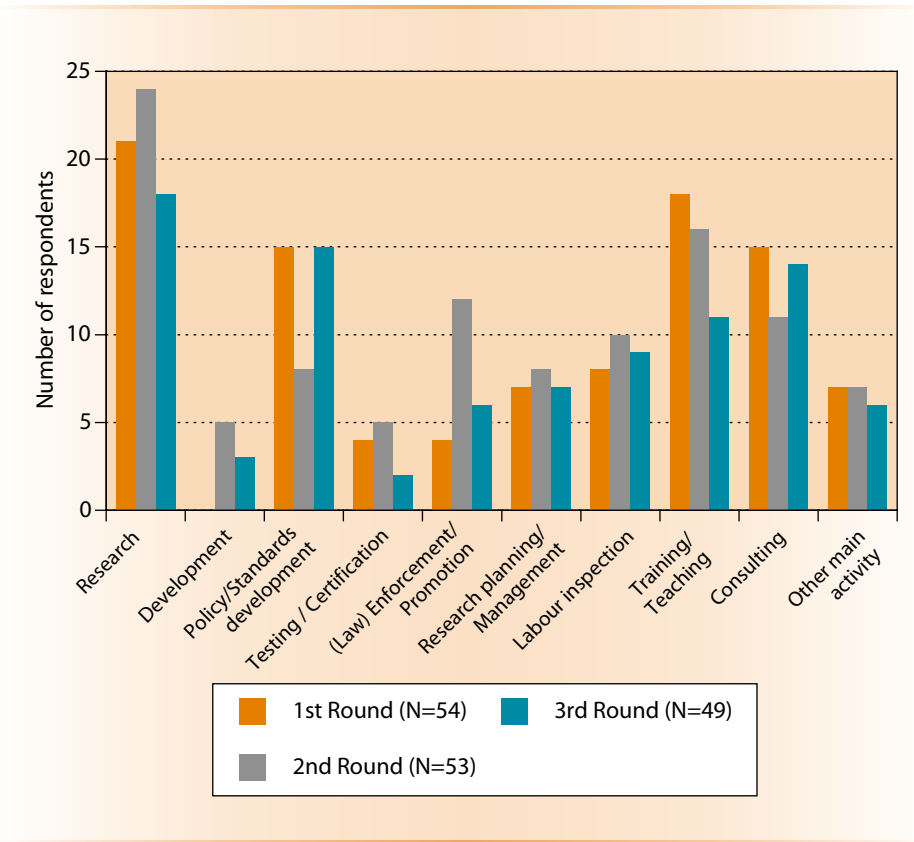
Six experts ticked ‘other main activity’:

- one indicated involvement in ‘measuring dangerous substances’ and ‘laboratory work’;
- one was involved in ‘clinical pneumology’ in addition to ‘training’;
- one was involved in ‘occupational health and hygiene’ in addition to ‘consulting’;
- two of them did not specify their ‘other main activity’ but also ticked ‘policies/ standards development’; /
- one did not specify any activity.

In view of their function and/or field(s) of activity, all respondents were considered to meet the selection criteria defined.



Diagram 4: Number of respondents to the first, second and third survey rounds, by field of activity



# 4.

## MAIN EMERGING CHEMICAL RISKS IDENTIFIED

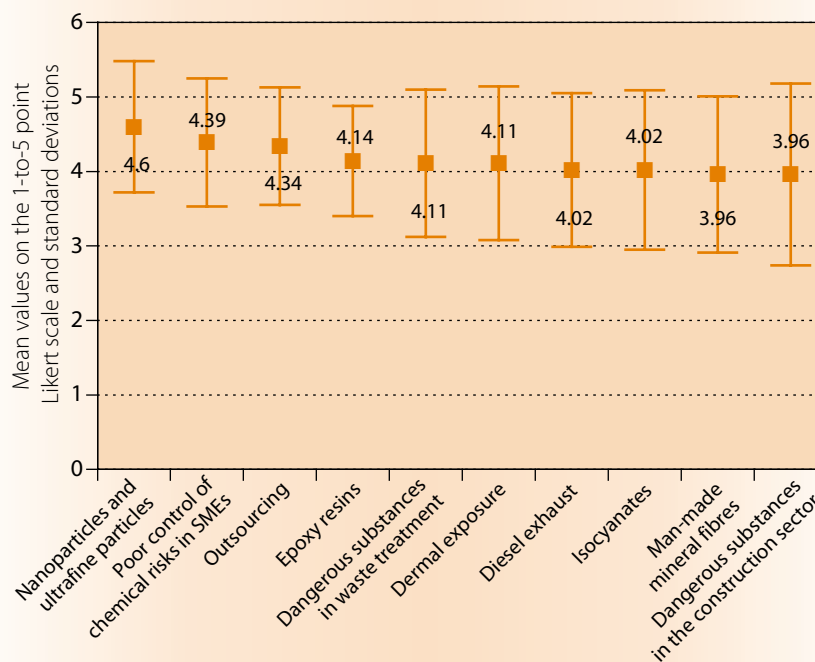


# 4.1. SURVEY RESULTS

The 10 main emerging risks highlighted in the forecast are presented in this chapter. The exact descriptions of the risks as rated by the experts are listed in Table 1 together with the number of respondents to each item, the mean value (MV) of the ratings and the standard deviation (SD). The rating (MV) given to these 'top ten' risks by the experts and the corresponding SDs are shown in Diagram 5.

It should be noted that the mean value of the last item of these 'top ten' ('dangerous substances in the construction sector': MV=3.96) is very close to the mean value of the following item ('combined exposure to particles and vapours': MV=3.95).

**Diagram 5: The 10 most important emerging chemical risks identified in the survey**



The expert forecast singled out eight risks **strongly agreed** as emerging (MV > 4):

- nanoparticles and ultrafine particles;
- the risks resulting from the poor control of chemical risks in small and medium enterprises (SMEs);
- outsourced activities performed by subcontracted workers with poor knowledge of chemical risks;
- the increasing use of epoxy resins;
- the exposure to dangerous substances in the treatment of domestic, clinical and industrial waste;
- dermal exposure leading to skin diseases;
- diesel exhaust;
- isocyanates.





Among the 'top ten' emerging risks, three items have in common their physico-chemical state as particles:

- 'nanoparticles and ultrafine particles' (MV=4.60) (see Section 4.2.1.);
- 'diesel exhaust' (MV=4.02);
- 'man-made mineral fibres' (MV=3.96) (see Section 4.2.3.).

It is interesting to note that, according to the Fourth European Working Conditions Survey <sup>(24)</sup>, 19.1% of the EU-27 workforce reported in 2005 that they 'breathe in smoke, fumes, powders or dust'.

#### 4.1.1. Nanoparticles and ultrafine particles

The risks posed by nanoparticles and ultrafine particles are by far the strongest agreed as emerging risks by the experts, with an acceptable degree of consensus among the respondents (SD=0.876). Nanoparticles and ultrafine particles have also been identified as one of the main OSH priorities in a review of various national, EU and international resources carried out by the Agency to identify future EU research needs in the field of OSH <sup>(25)</sup>.

In addition, in 2005, the Agency organised the first seminar of the series 'Promoting OSH research in the EU' where the results of the expert forecast on emerging risks as well as the research review report were discussed with representatives from:

- major European OSH research institutes;
- Union of Industrial and Employers' Confederations of Europe (UNICE);
- International Labour Organisation (ILO);
- Research DG of the European Commission;
- Employment, Social Affairs and Equal Opportunities DG of the European Commission;
- European Agency for Safety and Health at Work.

Nanoparticles and ultrafine particles were included in a summary list of top OSH research priorities drawn up at the seminar and consolidated in a broader consultation process among the Agency's stakeholders. More information on nanoparticles is available in Section 4.2.1.



Formation of ultrafine particles when processing material with laser beam, BGIA – Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung, Germany.

#### 4.1.2. Diesel exhaust

Exposure to diesel exhaust is the second most emerging risk highlighted in the forecast. Of the 32 million workers (23% of the workforce) exposed to the 139 carcinogens covered by CAREX (CARcinogen EXposure) in the EU-15 between 1990 and 1993,

*Diesel exhaust is the fourth most common carcinogen found in the workplace.*

<sup>(24)</sup> Parent-Thirion, A., Fernández Macías, E., Hurley, J., Vermeylen, G., *Fourth European Working Conditions Survey*, European Foundation for the Improvement of Living and Working Conditions, Luxembourg, 2007. <http://eurofound.europa.eu/pubdocs/2006/98/en/2/ef0698en.pdf>

<sup>(25)</sup> Rial-González, E., Copsey, S., Paoli, P., Schneider, E., *Priorities for occupational safety and health research in the EU-25*, European Agency for Safety and Health at Work, Office for Official Publications of the European Communities, Luxembourg, 2005. <http://osha.europa.eu/en/publications/reports/6805648/view>



*Diesel exhaust may cause lung cancer as well as non-cancer damage to the lung.*

3.1 million were exposed at least 75% of their working time to diesel exhaust – the fourth most common carcinogen found in the workplace after solar radiation, tobacco smoke and crystalline silica <sup>(26)</sup>.

Hazardous levels of diesel exhaust can be found in occupations ranging from mining to driving diesel-fuelled trucks or forklifts.

Diesel exhaust is made up of a complex mixture of thousands of gases, vapours and fine particles; the major components are carbon dioxide, carbon monoxide, nitrogen dioxide, nitric oxide, particulate matter and sulphur dioxide <sup>(27)</sup>.

The International Agency for Research on Cancer (IARC) has classified diesel engine exhaust as ‘probably carcinogenic to humans’ (Group 2A) <sup>(28)</sup>. More specifically with regard to lung cancer, a positive association between diesel exhaust emissions and lung cancer is suspected but is still controversial, and many aspects of this complex topic remain unclear <sup>(29)</sup>. In addition to cancer, a link between emissions from diesel-fuelled engines and non-cancer damage to the lung has been found <sup>(30)</sup>.

In order to reduce occupational exposure to diesel exhaust, companies should increase the use of:

- modern, low emission engines;
- low sulphur fuel;
- appropriate exhaust after-treatment devices such as filters and oxidation catalysts;
- ventilation;
- closed, environmentally-conditioned cabs.

Diesel engines should be appropriately operated and maintained <sup>(31)</sup>. Additional information and research are needed on methods to monitor diesel particulates and to determine the level of risk that such particulates cause.

### 4.1.3. Isocyanates

Another three items were mentioned by the respondents with a view to their allergens and sensitising effect:

- ‘epoxy resins’ (MV=4.14) (see Section 4.2.2.);
- ‘dermal exposure leading to skin diseases’ (MV=4.11) (see Section 4.2.4.);
- ‘isocyanates’ (MV=4.02).

Exposure to isocyanates does not only occur when they are produced but also when polyurethane products containing isocyanates are used (e.g. when spraying), are processed (e.g. grinding or welding) or when they undergo a thermal or chemical degradation.

Isocyanates are widely used in the manufacture of flexible and rigid foams, fibres, coatings (e.g. paints and varnishes), elastomers and building insulation materials. They

*Exposure to isocyanates occurs also when polyurethane products containing isocyanates are used, processed or when they undergo a thermal or chemical degradation.*

<sup>(26)</sup> Kauppinen, T. et al., CAREX – International Information System on Occupational Exposure to Carcinogens. Occupational exposures to carcinogens in the European Union in 1990-1993, Finnish Institute of Occupational Health, Helsinki, 1998. [http://www.ttl.fi/NR/rdonlyres/4444380F-B1FB-4D01-A974-0B6A9E663CFA/0/1\\_description\\_and\\_summary\\_of\\_results.pdf](http://www.ttl.fi/NR/rdonlyres/4444380F-B1FB-4D01-A974-0B6A9E663CFA/0/1_description_and_summary_of_results.pdf)

<sup>(27)</sup> <http://www.osha.gov/SLTC/dieselexhaust/recognition.html>

<sup>(28)</sup> <http://monographs.iarc.fr/ENG/Classification/crthgr02a.php>

<sup>(29)</sup> <http://www.hvbg.de/e/bia/pro/pro1/pr0063.html>

<sup>(30)</sup> <http://www.arb.ca.gov/toxics/dieseltac/factsht1.pdf>

<sup>(31)</sup> <http://www.msha.gov/S&HINFO/TOOLBOX/DTBFINAL.HTM>



are also increasingly used in industrial painting companies<sup>(32)</sup>, in the automobile industry, in autobody repair and in car paints<sup>(33)(34)</sup>. In body repair shops (e.g. during abrasion of a car body), isocyanates may be released into the air as the heat generated by the abrasion leads to the thermal degradation of the car paint containing isocyanates<sup>(35)</sup>.

Spray-on polyurethane products containing isocyanates are used for a wide range of retail, commercial, and industrial applications; for example to protect cement, wood, fibreglass, steel and aluminium, as well as in protective coatings for truck beds, trailers, boats, foundations, and decks<sup>(32)</sup>.

Exposure may occur by inhalation and skin contact. Isocyanates are powerful irritants to the mucous membranes of the eyes, and of the gastrointestinal and respiratory tracts. They are also powerful asthmatic sensitising agents. Direct skin contact can cause serious inflammation and dermatitis.

Isocyanates can also sensitise workers. If sensitised, they may suffer severe asthma attacks if a subsequent exposure occurs. Death from severe asthma in some sensitised subjects has been reported<sup>(33)</sup>. Early recognition of sensitisation, and prompt and strict elimination of the source of exposure is essential to reduce the risk of long-term or permanent respiratory problems for workers who have become sensitised<sup>(33)</sup>.

#### 4.1.4. Dangerous substances in specific sectors

Other major emerging risks identified are specific to certain workplaces, for example the exposure to dangerous substances in 'waste treatment' (MV=4.11) (see Section 4.2.5.) and in the 'construction sector' (MV=3.96).

These jobs are neither in the chemical industry nor in industries where chemicals are used intentionally in the work process, but rather where dangerous substances are incidental products of the work.

##### 4.1.4.1. Dangerous substances in waste treatment activities

Dangerous substances in waste treatment activities were also agreed to pose emerging risks to workers in the Agency's expert survey on emerging biological risks<sup>(36)</sup>. Other studies indicate that waste management is one of the most hazardous occupations with an illness rate 50% higher and an infectious diseases rate six times higher than in other workers<sup>(37)</sup>.

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*Waste management is one of the most hazardous occupations with an illness rate 50% higher and an infectious diseases rate six times higher than in other workers.*

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<sup>(32)</sup> Pronk, A., Tielemans, E., Skarping, G., Bobeldiuk, I., Van Hemmen, J., Heederik, D., Preller, L., *Inhalation exposure to isocyanates of car body repair shop workers and industrial spray painters*, *Annals of Occupational Hygiene*, Vol. 50, 2006, pp. 1-14.

<sup>(33)</sup> National Institute for Occupational Safety and Health (NIOSH), *NOISH Safety and Health Topic: Isocyanates*. <http://www.cdc.gov/niosh/topics/isocyanates/>

<sup>(34)</sup> Sparer, J., Stowe, M.H., Bello, D., Liu, Y., Gore, R.J., Youngs, F., Cullen, M.R.; Redlich, C.A., Woskie, S.R., *Isocyanate exposures in autobody shop work: the SPRAY study*, *Journal of Occupational and Environmental Hygiene*, Vol. 1, No 9, 2004, pp. 570-581.

<sup>(35)</sup> Boutin, M., Dufresne, A., Ostiguy, C., Lesage, J., *Determination of airborne isocyanates generated during the thermal degradation of car paint in body repair shops*, *Annals of Occupational Hygiene*, Vol. 50, No. 4, 2006, pp. 383-393.

<sup>(36)</sup> European Agency for Safety and Health at Work, *Expert forecast on emerging biological risks related to occupational safety and health*, Office for Official Publications of the European Communities, Luxembourg, 2007. [http://riskobservatory.osha.europa.eu/risks/forecasts/biological\\_risks/](http://riskobservatory.osha.europa.eu/risks/forecasts/biological_risks/)

<sup>(37)</sup> Bomel Limited, *Mapping health and safety standards in the UK waste industry*, Research Report 420, Health and Safety Executive (HSE), Sudbury, UK, 2004. <http://www.hse.gov.uk/research/rrpdf/rr240.pdf>



*The construction sector is one of Europe's largest industries. Unfortunately, it also has one of the worst OSH records.*

*Respiratory problems are widespread, not least due to asbestos.*

*There is no known safe exposure level to asbestos.*

#### 4.1.4.2. Construction sector

The construction sector is one of Europe's largest industries, with an annual turnover in excess of €1.304 billion in 2007 <sup>(38)</sup>. Unfortunately, it also has one of the worst OSH records <sup>(39)</sup>. Officially, there are 12.7 million employees in the sector, equivalent to 7.9% of the EU total workforce <sup>(40)</sup>. The real number, however, is likely to be substantially higher as it is estimated that a significant proportion of the labour force in construction is undeclared.

Construction workers are exposed to a wide range of dangerous substances in addition to noise, vibrations, falls from height, and musculoskeletal disorders (MSDs).

#### Asbestos

Respiratory problems are widespread, not least due to asbestos <sup>(38)</sup>. Although the use of asbestos is now virtually banned in the European Union, 600,000 construction workers are still exposed to asbestos each year <sup>(41)</sup>. Asbestos fibres can have serious health effects if inhaled including asbestosis, lung cancer and mesothelioma. There is no known safe exposure level to asbestos. The more one is exposed, the greater the risk of developing an asbestos-related disease. As the time between exposure to asbestos and the first signs of disease can be as much as 30 years, the effects of past exposure are only now apparent and are still expected to rise <sup>(42)</sup>.



Formation of wood dust, INSHT, Spain.

#### Wood dust

At the beginning of the 21st century, the construction industry in the EU-27 employed 1.2 million workers exposed to wood dust – mostly carpenters. These workers have an elevated risk of contracting nasal cancer as a result of breathing in wood dust. Mixed exposure to more than one species of wood and dust from wooden boards was found to be very common, but reliable data on exposure to different species of wood could not be retrieved <sup>(43)</sup>.

#### Crystalline silica-based products

Construction workers may also be exposed to dust generated from cutting or handling crystalline silica-based products such

<sup>(38)</sup> European Construction Industry Federation (FIEC), *Construction in Europe – key figures*. <http://www.fiec.org/Content/Default.asp?PageID=5>

<sup>(39)</sup> European Agency for Safety and Health at Work, *Building in Safety – European Week 18–22 October 2004*. <http://ew2004.osha.europa.eu/static/about2004>

<sup>(40)</sup> Eurostat, *European Social Statistics: Labour force survey results 2002*, European Commission, Brussels, 2002.

<sup>(41)</sup> Kauppinen, T. et al., *CAREX – International Information System on Occupational Exposure to Carcinogens. Occupational exposures to carcinogens in the European Union in 1990-1993*, Finnish Institute of Occupational Health, Helsinki, 1998. [http://www.ttl.fi/NR/rdonlyres/4444380F-B1FB-4D01-A974-0B6A9E663CFA/0/1\\_description\\_and\\_summary\\_of\\_results.pdf](http://www.ttl.fi/NR/rdonlyres/4444380F-B1FB-4D01-A974-0B6A9E663CFA/0/1_description_and_summary_of_results.pdf)

<sup>(42)</sup> European Agency for Safety and Health at Work, *Facts 51: Asbestos in construction, Factsheet 51*, Office for Official Publications of the European Communities, Luxembourg, 2004. <http://osha.europa.eu/en/publications/factsheets/51/view>

<sup>(43)</sup> Kauppinen, T. et al., *Occupational exposure to inhalable wood dust in the Member States of the European Union, Annals of Occupational Hygiene*, Vol. 50, No. 6, 2006, pp. 549-561.

as sand <sup>(44)</sup>. Crystalline silica is classified as a 'Group 1 human lung carcinogen' in the IARC classification <sup>(45)</sup>, but is not classified as a carcinogen under European legislation.

The European Chemical Bureau (ECB) last addressed the issue of crystalline silica in 1998 <sup>(46)</sup> and decided that crystalline silica was not a priority for classification under Annex 1 of Directive 67/548/EEC. However, the European Commission's Scientific Committee for Occupational Exposure Limits (SCOEL) <sup>(47)</sup> concluded in 2003:

'that the main effect in humans of the inhalation of respirable crystalline silica is silicosis. There is sufficient information to conclude that the relative lung cancer risk is increased in persons with silicosis [ . . . ]. Therefore, preventing the onset of silicosis will also reduce the cancer risk. Since a clear threshold for silicosis development cannot be identified, any reduction of exposure will reduce the risk of silicosis'.

Silicosis is an irreversible, but preventable, disease where scar tissue forms in the lungs and reduces the ability to extract oxygen from the air. According to estimates from 1990-1993 from CAREX, 3.2 million of the 32 million workers exposed to carcinogens in the EU-15 were exposed at least 75% of their working time to crystalline silica – the third most common carcinogenic agent <sup>(48)</sup> after solar radiation and environmental tobacco smoke.

There is currently no Occupational Exposure Limit (OEL) for respirable crystalline silica at the EU level and the national OELs vary <sup>(49)</sup>. In its draft report of 14 September 2007 on the Community strategy 2007-2012 on health and safety at work <sup>(50)</sup>, the Committee on Employment and Social Affairs of the European Parliament considered the establishment of a Binding Occupational Exposure Limit Value (BOELV) for crystalline silica to be a priority in the context of the revision of Directive 2004/37/EC <sup>(51)</sup> – the

*Crystalline silica is classified as a 'Group 1 human lung carcinogen' in the IARC classification (45), but is not classified as a carcinogen under European legislation.*

*There is sufficient information to conclude that the relative lung cancer risk is increased in persons with silicosis.*

<sup>(44)</sup> European Agency for Safety and Health at Work, *Building in Safety – European Week 18–22 October 2004*. <http://ew2004.osha.europa.eu/static/about2004>

<sup>(45)</sup> International Agency for Research on Cancer (IARC) and World Health Organization (WHO), *Silica and some silicates*, Volume 68, IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. WHO and IARC, Lyon, 1997. <http://monographs.iarc.fr/ENG/Monographs/vol68/volume68.pdf>

<sup>(46)</sup> European Chemicals Bureau (ECB), *Summary record. Meeting of the Commission Working Group on the Classification and Labelling of Dangerous Substances, held Ispra, 7–9 October 1998*, ECB/55/98 – Rev.2, ECB, Ispra, 1999. [http://ecb.jrc.it/documents/Classification-Labelling/ADOPTED\\_SUMMARY\\_RECORDS/5598r2\\_cmr1098.pdf](http://ecb.jrc.it/documents/Classification-Labelling/ADOPTED_SUMMARY_RECORDS/5598r2_cmr1098.pdf)

<sup>(47)</sup> Scientific Committee for Occupational Exposure Limits (SCOEL) *SUM Doc 94-final on respirable crystalline silica*, June 2003.

<sup>(48)</sup> Kauppinen, T. et al., *CAREX – International Information System on Occupational Exposure to Carcinogens. Occupational exposures to carcinogens in the European Union in 1990-1993*, Finnish Institute of Occupational Health, Helsinki, 1998. [http://www.ttl.fi/NR/rdonlyres/4444380F-B1FB-4D01-A974-0B6A9E663CFA/0/1\\_description\\_and\\_summary\\_of\\_results.pdf](http://www.ttl.fi/NR/rdonlyres/4444380F-B1FB-4D01-A974-0B6A9E663CFA/0/1_description_and_summary_of_results.pdf)

<sup>(49)</sup> European Network on Silica, *Agreement on workers health protection through the good handling and use of crystalline silica and products containing it*, <http://www.nepsi.eu/agreement.aspx>

<sup>(50)</sup> European Parliament Committee on Employment and Social Affairs, *Draft report on the Community strategy 2007-2012 on health and safety at work*, Provisional 2007/2146(INI), 14 September 2007. [http://www.europarl.europa.eu/registre/commissions/empl/projet\\_rapport/2007/393990/EMPL\\_PR\(2007\)393990\\_EN.doc](http://www.europarl.europa.eu/registre/commissions/empl/projet_rapport/2007/393990/EMPL_PR(2007)393990_EN.doc)

<sup>(51)</sup> *Directive 2004/37/EC on the protection of workers from the risks related to exposure to carcinogens or mutagens at work*, *Official Journal*, L158, 30 April 2004, p. 50 plus correction in *Official Journal*, L229, 29 June 2004, pp.23-34. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:229:0023:0034:EN:PDF>



*Frequent contact with oils, resins and cement-based products containing chromium (VI) exacerbate the likelihood of skin problems.*

carcinogens directive. However, this proposal was rejected in a vote of the European Parliament in January 2008.

A European multi-sector agreement – the first of its kind – aimed at reducing workers' exposure to crystalline silica dust through good practice in the workplace was signed in 2006 by the social partners (trade unions and employers' representatives) in the presence of the EU Commissioner for Employment, Social Affairs and Equal Opportunities <sup>(52)</sup>. The agreement covers more than two million workers in many different sectors across Europe. See Section 5.1. for more information on crystalline silica.

### Solvents and other chemicals

Workers in the construction sector are also exposed to solvents and other dangerous substances that heighten their health risks. Frequent contact with liquid-based substances such as **oils, resins and cement-based products containing chromium (VI)** exacerbate the likelihood of skin problems.

Excessive contact with **lead** (e.g. when working with old lead piping or removing lead-based paints) can damage the central nervous system producing nausea, headaches, tiredness and other symptoms.

Studies have also shown an increased risk of early retirement among floor layers and painters due to **'solvent syndrome'** – the neuro-psychiatric symptoms associated with excessive exposure to organic solvents such as glycol ethers and esters. These symptoms can include memory loss, severe fatigue and other problems of the central nervous system <sup>(53)</sup>.

#### 4.1.5. Combined exposure to chemicals and psychosocial risk factors

*There is an increasing concern for the multiple effects of multiple risk factors and exposures. A holistic approach should be taken when managing OSH risks.*

Last, but not least, some of the main emerging risks identified are a consequence of the combination of chemical hazards and poor organisational factors as shown by the items 'poor control of chemical risks in small and medium enterprises' (MV=4.39) (see Section 4.2.6.) and 'outsourced activities performed by subcontracted workers with poor knowledge of chemical risks' such as cleaning and maintenance activities (MV=4.34). This reflects the increasing concern for the multiple effects of multiple risk factors and exposures and the importance of taking a holistic approach when managing OSH risks.

With regard to outsourcing and subcontracting, these practices have particularly increased during the last 15 years <sup>(54)</sup>. An Agency report on emerging psychosocial risks shows that these new forms of employment have serious negative effects on workers' health and on OSH <sup>(55)</sup>.

<sup>(52)</sup> European Network on Silica, *Agreement on workers health protection through the good handling and use of crystalline silica and products containing it*, <http://www.nepsi.eu/agreement.aspx>

<sup>(53)</sup> European Agency for Safety and Health at Work, *Building in Safety – European Week 18–22 October 2004*. <http://ew2004.osha.europa.eu/static/about2004>

<sup>(54)</sup> Johnstone, R., Mayhew, C., Quinlan, M., *Outsourcing risk? The regulation of occupational health and safety where subcontractors are employed*, *Comparative Labor Law and Policy Journal*, Vol. 22, No. 2, 2005, pp 351-393. [http://www.law.uiuc.edu/publications/cll&pj/archive/vol\\_22/issue\\_2/JohnstoneArticle22-2&3.pdf](http://www.law.uiuc.edu/publications/cll&pj/archive/vol_22/issue_2/JohnstoneArticle22-2&3.pdf)

<sup>(55)</sup> European Agency for Safety and Health at Work, *Expert forecast on emerging psychosocial risks*, Office for Official Publications of the European Communities, Luxembourg, 2007. [http://osha.europa.eu/en/riskobservatory/risks/forecasts/psychosocial\\_risks/index\\_html](http://osha.europa.eu/en/riskobservatory/risks/forecasts/psychosocial_risks/index_html)



Subcontracted workers increasingly perform high-risk work across many industries. They have less control over working times, often work in less skilled jobs, have fewer opportunities for training and life-long learning and subsequently less insight into their work environment. In addition, they are often under-represented on health and safety committees. All these factors contribute to making outsourced workers more vulnerable towards OSH risks.

*Subcontracted workers increasingly perform high-risk work across many industries.*

Outsourcing practices are also often associated with an unclear repartition of legal responsibilities between the host company and the contractor<sup>(53)</sup>. Some studies in the petrochemical industry have shown that accident rates are reduced when the host plant has greater incentives to take primary responsibility for the safety training and supervision of contract workers<sup>(56)</sup>.

**Table 1: The 10 most important emerging chemical risks identified in the survey**

<span style="display: inline-block; width: 15px; height: 15px; background-color: #f08080; border: 1px solid black;"></span> MV > 4: risk strongly agreed as emerging	<span style="display: inline-block; width: 15px; height: 15px; background-color: #ffff00; border: 1px solid black;"></span> 2.75 ≤ MV ≤ 3.25: status undecided
<span style="display: inline-block; width: 15px; height: 15px; background-color: #f4a460; border: 1px solid black;"></span> 3.25 < MV ≤ 4: risk agreed as emerging	<span style="display: inline-block; width: 15px; height: 15px; background-color: #66b3ff; border: 1px solid black;"></span> 2 ≤ MV < 2.75: risk agreed as non-emerging

NB: None of the risks was strongly agreed as non-emerging (MV < 2).

Top 10 chemical risks	N	Mean value (MV)	Standard deviation (SD)
Nanoparticles and ultrafine particles: emerging risks due to increasing (new) industrial applications creating ultrafine particles (e.g. laser treatment of material) and nanoparticles, to lack of knowledge on toxicity of ultrafine particles leading to inappropriate or insufficient protective measures, to poor risk assessment and to unfavourable workplace design and environment. Health effects of ultrafine particles in general may have been underestimated so far. Potential health effects: inflammatory lung diseases, secondary effects on cardiovascular system (e.g. heart attack, stroke), tumours.	47	4.60	0.876
Poor control of chemical risks in SMEs.	46	4.39	0.856
Outsourcing (e.g. for cleaning and maintenance activities) performed by subcontracted workers with poor knowledge of chemical risks.	47	4.34	0.788
Increasing use of epoxy resins (e.g. in the construction of wings for wind turbines as power generators or in the cabins of large aircraft, or on construction sites).	43	4.14	0.743
Exposure to dangerous substances in the treatment of domestic, clinical and industrial waste.	46	4.11	0.994
Dermal exposure leading to skin diseases.	45	4.11	1.027
Diesel exhaust.	45	4.02	1.033
Isocyanates leading to allergic reactions: exposure occurs not only at the production stage but also during further processing (e.g. thermal or chemical degradation of polyurethane, grinding and welding of products containing polyurethane, for example, in car repair shops).	44	4.02	1.067

<sup>(56)</sup> Rebitzer, J.B., *Job safety and contract workers in the petrochemical industry*, *Industrial Relations*, Vol. 34, No. 1, 1995, pp. 40-57.



Top 10 chemical risks	N	Mean value (MV)	Standard deviation (SD)
Man-made mineral fibres (e.g. refractory ceramic fibres, carbon/graphite fibres or composites): lack of knowledge on health effects of (new) fibre substitutes for asbestos, the use of which is increasing and for which exposure levels seem high enough for concern in certain areas. Potential health effects: respiratory diseases, cancer.	46	3.96	1.053
Construction industry (civil and industrial sector, including demolition, rebuilding and renovation activities): exposure to dangerous substances (crystalline silica dust, asbestos, wood dust, diesel engine exhaust, welding fumes) leading to occupational cancers.	45	3.96	1.224

Note: N = number of experts answering the specific item.

#### 4.1.6. Experts' comments

When available, the comments added by the respondents to the items are listed below to provide some context and support to the ratings.

##### *Risks strongly agreed as emerging (MV > 4):*

#### **Nanoparticles and ultrafine particles**

According to one respondent, the reason the item is mentioned as the first emerging risk in the survey is because nanoparticles are new although they cannot be considered as a characterised risk in terms of 'hazard × probability' – neither the hazards of nanoparticles nor the probably of exposure based on measurement and exposure assessment are well-defined – and it is not a risk spread among many workers (only 25,000 workers may be affected in a population of hundreds of millions).

But according to other experts, nanoparticles and ultrafine particles present many new chemical compositions and possess new, different properties than the very same materials at the macro scale. There is a need for well-established methods to assess workers' exposure and for more research into the effects of nanoparticles on workers' health – including reproductive health – in order to allow for risk assessment. The precautionary principle should be followed whenever there is any doubt about potential risks posed by nanoparticles and nanotechnologies.

One respondent reminded us that exposure to ultrafine particles is not only an OSH issue as, for instance, diesel-engines are used in daily life and create such particles.

Last, but not least, it was mentioned that the potential damage caused by new technologies to reproductive health – which is particularly vulnerable – should be further investigated.

#### **Poor control of chemical risks in SMEs**

There is a general lack of information on OSH and a low level of awareness of such issues in SMEs, which needs to be remedied. More attention must be paid to SMEs; in particular more resources for OSH should be made available to this group which is the biggest employer in Europe. This factor, together with the trend to outsource, results in dangerous work often being performed by workers with poor knowledge





of dangerous substances. However, one respondent from Denmark commented that this is a very well-known problem in Denmark and that it is not an emerging problem.

### **Outsourced workers with poor knowledge of the chemical risks related to the workplace they have been assigned to**

Outsourced activities performed by subcontracted companies (e.g. cleaning and maintenance activities) increasingly involve workers from the new Member States. These are a high risk group as they may have a poor knowledge of dangerous substances and chemical risks, and may have difficulties in communicating in the workplace in the host country.

### **Increasing use of epoxy resins**

One respondent mentioned that there is compulsory training in Denmark for workers who use epoxy resins (and isocyanates) at work. One objective is to train workers on how to work safely with these products. Although not all workers using epoxy resins (and isocyanates) have actually completed the training, and the problems with these products are not completely solved in Denmark, the respondent's view is that the risks linked to these products are not emerging risks in Denmark – as confirmed in a Nordic report on the subject a few years ago. However, the same respondent expected the use of epoxy (and isocyanates) to increase and felt that the issue required continual monitoring.

### **Exposure to dangerous substances in the treatment of domestic, medical and industrial waste**

Hygiene conditions are often poor during waste treatment activities and workers are exposed to dangerous substances including dust, endotoxins and some pathogens. One respondent added that dangerous substances in waste treatment could indeed be an emerging problem since new environmental legislation with respect to the recycling of materials from used cars and electronics will result in more workers carrying out dismantling jobs. According to this respondent, the demand for electronics and hence the production of electronic waste is also increasing in Denmark – as in most other countries.

### **Dermal exposure leading to skin diseases**

Health effects resulting from dermal exposure to dangerous substances are underestimated. Such exposures can lead not only to allergies but also to many other adverse, cumulative effects. In Spain, the social security department supported a study on occupational diseases conducted by the main mutuals, including Mutua Universal. The study carried out by Mutua Universal covering the period 2005-2007 demonstrated that work-related dermal diseases are increasing in absolute as well as in relative numbers.

In addition, three of the items identified as emerging risks are interrelated at the level of the effects on workers. These are:

- epoxy resins
- isocyanates
- dermal exposure.

Epoxy resins and isocyanates are chemical sensitisers for which dermal exposure is the main way of penetration into the human body. All three items are a concern



in the construction industry, and particularly affect SMEs and self-employed workers.

### **Diesel exhaust**

Workers are especially exposed to diesel exhaust in mining activities and where diesel-driven loaders and trucks are used.

Evidence from animal studies indicates that diesel exhaust may harm the foetus; risks include post-natal occurrence of allergies, reduced male fertility, hormone-like effects, and even degradation of cognitive functions in the future child.

One respondent underlines the fact that modern diesel engines with high-pressure injection are not only used in the workplace and thus a risk to occupational safety and health; they are also a risk to public health. One respondent added that diesel exhaust is also an emerging problem in Denmark as a consequence of increasing road transport of goods, as well as a consequence of new engine technology resulting in smaller diesel particles. The number and percentage of private diesel cars is also increasing in Denmark, leading to a higher level of emissions of diesel particles both in the environment in general and in the work environment. Another respondent was of the opinion that diesel exhaust is an 'old risk' which should perhaps be better considered as a public health issue as most of the engines used in industry are electrically powered while ambient air in cities is the most polluted by diesel exhaust.

### **Isocyanates**

According to one expert, exposure to isocyanates is more common than generally believed. Another respondent mentioned that in Denmark there is compulsory training for workers who use isocyanates and epoxy resins at work. One objective is to train workers on how to work safely with these products. Although not all workers using isocyanates and epoxy resins have actually completed the training, and the problems with these products are not completely solved in Denmark, the respondent's view was that the risks linked to these products are not emerging risks in Denmark – as confirmed in a Nordic report on the subject a few years ago. However, the same respondent expected the use of epoxy (and isocyanates) to increase and felt that the issue required continual monitoring. (Same comment by the same respondent as for the item 'Increasing use of epoxy resins – see above).

### ***Risks agreed as emerging (3.25 < MV ≤ 4)***

#### **Man-made mineral fibres**

Man-made mineral fibres are widely used in modern composite materials, which are a source of occupational exposure. According to some experts, the properties of such fibres are well-known and have been acknowledged by scientists and regulators.

Most of these fibres have a diameter big enough not to present a major health hazard to humans. According to an employers' association, there was an over-reaction of the public authorities based on fear that the man-made mineral fibres could have similar properties as asbestos. However, their properties are very different and there is no new scientific evidence for an increased risk.

According to the same employers' association, there is new scientific evidence which shows that the animal studies which served to classify aluminium silicate wools (ASW) – known as refractory ceramic fibres (RCFs) – in category 2 were misinterpreted because of the overload of particles in the samples tested which would have led to lung cancers



with any other fibre type or nuisance dust<sup>(57)</sup>. The risk is also not 'increasing'; there are no new hazards and exposure of people.

Exposure to ASW/RCFs is falling. The European Ceramic Fibres Industry Association (ECFIA), which represents the European high-temperature insulation industry, has implemented a long-lasting programme (called CARE) aimed at controlled and reduced exposure which shows exposure levels have been falling over the years. Furthermore, in France, 70% of applications using ASW/RCFs now use alkaline earth silicate wools, which have been widely tested and are exonerated from classification.

ASW/RCFs have been used for more than 50 years and have not shown any disease in workers. But according to other respondents, their properties have not yet been studied adequately. They also highlighted the fact that new types of fibres are always being synthesised. Any new types of fibres potentially harmful to health should continue to be studied.

### Exposure to chemical agents in the construction industry

The respondents highlighted the issue of multiple exposures in the construction industry which are not well assessed and difficult to control. It was also stated that the exposure to wood dust is higher than previously thought, and that more and more poorly qualified workers in the construction industry are exposed to isocyanates. Demolition and renovation activities were mentioned to be increasingly common. But, according to one respondent, dangerous substances in the construction industry are not seen as a new or increasing problem in Denmark.

## LITERATURE REVIEW

# 4.2.

Six literature reviews explore in more depth some of the main emerging risks singled out in the forecast in terms of context, workers at risk, health and safety outcomes, and prevention.

All the papers selected for this review originate from scientific peer-reviewed journals, reputable research or OSH organisations, or conference proceedings (the interventions of which are reviewed by a scientific committee).

### 4.2.1. Nanoparticles

Nanotechnology is the science of the small. It encompasses the research and applications of nanomaterials, i.e. new materials and devices with at least one dimension of less than 100 nanometres. As an illustration of this range of dimensions, a human hair is about 80,000 nm wide and a red blood cell is approximately 7,000 nm wide. The US National Academy of Sciences describes nanotechnology as the 'ability to manipulate and characterise matter at the level of single atoms and small groups of atoms' [1] [2] [3] [4].

<sup>(57)</sup> Brown, R.C., Bellmann, B., Muhle, H., Davis, J.M.G., Maxim, L.D., *Survey of the biological effects of refractory ceramic fibres: overload and its possible consequences*, *Annals of Occupational Hygiene*, Vol 49, No. 4, 2005, pp. 295-307.



Although no formal distinction exists between ultrafine particles (UFPs) and nanoparticles (NPs), the term ‘ultrafine’ is frequently used for nanometre diameter particles that have not been intentionally produced but are the incidental by-products of processes involving combustion (e.g. diesel exhaust) or high energy manufacturing processing (e.g. welding or grinding). Conversely, the term ‘nanoparticle’ designates nanometre diameter particles manufactured intentionally and whose overall dimension and/or structural features are specifically controlled to exploit novel size-dependent physico-chemical properties, particularly from a materials science perspective, for instance either to exploit novel quantum-based characteristics or to create more functionality in a smaller volume than was previously possible [3] [5].

Key applications of nanotechnology are found in the following fields [2]:



Some cosmetics contain nanoparticles.

- ICT (nano-electronics, increasing speed of computing or chip performance);
- biomedical applications (prostheses, implants, ultra-efficient medicines, autodiagnostic kits, detectors, etc.);
- environmental technology (selective membrane filters) and cleaner products;
- energy technology (solar cells, batteries, fuel cells, etc.);
- transport, aviation and space travel (lighter and stronger materials, fuels and catalysts);
- agriculture and nutrition (sensors, freshness indicators, seed improvement, etc.);
- medical applications;
- cosmetics;
- military technology.

Probably because the nanotechnology industry is still relatively new, no official data are available as to the number of workers exposed to NPs. However, one survey has estimated that companies engaged only in nanotechnology employed a total of 24,388 people in 2004 – including all workers (i.e. even the ones in, for example, administrative functions not related to NPs) [6].

*Nanotechnology is expected to grow rapidly into a global, multi-billion euro market. However, little research attention has been paid so far to health and safety issues.*

Nanotechnology is expected to grow rapidly into a global, multi-billion euro market. Analysts have estimated that the worldwide market for nanomaterials will reach 700–1,000 billion euros in 2011. Further estimations predict that 2.6 trillion dollars worth of products in the global market could incorporate nanotechnology in 2014 (i.e. 15% of manufacturing output) and that 10 million jobs worldwide will be involved in the manufacturing of nanotechnology-based products (i.e. 11% of manufacturing jobs) [4] [7] [8].

Despite the enormous possibilities of nanotechnology, very little research attention has been paid so far to health, safety and environmental issues. In 2003, the US Environmental Protection Agency (US EPA) identified a serious lack of information about the human health and environmental implications of manufactured nanomaterials such as NPs, nanotubes, nanowires, fullerene derivatives and other nanoscale materials. Independent experts making up the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) recently adopted an opinion on the appropriateness of methodologies for assessing the risks of nanotechnologies and concluded that nanotechnologies, although very beneficial to individuals and organisations thanks to their radically different properties, may however have potential implications for safety and therefore need to be assessed in advance [9]. The potential impact of these new materials on human health and the environment is viewed with apprehension. These preoccupations need to be allayed if this new industry is to develop dynamically [10] [11].



Europe enjoys a strong position in terms of producing knowledge on nanotechnology, which is reflected by the high numbers of publications in this field. The European Commission has supported a strong portfolio of activities in nanotechnology since 1994, with significant increases in the 6th Framework Programme (2002-2006). One of the nine thematic priorities of the 7th Framework Programme (2007-2013) is dedicated to 'Nanosciences, nanotechnologies, materials and new production technologies' – one of the objectives being to increase and support the take-up of knowledge generated in this field for all industrial sectors including impacts on health and safety [12] [13] [14] [15] [16] [17] [18].

### **Workers groups and workplaces at risk**

At present there is insufficient information on measured exposure to nanoparticles in the workplace. However, the manufacturing phase of nanomaterials is a concern as workers may repeatedly be exposed to large amounts of nanoparticles [4]. But the maintenance and clean-up of equipment used to produce nanomaterials are also sources of exposure [19]. Cleaning the dust collection systems used to capture NPs in particular poses a risk of both skin and inhalation exposure [5]. The following working situations have also been identified as increasing the likelihood of exposure [5]:

- working with nanomaterials in liquid media without adequate protection (e.g. gloves), which increases the risk of skin exposure;
- working with nanomaterials in liquid media during pouring or mixing operations, or where a high degree of agitation is involved, which increases the likelihood of inhalable and respirable droplets being formed;
- generating NPs in the gas phase in non-enclosed systems, which increases the chances of aerosol release into the workplace;
- handling nano-structured powders, which leads to the possibility of aerosolisation.

More generally, factors affecting exposure to engineered NPs include the amount of material being used and whether the material can be easily dispersed (in the case of a powder) or can form airborne sprays or droplets (in the case of suspensions). The degree of containment and duration of use also influences exposure [5] [20].

Based on these findings, it may be assumed that exposure to NPs occurs in the following main industrial activities [9] [21] [22]:

- nanotechnology sector, primary research and development (universities and other research groups and spin-offs);
- powder handling processes including paints, pigments and cement manufacture;
- welding;
- other processes where NPs are by-products.

Future research should concentrate on understanding the complete life-cycle of a given nanomaterial (i.e. exposure during its production and use, as well as when it is released into the environment) in order to [23]:

- predict situations and scenarios likely to lead to exposure to nanomaterials;
- identify the workplaces concerned;
- realistically assess the health and safety implications of working with NPs.

### **Properties, characterisation and metrology of nanoparticles**

NPs can have very different properties from the very same materials at the macro scale. Gold, for instance, is normally inert but is very reactive at nano-scale. These properties include physico-chemical properties such as:

- size

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*Workers may be exposed to nanoparticles during the manufacturing phase, and the maintenance and clean-up of equipment.*

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*NPs can have very different properties from the very same materials at the macro scale.*

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- size distribution
- agglomeration state
- shape
- crystal structure
- chemical composition
- electrical resistivity
- electrical conductivity
- optical absorption
- porosity
- surface chemistry
- surface charge
- surface area.

*It is partly because of their large surface area in relation to their small mass that NPs are more reactive with their surroundings.*

It is, for example, partly because of their large surface area in relation to their small mass that NPs are more reactive with their surroundings. Furthermore, minor changes, such as altering the coatings of buckyballs – soccer-ball-shaped form of fullerene (C<sub>60</sub>) – can significantly modify the physical properties (and hence the potential toxicity) of the particles [4] [9] [16] [24] [25] [26] [27] [28].

In order to understand the toxic effects of NPs, it is necessary to fully appreciate their properties at nano- and macro-scale. The characterisation and classification of NPs by their physico-chemical properties and by toxicity is therefore recommended. However, the possibility of classifying NPs by behaviour rather than by toxicity should be explored, as particle behaviour may provide a more accurate classification. In all cases, information on nanomaterial production, preparation, storage, heterogeneity and agglomeration state should also be recorded [19] [28].

A wide range of analytical methods are applicable to the characterisation of NPs. In many cases, the use of transmission electron microscopy analysis is highly appropriate, although time-consuming. In toxicity screening studies, characterisation of nanomaterials after administration *in vitro* or *in vivo* is considered the best way to proceed, though it still presents significant analytical challenges. Indeed, the following questions remain for toxicologists attempting to design studies to identify adverse biological interactions of nanomaterials [28] [29]:

- how to properly express and administer the dose of nanomaterials (e.g. mass, dimension, surface area, surface coating, aggregation state);
- how to ensure that the material given to the animal or cell culture is in the desired form and that the exposure dose and route of exposure imitate those of human exposure;
- how to detect and quantify nanomaterials in cells and tissues;
- how to characterise nanomaterials in all stages of toxicological testing.

Furthermore, the following gaps impairing the characterisation of nanoparticles were identified during the 'NANOSH' project – funded under the EU 6th Framework Programme [30]:

- lack of suitable reference materials to be used in comparative studies for characterisation of different types of NP;
- lack of understanding of metrics that should be used as the basis for measurement of levels of NP in the environment, or as determinants of dose (e.g. in toxicological studies).



## Potential safety and health outcomes

### Health

Ultrafine particles produced by human activities are ubiquitous (e.g. diesel exhaust particles) and people are exposed in their daily life through air pollution. Epidemiological studies have provided valuable information on the adverse health effects of particulate air pollution in the community, indicating that ultrafine particles act as an important environmental risk factor for cardiopulmonary mortality [12] [25] [26] [31] [32] [33].

There is considerable evidence that some NPs are toxic to human health. Many studies indicate that the toxicity of particles increases with decreasing diameter and increasing surface area, thus challenging current mass-based risk evaluation approaches. However decisive scientific information is still lacking.

As there is no universal 'nanoparticle' to fit all cases, it is not possible to apply generic rules about their potential health effects. Indeed, novel nanomaterials such as single-walled carbon nanotubes vary in terms of their physical form, chemical composition and physical properties. Quartz particles, for instance, were found to generate variable hazards mediated by a very small level (<0.1%) of surface impurity. Considering that surface modification is the fastest growing market for NP applications, the implications of these treatments should be investigated from a toxicological point of view [8] [31] [33] [34] [35] [36] [37] [38] [39] [40] [41] [42].

NPs can enter the body via inhalation, dermal contact, ingestion and inoculation (mainly relevant in the case of medicinal applications) [11] [24] [25] [26] [27] [35] [43] [44].

The studies available mostly relate to fullerenes, carbon nanotubes and inorganic nanoparticles (titanium dioxide, colloidal titanium, selenium, arsenic trioxide, zinc oxide, zinc) [45]. With regard to fullerenes, one study in rats shows toxicity in the kidney when inoculated but no toxicity following oral exposure. Toxicological studies on carbon nanotubes were mainly performed with monolayer carbon nanotubes and show a respiratory toxicity but no effect resulting from cutaneous exposure. As to inorganic nanoparticles, inhalation of titanium dioxide nanoparticles was found to be toxic and the toxicity to increase with the surface area of the particles [45]. Preliminary data from the 'NANOSH' project concerning the direct effects of titanium dioxide (TiO<sub>2</sub>) particles on airway inflammation in mice suggest that nano-sized particles may be more potent than larger particles in evoking inflammatory responses in the lungs [46]. Further results suggest that both carbon nanotubes and graphite nanofibres have genotoxic potential *in vitro* [47]. However, it is interesting to note that some studies show a reduced general toxicity or cytotoxicity of colloidal gold, selenium and arsenic trioxide nanoparticles compared with larger particles of the same materials. Regarding dermal exposure, studies on titanium dioxide nanoparticles contained in different types of sunscreens did not show any absorption deeper than healthy human dermis [45].

The basis of the toxicity of NPs is not fully established but appears primarily expressed through an ability to cause inflammation [35]. Several studies indicate that, once in the body, NPs can translocate to organs or tissues of the body distant from the portal of entry. With regard to skin exposure, recent studies have shown that NPs – and even fine particles (i.e. up to 1 µm in diameter) – can penetrate deep enough into the skin to be taken up into the lymphatic system, although the exact proportion of particles absorbed remains unknown [35] [48]. As for inhaled NPs, there is evidence that they may travel via the nasal nerves to the brain and gain access to the blood, nervous

*There is considerable evidence that some NPs are toxic to human health. However, decisive scientific information is still lacking and, as there is no universal 'nanoparticle' to fit all cases, generic rules about their potential health effects cannot be applied.*

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*Durable, biopersistent nanoparticles may also bioaccumulate in the body – in particular in the lungs, the brain and the liver.*

system and other organs; it is likely that they will not be detected by the normal phagocytic defences [34]. Once in the bloodstream, particles could interact with the vascular endothelium or have direct effects on atherosclerotic plaque. Local inflammation could destabilise a coronary plaque, resulting in rupture, thrombosis and acute coronary syndrome. Furthermore, particles may interact with circulating coagulation factors to promote thrombogenesis [12]. Moreover, NPs could act like haptens to modify protein structures, altering their function or rendering them antigenic – hence raising the potential for autoimmune effects. Durable, biopersistent nanoparticles may also bioaccumulate in the body – in particular in the lungs, the brain and the liver. Some studies suggest that a variety of nanoparticles damage cells through oxidative stress, which is believed to induce many diseases such as cancers. Nanomaterials may also be genotoxic – either through direct interaction with DNA, or indirectly via oxidative stress and inflammatory responses [47].

However, health outcomes caused by exposure to NPs are a subject of controversy and further research is needed [4] [5] [9] [20] [27] [33] [35] [38] [41] [43] [44]. In particular, the knowledge gaps identified in the ‘NANOSH’ project in relation to the determination of health effects are [30]:

- identification of key effects in most important target organs of NPs;
- identification of the underlying mechanisms of these effects;
- exploring the translocation of NPs in man and experimental animals;
- effects of low exposure levels of nanoparticles to exposed humans, particularly those being exposed in workplaces to nanoparticles.

France’s National Advisory Committee on Ethics (CCNE) published an opinion on the ethical implications of nanoscience and nanotechnology for health in March 2007 in which members called for more basic research and greater transparency to improve understanding of how nanoproducts may affect humans. They deplored the fact that only 0.4% of world nanoscience and nanotechnology spending (\$40 million out of a total \$10 billion) funds research on risks and side effects [45].

### **Safety [5] [19] [36] [40] [49]**

According to currently available information, potential safety concerns involve catalytic effects, or fire and explosion hazards.

Depending on their composition and structure, some nanomaterials may initiate catalytic reactions that would not otherwise be anticipated from their chemical composition alone.

Although insufficient information exists to predict the fire and explosion risk associated with nanoscale powders, nanoscale combustible material could have an increased combustion potential and combustion rate and hence present a higher risk than a similar quantity of larger particles of the same material. Even relatively inert materials may become highly reactive as nanomaterials. Small-scale testing could help to identify such effects.

While considerable information is available on the explosion characteristics of micro-scale powders, there are few data relative to nanopowders. In a study carried out within the frame of the European Nanosafe2 project, the safety parameters of nanopowders and their associated techniques and practices were characterised for a representative set of particles of industrial relevance. Studied carbon nanotubes exhibited explosion severities and sensitivities of the same order as those found for various coals, food flours and other nanostructured carbon blacks. For metallic aluminium nanopowders, the small oxide layer wrapping passivated nanoparticles may make them less explosive

*Potential safety concerns involve catalytic effects, or fire and explosion hazards.*





than micropowders. Nanopowders, which tend to agglomerate, show explosion violence characteristics of the same order as those observed with micropowders of the same substance.

The onset temperature of carbon materials depends strongly on the specific surface area of those materials. For aluminium, combustion mechanisms of nano-sized particles are different from those observed with micro-sized particles. This may lead to potential problems with large-scale industrial storage of such particles and specific prevention and protection measures should be taken. The classical Harmann test tube was found to be inappropriate for experiment with nanopowders because of potential emission of nanoparticles. The use of new confined stainless steel Hartmann tube and falling hammer equipment is recommended to help bring experiments to a higher degree of safety and efficiency.

### **Risk assessment and prevention**

Risk assessment should be responsibly integrated at all stages of the life-cycle of nanotechnology. Appropriate assessments should be carried out and risk management procedures elaborated before commencing mass production of engineered nanomaterials [8].

However, there is insufficient knowledge and data concerning nanoparticle characterisation, detection, measurement, toxicology and fate in humans and the environment to allow for satisfactory risk assessment. The very limited data published on the release of nanostructured aerosol into the workplace indicate relatively low release rates of respirable particles on a mass basis [42]. Nevertheless, accurate information on the physico-chemical characteristics of NPs – especially size, chemistry and structure-dependant toxicity – is needed to quantify the significance of these findings to occupational health and to allow for reliable risk assessment [42]. In addition, the NANOSH project underlined the lack of easy-to-use, portable devices for measurement of nanoparticles in the air and therefore lack of exposure information, especially in working environments [30].

Yet many data are available on environmental and occupational exposures to aerosols of larger particles. Moreover, relevant hazard information is already available for some materials that are being manufactured in the nanometre size range such as titanium dioxide. This information should be considered a starting point for assessing the levels at which exposure to NPs may harm workers' health and for developing an initial assessment of potential risk and risk reduction strategy. For example, theoretical and limited experimental data indicate that conventional ventilation, engineering control and filtration approaches may be applicable, in many cases, to particles a few nanometres in diameter and larger [40] [42]. ISO standard ISO/TR 27628:2007 *Workplace atmospheres – ultrafine, nanoparticle and nano-structured aerosols* provides practical guidance for the characterisation and assessment of inhalation exposure to NPs [50].

Collective and personal protective equipment should be evaluated and improved for reducing workplace exposures to NPs. The development of effective educational and training materials for workers and occupational health professionals is also required [8] [9] [38] [44] [51].

In any case, in the absence of any other evidence, it should be assumed that nanoparticles are at least as harmful as larger particles of the same material. On this basis, interim precautionary measures should be developed and implemented until further information on the possible health risks and extent of occupational exposure to nanomaterials is available [5] [9] [25] [26] [40] [42].

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*Risk assessment should be responsibly integrated at all stages of the life-cycle of nanotechnology.*

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*Although the quantitative data needed for satisfactory risk assessment are still missing, sufficient information is available to start preliminary assessment and to develop interim working practices to reduce workplace exposure.*

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### Conclusion

Nanotechnology is a booming business and has great potential. However, relatively little research attention has been paid so far to health, safety and environmental issues. It is certain that NPs can enter the human body, but the degree of damage they can cause is still unknown and is very specific to the type of nanomaterial; hence the need to:

- determine the physico-chemical, toxicological and behavioural properties of each NP type;
- develop reliable methods for their detection and measurement in the environment and in the human body.

Although the quantitative data needed for satisfactory risk assessment are still missing, sufficient information is available to start preliminary assessment and to develop interim working practices to reduce workplace exposure. Collective and personal protective equipment should be evaluated.

In parallel, further research should be undertaken to guarantee the development of 'responsible' nanotechnology, which integrates health and safety considerations [42]. In light of new available information on NPs, the European Commission will examine and propose adaptations of EU regulations in relevant sectors. The European Environment and Health Action Plan 2004-2010 and the Community Strategy on Health and Safety at Work 2007-2012 also provide a basis for future possible initiatives [8] [52].

#### 4.2.2. Increasing use of epoxy resins

*Epoxy resins are one of the most important and widely used polymeric systems.*

Epoxy resins are one of the most important and widely used polymeric systems. Epoxy resin molecules contain at least two cyclic three-membered ring structures known as epoxy, epoxide, oxirane or ethoxyline group. Epoxy resins are prepared by the coupling of epichlorohydrin with compounds possessing at least two reactive hydrogen atoms.

The reaction products of epichlorohydrin and bisphenol A resulted in the first commercial epoxy resins known as diglycidyl ether of bisphenol A (DGEBA) resins. DGEBA resins are generally mixtures of monomeric diglycidyl ether of bisphenol A with a molecular weight (MW) of 340, and oligomers with a higher MW. DGEBA resins with an average MW of 350–400 are viscous liquids. Resins with an average MW higher than 900 are solid. DGEBA is the lowest molecular weight oligomer in commercial epoxy resins and the major component in commercial liquid epoxy resins [53].

DGEBA resins account for about 75% of the epoxy resins used worldwide. Competitive non-DGEBA epoxy resins are often produced to obtain a desired balance of special properties in certain applications. For example, epoxy novolac resins – generally based on bisphenol F diglycidyl ethers (DGEBF) – have better chemical resistance and heat resistance compared with conventional epoxy resins [54]. A further example is a new thermal stable ultraviolet (UV) curable epoxy coating with better adhesion properties and thermal stability [55]. Brominated epoxy resins have better fire resistance properties [56].

Strictly speaking, the term 'epoxy resins' refers only to the uncured thermoplastic state with uncrosslinked monomers and oligomers characterised by epoxy groups in their molecular structure. In practice, however, the term 'epoxy resin' is loosely used to include cured thermoset epoxy systems [57]. The uncured resins can be crosslinked through the use of a variety of agents to form cured plastics with insoluble three-dimensional structures. Very high molecular weight epoxy resins and cured epoxy resins may contain very few or no epoxy groups.



Curing agents (amines, amides and anhydrides of carbonic acids), accelerators (tertiary amines), copolymers, reactive diluents and softeners [58], fillers, modifiers, pigments, flexibilisers and reinforcements are used to convert the uncured epoxy resin into various types of cured end products. The reactive diluents are often glycidyl ethers that also contain epoxy groups. A variety of available epoxy resins, reactive diluents, polyamine hardeners, anhydride hardeners, catalyst curing agents and miscellaneous curing agents are listed in the *Condensed Handbook of Occupational Dermatology* [54].

The range of uses of epoxy resins includes:

- adhesives;
- paints and coatings;
- sealants;
- inks;
- varnishes;
- reinforced polymer composite structures with glass fibre, carbon fibre or metal substrates;
- protective coatings of canned food.

A number of comprehensive reviews on epoxy resins, their formulations, markets, applications and effects have been published in the recent literature [53] [54] [57] [59] [60] [61].

The use of epoxy resins has increased continuously in recent decades and is expected to grow in the future as a result of the growing acceptance of epoxy systems in a variety of different industrial applications as adhesives, coatings, fillers and epoxy grouts, etc. [60]. Epoxy resin sales increased rapidly in the 1970s and 1980s in the USA, Europe and Japan. More recently the Asia–Pacific markets – particularly Taiwan and China – have had the highest growth rate and now surpass both the North American and European markets.

In the USA and Europe, the production of epoxy resin is concentrated in a few large companies. The Japanese epoxy industry is known for its special focus on high performance, high purity resins for the electronics industry. In Asia – apart from Japan – there has been a significant increase in epoxy market demands and capacity in recent decades. This is due to the relocation of many printed circuit board, electronics, computers and durable goods manufacturing plants to this region, which has lower manufacturing costs. The output of the small number of large companies in Korea and Taiwan accounts for a rather large portion of the world market [57]. In China, there are over 200 small domestic producers of epoxy resins as well as a few larger ones. According to the US Commercial Service, China's demand for epoxy resins has grown rapidly in the past decade [62]. Epoxy resin market growth has correlated with economic development and demand for durable goods and, in the coming years, both production and demand will continue to grow. In Finland, for example, the volume of imports of bisphenol A and bisphenol F based epoxy resins, reactive diluents and hardeners has increased in recent years [63].

For new product development and applications, better properties such as thermal, chemical or fatigue resistance, processability and performance characteristics are always sought. There are numerous variations of epoxy resins products for special purposes with specific properties and many new applications can be found in the patent literature [64]. New additional components, new advanced materials and products based on epoxy resins are presented in the scientific literature [65] [66] [67] [68] [69] [70].

*The use of epoxy resins has increased continuously in recent decades and is expected to grow in the future.*



Spraypainting, INSHT, Spain



*Epoxy resins can cause skin sensitisation and photosensitisation. The reaction may be due to the uncured epoxy resin, curing agents, diluents or other constituents in epoxy formulations.*

### **Workers groups most at risk and workplaces concerned**

Epoxy resins are used in many industrial areas. Epoxy skin sensitisation is particularly problematic in the construction industry where a safe and healthy working environment (e.g. clean room) and the use of protective clothing (e.g. gloves) is less common or less practical [60]. Painters, workers in the electrical and electronics industry, and those employed in the manufacture of composite products, form the groups most at risk [59] [60] [61] [63].

The production systems in epoxy resin plants are usually closed but, in the case of accidental leakage or during the maintenance and repair work, workers may be at risk of exposure to dangerous substances such as epichlorohydrin [71].

### **Toxicology and health effects**

Epoxy resins can cause skin sensitisation and photosensitisation. Sensitisation of the skin of the hands, arms, face and throat due to epoxy systems has been reported. The adverse reaction caused by an epoxy system may be due to the uncured epoxy resin, curing agents, diluents or other constituents in epoxy formulations.

Epichlorohydrin is classified as a Group 2A carcinogen ('probably carcinogenic to humans') in the International Agency for Cancer Research (IARC) classification [72] and as 'carcinogenic category 2' in the EU classification [71].

Bisphenol A was found to be a weakly estrogenic monomer [73]. Cases of contact allergy to bisphenol A have been reported from, for example, dental composite resins, semisynthetic waxes, plastic footwear and plastic gloves [61] [74].

The toxicity of many of the glycidyl derivatives is low, but the diversity of compounds found within this group does not permit generalisation of this finding [57]. Photosensitivity has been reported in relation to the heating of DGEBA epoxy resin and the use of epoxy resin paints [54].

Diluting agents and hardeners used for the production of modified epoxy resins – especially aliphatic, alicyclic and aromatic amines – have to be treated with the utmost care. Polyamines are often troublesome to work with because of their reactivity and volatility, and their irritating and sensitising properties to the skin and respiratory tract [54].

Anhydrides of carbonic acids are widely used as curing agents for epoxy resins. They are potent respiratory sensitising agents and, even at low exposure intensities, they may cause severe irritation to the eyes, skin and airways [75]. All anhydrides are classified as skin and mucous membrane irritants. High concentrations of anhydrides have been measured in the air of some workplaces where anhydrides are used as hardeners in epoxy products. Some phthalic anhydrides are used in processes where they are added to molten epoxy resins at elevated temperatures to produce insulating materials used in the electrical and electronics industry. Chlorinated anhydrides such as tetrachlorophthalic anhydride are used as flame retardants in resins [76].

Some of the components can also cause irritations of the eyes and respiratory tract, contact urticaria, rhinitis and asthma [60] [63].

The toxicology of epoxy compounds frequently encountered in industrial use as uncured epoxy resins or reactive diluents has been comprehensively reviewed in *Patty's Toxicology* [77] [78].

It is well known that epoxy resins can cause skin diseases. The first reports of sensitisation to epoxy compounds were published in the 1950s soon after the large-scale production



of epoxy resins began [59] [79]. Epoxy resins consist of a broad family of chemicals, with the frequent emergence of new potentially allergenic compounds. They have become one of the most common causes of occupational allergic contact dermatitis (ACD). In Finland, epoxy resin compounds had begun to cause increasing numbers of occupational dermatoses by the beginning of the 1970s. During 1990-1995, epoxy resin compounds were more frequent causes of ACD than other plastic chemicals – which have been common causes of occupational ACD since the 1960s – and induced about 12% of the reported cases of occupational ACD [61].

The reported cases of ACD are mainly caused by direct dermal contact with epoxy resin and related compounds. However, airborne exposure to these substances may also cause ACD [80].

Occupational ACD from epoxy resins, reactive diluents and hardeners is reviewed in several recent publications [54] [63] [81] [82]. For example, companies producing rotor blades for wind turbines using epoxy-based technology have experienced an increasing number of workers with dermatitis [83] [84]. A number of references to publications related to epoxy allergies can be found in the research database of the Finnish Institute of Occupational Health [85]. In the UK, concern by the Health and Safety Executive (HSE) about epoxy resin sensitisation problems – particularly in the construction industry – resulted in the commissioning of The Welding Institute (TWI) Ltd to carry out a project aimed at studying skin sensitisation due to epoxy resins [60].

In France, 'eczema due to exposure to epoxy resins and their constituents' was defined in 2006 as an occupational disease (number 51 on the official list of occupational diseases) [86].

### **Preventive measures**

Epoxy products have many good technical properties and thus epoxy resins are not easy to replace with other less harmful products.

The continuous demand for always newer generations of epoxy resins and derived products with enhanced properties may introduce new, unknown adverse health effects.

The proper identification of the epoxy system involved in the process is essential for the choice of appropriate prevention measures. Therefore, suppliers have to provide safety data sheets (SDS) of their products, which should contain the most recent toxicity and safety data. These should be consulted before handling the materials. The availability of safety data sheets in the workplace should be ensured.

If the most effective prevention methods are not implemented in the workplace, the number of work-related diseases due to epoxy resins will probably rise further still with the increasing use of epoxy resins.

In principle, complete avoidance of contact with causative allergens is indispensable in preventing epoxy dermatitis. Even a minimal amount of allergen may be enough to evoke the symptoms on the exposed skin in a worker highly sensitive to epoxy compounds. The use of higher molecular weight (>900) epoxy resins or diluents may reduce the possibility of developing allergy [60] [61].

For reducing or preventing epoxy sensitisation, the following further recommendations are given [60]:

- avoid contact with incompletely cured epoxy resins;
- wherever possible, use one-part epoxies rather than two-part ones to reduce the risk of dermal contact during hand mixing;

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*Epoxy resins have become one of the most common causes of occupational allergic contact dermatitis.*

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*In France, 'eczema due to exposure to epoxy resins and their constituents' was defined in 2006 as an occupational disease.*

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*The continuous demand for always newer generations of epoxy resins and derived products with enhanced properties may introduce new, unknown adverse health effects.*

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*Complete avoidance of contact with causative allergens is indispensable in preventing epoxy dermatitis. Even a minimal amount may be enough to evoke the symptoms on the exposed skin in a worker highly sensitive to epoxy compounds.*

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- if using two-part or pre-mixed epoxies, choose those supplied in single or twin cartridges, or mix the two components with an automated internal mixer or dispensing equipment;
- whenever possible, replace harmful epoxies by alternative epoxy systems with reduced risk of sensitisation;
- provide proper ventilation to prevent airborne dermatitis;
- protect damaged skin, including even small wounds and abrasions, from epoxy-compound exposure because of increased skin sensitisation;
- wear protective clothing, particularly effective gloves (e.g. fluorinated rubber gloves). This should be mandatory.

The use of some barrier creams and spray coatings may be effective although their use in some applications, particularly in the construction industry, is often impractical. Laminated 4-H gloves have been found to be effective during exposure to epoxy resins, but again their use within the construction industry is impractical due to their shape and the lack of acceptable mechanical properties (tear and puncture resistance). Thus there is a need to develop effective hand protection for the construction sector [60].

The Society of the Plastics Industry provides general guidelines for the safe handling and processing of epoxy resin systems [87].

It is also necessary to provide adequate OSH training to workers using epoxy compounds. Workers should be made aware of the risk of sensitisation and be encouraged to understand the importance of good working practices for their personal protection [60] [63]. In Denmark, for example, workers who use epoxy resins (or isocyanates) have to undergo compulsory education; however, not all employees working with these products have completed this training.

Last, but not least, Occupational Exposure Limits (OELs) should be determined for all anhydrides in use. Criteria documentation of health risks from cyclic acid anhydrides was published in 2004 in co-operation with Nordic and Dutch expert groups [88].

Although some information is available on epoxy resin sensitisation, there is little about how to prevent or reduce the harmful effects in industrial applications such as building and construction [60].

#### 4.2.3. Man-made mineral fibres

In the hygiene and safety field, a fibre is a particle with a length/diameter ratio greater than three and with approximately parallel sides (cylinder-like shaped) [89]. The World Health Organization (WHO) provides a more accurate definition, namely [90]:

‘a fibre is a particle with a diameter less than or equal to 3 µm, a length greater than or equal to 5 µm and a length/diameter ratio greater than or equal to 3’.

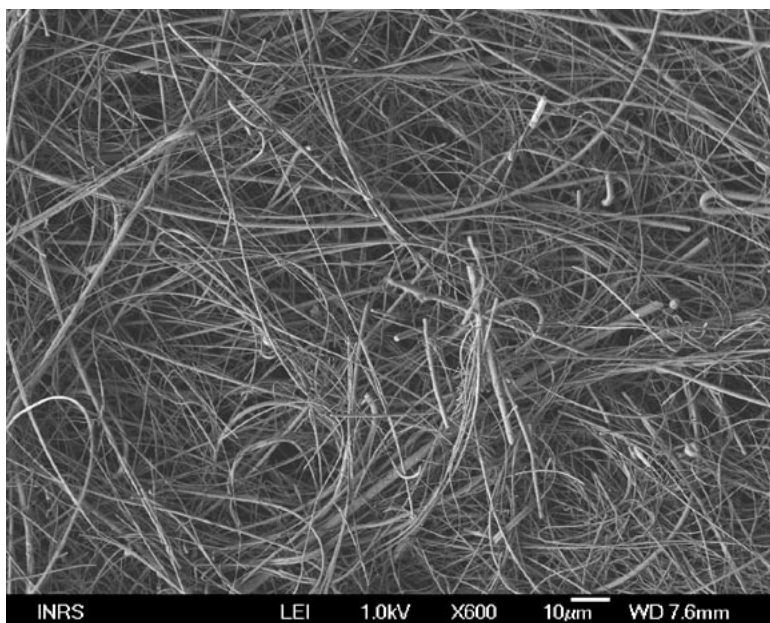
Man-made mineral fibres are divided into siliceous and non-siliceous fibres (Table 2).

Aluminium silicate wool (ASW), also more commonly called refractory ceramic fibres (RCFs), are aluminium silicates with a diameter varying between 1 and 3 µm. There are three types of mineral wools – glass, rock and slag wools – classified according to the type of material they are made out of. Their average geometric diameters are of the order of 1.7–3.5 µm. While ASW/RFC are vitreous aluminium silicate fibres, mullite fibres are crystalline aluminium silicate fibres. Mullite fibres are sometimes used as a substitute for ASW/RFC at high temperature, above 1,000 °C. Special purpose glass fibres are borosilicate glass fibres with a diameter <1 µm. Diameters of continuous glass filaments



are  $\geq 6 \mu\text{m}$ . All these fibres fragment transversely, meaning that they become progressively shorter; unlike asbestos which fragments longitudinally and becomes thinner.

Carbon fibres have an average diameter of  $5\text{--}8 \mu\text{m}$ , but include a fraction of fibres with a diameter  $< 3 \mu\text{m}$ . The diameter of alumina fibres is of the order of  $3\text{--}3.5 \mu\text{m}$ . Whiskers of any type and potassium titanate fibres have a diameter  $< 1 \mu\text{m}$ .



Man-made mineral fibres, Institut National de Recherche et de Sécurité, France.

Table 2: Types of man-made mineral fibres

Siliceous	Non-siliceous
Aluminium silicate wool (ASW) – also called refractory ceramic fibres (RCFs)	Carbon fibres
Mullite fibres	Alumina fibres
Glass wool	Whiskers
Rock wool	Potassium titanate fibres
Slag wool	Others
Special purpose glass fibres	
Continuous filaments	

### Toxicity and health outcomes [89] [90] [91] [92] [93] [94] [95] [96] [97]

Fibres are dangerous through inhalation. Fibres with a geometric diameter  $< 3 \mu\text{m}$  may reach the deep lung (pulmonary alveolar zone).

Fibrous structure increases the inflammatory, cytotoxic and carcinogenic potential. In general, the longer and thinner the fibres, the more dangerous they are. The size determines the region of the lung where a fibre will deposit and its ability to produce toxic effects in cells [97].

The chemical composition of these fibres conditions the dissolution rate and surface reactivity of these substances.

Fibres differ in their biopersistence and so accumulate in the lungs to different extents. Some are biopersistent; in other words, lung biological media do not eliminate them and they accumulate in the lungs [98]. The quantitative relation between biopersistence and carcinogenicity in animals has not yet been established. While carcinogenic potential is probably linked to biopersistence for pleural tumours, its role is less obvious

*Fibrous structure increases the inflammatory, cytotoxic and carcinogenic potential. The longer and thinner the fibres, the more dangerous they are.*



*Some fibres contain up to 25% additives. However, the presence of additives is very rarely taken into account in experimental studies on man-made mineral fibres.*

in generating bronchopulmonary cancers. Other phenomena such as oxidising stress (generation of free radicals which are harmful for the cells) can occur, especially in the case of repetitive exposure.

When RCFs are exposed to high temperatures (over 1,000°C) – for example in kilns and furnaces where they are used as lining materials – they devitrify at the surface of the kiln or furnace linings to crystalline phases, including crystalline silica and cristobalite – a form of crystalline silica which can cause silicosis. Therefore, workers could be exposed to both RCFs and crystalline silica during maintenance activities [99].

Finally, some fibres contain up to 25% additives. However, the presence of additives is very rarely taken into account in experimental studies on man-made mineral fibres.

In 2002 the International Agency for Research on Cancer (IARC) conducted an evaluation of risks to humans to assess the health effects of man-made mineral fibres (Table 3).

**Table 3: Summary of toxicology data on man-made mineral fibres analysed by the IARC [90]**

Fibre categories	Cancer risk (after inhalation)		Persistence in lungs	Non-cancerous respiratory diseases		Assessment for man	Assessment for animals	Classification (category)
	man	animal		pleura	lung			
Glass wools	–	–	low	–	–	IE	LE	3**
Rock wools	–	–	high	–	?	IE	LE	3**
Slag wools	–	–	low	–	–	IE	LE	3**
Refractory ceramic fibres	?	+	high	+	+	IE	SE	2B
Special purpose glass microfibres: type E and 475	ND	+	high	ND	ND	ND	SE	2B

+ = at least one study considered positive  
 – = all available studies considered negative  
 ? = IARC could not express an opinion  
 IE = insufficient evidence  
 LE = limited evidence  
 SE = sufficient evidence  
 ND = no data (no published study)  
 Category 3 = unclassifiable  
 Category 2B = possibly carcinogenic for man

\* Anomalies observed in the aluminium ceramic fibre production sector were altered respiratory capacity in smoking workers (linked to cumulative exposure levels) and X-ray images showing pleural plaques.

\*\*The IARC could not classify rock, glass and slag wools because of conflicting variations in epidemiological study results. These initially showed excessive cancer risk but did not confirm these conclusions when continued over time and with greater consideration for tobacco addiction. The few mesothelioma cases were attributed to earlier asbestos exposure.

According to the International Chemical Safety Card (ICSC) on ASW/RFC (ICSC:0123) by the International Labour Organization (ILO), lungs may be affected by repeated or prolonged exposure, and ASW/RFC fibres are possibly carcinogenic to humans [290].

Since 1997, manufacturers have modified the composition of siliceous fibres to reduce their biopersistence. The new products replacing ASW/RFCs have been tested by both life-time and short-term animal studies using several routes. There has also been *in vitro* experimentation on both the ‘as manufactured’ and ‘after use’ materials. However, more toxicological data are still needed for these new products and the

*Repeated or prolonged exposure to ASW/RFC may affect the lungs. ASW/RFC are possibly carcinogenic to humans.*





constant modifications of their composition make it difficult to conduct epidemiological studies [100].

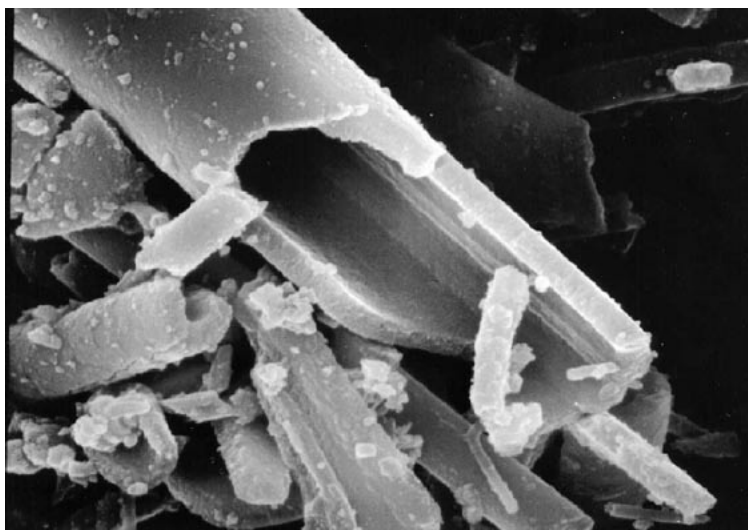
The ILO's ICSC for glass wool (ICSC:0157) indicated that repeated or prolonged contact with skin may cause dermatitis, and that tumours have been detected in experimental animals but may not be relevant to humans [291]. ILO's ICSC:0194 for rock wool and ICSC:0195 for slag wool warns that both substances are possibly carcinogenic to humans, and that the carcinogenic potential depends on the length, diameter, chemical composition and biological persistence of the fibre [292][293].

Data on carbon fibres remain insufficient. Some information inclines to be cautious due to the capacity for carbon fibres to break into thinner fibrilla and to create ultra-fine particles during certain operations [101] [102] [103].

The toxicological potential of other non-siliceous man-made mineral fibres has been little investigated and only in experimental studies, but they seem to be biopersistent. There are few toxicological data on tungsten oxide and magnesium sulphate whiskers or on alumina fibres [104] [105] [106], while silicon carbide whiskers appear carcinogenic in animals according to experimental study results [107]. Potassium titanate fibres have provided several positive carcinogenic results, but these data are insufficient to conclude their carcinogenic effect [108].

In addition, there is a lack of information in some cases on the composition of the fibres provided by the manufacturer. Chemical compositions are diverse and, for the same type of fibre, composition ranges vary between manufacturers. In addition, some fibres sold under the same commercial name may be produced with different types of composition. Information is lacking on:

- occupational exposure to these fibres (exposure data by type of fibres being illusory at the moment);
- their applications – more particularly the link between these and the type of glass used;
- their accessibility;
- the ageing of products containing these fibres.



Corroded man-made mineral glass fibre, BGIA, Germany.

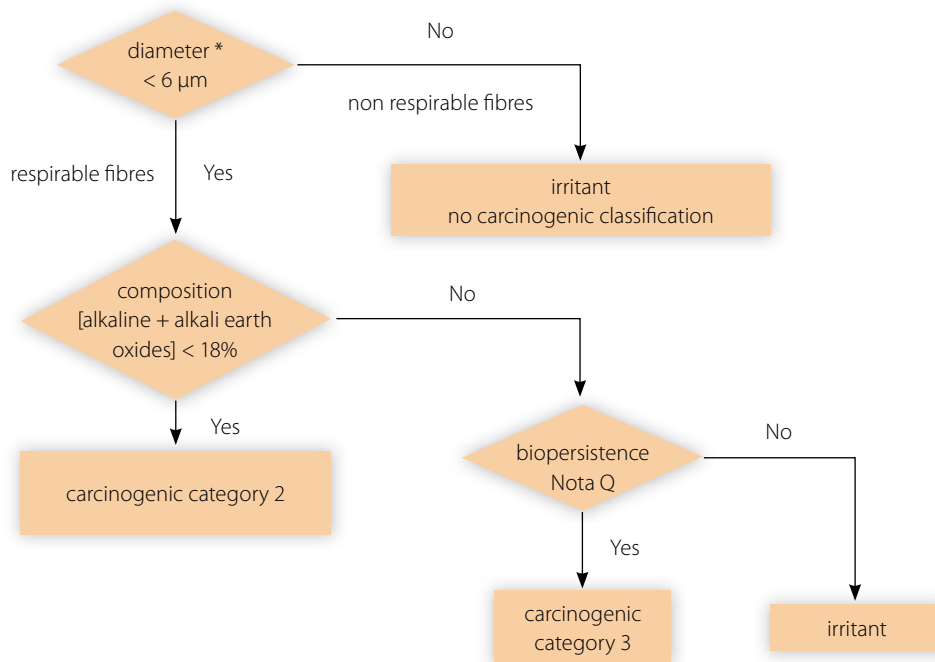
Last, but not least, in the case of special purpose glass fibres, existing data are mainly concerned with special purpose glass fibres types E and 475. However, this family includes a great diversity of fibre types for which there is a lack of characterisation with regard to their potential toxic effects as well as to all the points mentioned above [100].

Figure 2 sets out the principles adopted for the European classification of vitreous silicate fibres as presented in Directive 97/69/EC [109].

*Repeated or prolonged contact with glass wool may cause dermatitis. Tumours have been detected in experimental animals.*



**Figure 2: Classification of man-made vitreous silicate fibres with random orientation [109]**



\* Length weighted geometric mean diameter less two standard errors

The current EU classification and labelling according to Directive 97/69/EC are summarised in Table 4.

**Table 4: Statutory classification and labelling – Directive 97/69/EC [100] [109]**

Fibre types	Classification	Risk phrases	Safety advices
Refractory ceramic fibres	carcinogenic category 2	Toxic (T) R38/49	S 45-53
Special purpose fibres glass type E	carcinogenic category 2	Toxic (T) R38/49	S 45-53
Special purpose fibres glass type 475	carcinogenic category 3 (nota Q)*	Harmful (Xn) – R38/40	S36/37
Mineral wools	carcinogenic category 3 (nota Q)*	Harmful (Xn) – R38/40	S36/37
Continuous filaments	Not classified		

\* Wools may be exempt from carcinogenic category 3 classification if they satisfy one of the conditions of nota Q on fibre biopersistence or carcinogenicity testing. Then they are classified as irritant.

Carcinogenic category 2 = substance which should be regarded as if it is carcinogenic to man.

Carcinogenic category 3 = substance which causes concern for man owing to possible carcinogenic effects.

R 38 Irritating to skin.

R 40 Limited evidence of a carcinogenic effect.

R 49 may cause cancer by inhalation.

S 36 wear suitable protective clothing.

S 37 wear suitable gloves.

S 45 In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

S 53 Avoid exposure – obtain special instructions before use.



## Exposure

ASW/RCFs are mainly used for high-temperature thermal insulation of industrial furnaces or blast furnaces and casting moulds, though it is also used in car manufacturing (catalytic exhausts, etc.) and in aeronautical applications. Mineral wools are used for thermal and acoustic insulation in housing, in the tertiary sector and in technical installations. Special purpose glass fibre types E and 475 are mainly used in filtering applications, and in the aerospace and aeronautics industry as thermal insulation. Carbon fibres are used for aeronautical and industry engineering applications; they are also used as part of the composition of sports and leisure items. Potassium titanate fibres and whiskers are used to reinforce high-temperature composite materials. Alumina fibres are mainly used as high-temperature thermal insulation.

Exposure during production of these fibres is usually low. However, workers handling fibre-based products – especially during laying, maintenance or removal operations – may be highly exposed [100] [110]. For example, recorded mean concentrations of mineral wool exceeded 1 fibre/cm<sup>3</sup> at material blowing and projection workstations [110]. Although recorded mean concentrations of RCFs in many cases are under 0.5 fibres/cm<sup>3</sup>, airborne concentrations above 1.5 fibres/cm<sup>3</sup> have been seen for some jobs when removing ASW/RCFs and when cutting and processing RCF materials [111] [112] [113] [114] [115] (Table 5).

ASW/RCF products put on the market are labelled according to Directive 67/548/EEC for substance and preparations. According to European Ceramic Fibres Industry Association (ECFIA) <sup>(58)</sup>, which represents the European high-temperature insulation wool industry, the manufacturing industry is also labelling articles containing ASW/RCFs even though this is not required by the regulations. But, according to a report by the French agency Afsset, there is no specific code or labelling clearly indicating the presence of ASW/RCF in items and equipment [100]. Moreover, ASW/RCFs cannot be reliably differentiated from other fibres by simple visual examination.

Marking ASW/RCF and other high-temperature wools is technically difficult as they are commonly used at temperatures over 1,000°C. However, according to ECFIA, the high-temperature insulation wool industry has produced a detailed list of products and applications. In addition, one manufacturer provides a simple test kit enabling less biopersistent high-temperature wools to be easily identified. The Afsset study also showed that some companies and manufacturers of electric household equipment mentioned that they order equipment or parts from their providers according to specific required characteristics but are not aware of the exact nature of their components [100]. Many exposure measurements have been made and the results could help these companies. Indeed, data from the Controlled and Reduced Exposure Programme carried out by ECFIA for 17 years are available and the Institute National de Recherche et de Sécurité (INRS) in France has published a number of papers giving the level of concentrations depending on the type of activity. ECFIA has also published and distributed a number of codes of good practice. In Germany, Technische Regeln für Gefahrstoffe (TRGS) 521 gives measures to be taken in connection with the type of activity as well as level of exposure [294].

According to the French SUMER survey 2003, 104,000 workers could be exposed to refractory ceramic fibres [116]. However, the industry itself believes the true number exposed is about 4,000 in France and 20,000 in Europe. In addition, INRS and eight laboratories of the French Regional Health Insurance Funds (CRAMs) carried out 869

<sup>(58)</sup> [www.ecfia.eu](http://www.ecfia.eu)



individual measurements of the concentrations of refractory ceramic fibres in over 101 establishments in a number of sectors. The highest exposures were found during work involving the removal and application of material composed of RCFs and during finishing work on the production of items made from RCFs (Table 5) [111].

**Table 5: Average exposure to refractory ceramic fibres by types of workplace [111], [116]**

Workplace	Mean airborne concentration (fibre/cm <sup>3</sup> )	Proportion of results over 0.6 fibres/cm <sup>3</sup> *
Manufacturing	0.4	22.7 %
Loose handling	0.3	14.5 %
Assembly	0.3	29.2 %
Laying	0.5	44.3 %
Removal	1.3	69.8 %
Cutting	1.5	78.5 %

\* Occupational Exposure Limit in force in 2003.

*In France, audits performed by Afsset revealed that most of the companies did not carry out any measurements to evaluate the exposure level of workers to refractory ceramic fibres.*

In France, the Occupational Exposure Limit (OEL) (weighted over eight hours exposure) is binding and has been lowered to 0.1 fibre/cm<sup>3</sup>, with a transitory value of 0.5 fibre/cm<sup>3</sup> until 30 June 2009 [116].

Audits performed by Afsset revealed that most of the companies did not carry out any measurements to evaluate the exposure level of workers to refractory ceramic fibres [100]. The industry runs a structured scheme to measure exposure to ASW/RCF and to substitute high-temperature wools in both manufacturing and customer premises; information from thousands of measurements is available from ECFIA. Exposures are similar in the USA, where the industry has an agreement with the Occupational Safety and Health Administration (OSHA) to collect these data.

Evalutil<sup>(59)</sup>, a French database, contains information on man-made mineral fibres – as well as on asbestos – including measuring methods for specific occupational situations. FIBREX<sup>(60)</sup>, another French database, contains more than 10,000 data collected since 1987 on occupational exposure to inorganic and organic artificial and natural fibres. Both are freely accessible from the Internet.

### Possible prevention measures

Many of the provisions of the ILO Code of Practice 'Safety in the use of synthetic vitreous fibre insulation wools', although written for insulation wools, represent good practice for the prevention of OSH hazards in general. This could also be applied to RCF, refractory fibres other than RCF, and special purpose glass fibres [113].

Collective prevention measures involve primarily [117] [118]:

- curtailing dust emission through implementation of closed systems;
- collecting dust at source;
- working under wet conditions;
- using manual or slow-speed tools;

<sup>(59)</sup> <http://www.invs.sante.fr/bdd/index.htm>

<sup>(60)</sup> [http://www.inrs.fr/inrs-pub/inrs01.nsf/IntranetObject-accesParIntranetID/OM:Rubrique:6DACBDF8FAEA599C1257364004D3B11/\\$FILE/Visu.html](http://www.inrs.fr/inrs-pub/inrs01.nsf/IntranetObject-accesParIntranetID/OM:Rubrique:6DACBDF8FAEA599C1257364004D3B11/$FILE/Visu.html)



- maintaining the working area in a proper state of cleanliness (vacuum cleaner fitted with a high efficiency particulate air (HEPA) filter, wet cleaning).

Material cutting operations should be avoided, for example by using ready-to-lay or pre-cut sections. Use of less dangerous materials should also be preferred and ASW/RCFs fibres should be used only when they are technically essential and cannot be substituted – particularly above 1,100°C.

Wearing personal protective equipment may complement collective prevention measures. Respiratory protection can range from a FFP2-type disposable filtering half-mask for short, low-exposure interventions involving non-carcinogenic fibres to a compressed air line breathing apparatus with full face mask for high emission levels of fibres suspected to have carcinogenic effects. Effective measures also include wearing disposable clothing fitted at the neck, wrists and ankles, and wearing protective glasses.

### Research needs

To reduce the negative health effects of existing products, manufacturers are developing new wool types to reduce their biopersistence, which is favourable to worker health and safety. This is also in line with the requirements under EU directives to substitute any fibres with a carcinogenic potential by unclassified substances, if possible and available. However, modification of the fibre composition makes it difficult to obtain epidemiological data on the new fibres [100].

Some fibres are unclassified by the European Union. These have been less studied and there is a need to acquire knowledge of their toxicity. New *in vitro* tests are being finalised to obtain more rapidly discriminating results [118].

While it is acknowledged that the size of the fibres is linked to their harmful toxic effects, standard air sampling methods using phase contrast optical microscopy (PCOM) do not allow the counting of finer size fibres, which are probably the most harmful. In more recent studies, newer methods have been developed to predict fibrous aerosol size fractions generated during glass wool fibre production. These could be used to size-adjust historical fibre concentration measurements for use in epidemiologic studies of respiratory disease [97].

In November 2005, the IARC conducted an evaluation of mineral and organic fibres. However, the results had not been published at the time of the drafting this report.

#### 4.2.4. Dermal exposure leading to skin diseases

Skin and inhalation exposure represent the main pathways of occupational exposure to dangerous substances. In EU Member States – as well as in many other developed countries – occupational skin diseases are second in the ranking of occupational diseases following musculoskeletal disorders (MSDs). According to the European Occupational Diseases Statistics (EODS) from Eurostat [119], skin diseases accounted for 13.6% (7,377 cases) of all occupational diseases in 2003 in the 11 Member States participating in the data collection <sup>(61)</sup>. Contact dermatitis had the highest incidence rate (8.3 per 100,000 workers) [119] [120].

These statistical data must be treated with caution for several reasons:

- not all EU countries were included in the data collection;

*Some fibres are unclassified by the European Union. These have been less studied and there is a need to acquire knowledge of their toxicity.*

*While it is acknowledged that the size of the fibres is linked to their harmful toxic effects, standard air sampling methods do not allow the counting of finer size fibres, which are probably the most harmful.*

*In EU Member States occupational skin diseases are second in the ranking of occupational diseases.*

<sup>(61)</sup> Belgium, Denmark, Spain, Italy, Luxembourg, the Netherlands, Austria, Portugal, Finland, Sweden and the United Kingdom



*At a European level, skin diseases represent between 10% and 40% of recognised occupational diseases. Chemicals are responsible for 80–90% of skin diseases.*

- there is no standard definition of skin diseases and the way occupational skin diseases are defined in several Member States is not the same;
- these figures correspond only to the skin diseases reported and recognised as occupational but do not include work-related skin diseases not included in the official list of occupational diseases.

As a consequence, these figures are underestimates. Nevertheless, they provide some indication of the extent of the problem. At a European level, skin diseases represent between 10% and 40% of recognised occupational diseases [121] [122]. Chemicals are responsible for 80–90% of skin diseases [123], though biological and physical agents must also be included as causative factors.

Although Occupational Exposure Levels (OELs) are available with regard to the inhalation of airborne dangerous substances and can be used as guidance for risk assessment, the lack of a ‘dermal OEL’ to chemical agents often impedes employers selecting adequate control measures for dermal exposure. The lack of a ‘dermal OEL’ is a consequence of a meagre toxicological database for skin effects – as well as for other health effects – resulting from dermal exposure. In particular, toxicological data on the effects of repeated exposure are lacking.

*The lack of ‘dermal OELs’ is a consequence of a meagre toxicological database for health effects from dermal exposure.*

The Organisation for Economic Co-operation and Development (OECD) guidelines on skin irritation, skin sensitisation and corrosivity of substances can be used to derive a classification and labelling, but give only poor information about the health effects of exposure under working conditions at specific workplaces. The effects of occupational dermal exposure to diluted preparations and co-exposure to other chemicals or physical factors such as humidity cannot usually be assessed in a quantitative way with sufficient certainty. A further point hindering the quantitative risk assessment of skin effects as a result of dermal exposure are the uncertainties related to the quantification of the level of dermal exposure itself. For a long time, the estimates of exposed surface of the body and the amount of substance were very vague.

*The uncertainties about the quantification of the level of dermal exposure hinder the quantitative risk assessment of skin effects.*

The comprehensive data that have been collected in the field of occupational dermatology and the increased rate of occupational skin diseases reveal that occupational dermal exposure leading to skin disease is an issue of major concern. New developments are described below and core literature is cited. The effects on inner organs as a consequence of skin exposure are not part of the literature survey and, indeed, the respective risk assessment is complicated due to the poor information on skin penetration of substances under workplace conditions. Biomonitoring is an appropriate way of considering systemic effects after dermal exposure, but it is rarely performed and very few valid data are available.

#### **Toxicity testing, exposure and risk assessment**

Some development can be observed in new OECD guidelines relevant to dermal toxicity testing. New tests – a transcutaneous electrical resistance test (TER) and a human skin model test – have been validated [124] and accepted for routine examination of a corrosive property of a substance [125] [126]. A test on phototoxicity has also been accepted [127]. In addition, the local lymph node assay, which is able to detect quantitative differences in the potency of a skin sensitiser, has been validated [128] [129] [130] [131] [132] [133] [134] [135] and accepted as an OECD



*“Be careful – Dangerous substances”, Artist: Igor Banaszewski, Monika Wojtaszek. Courtesy of the Occupational Safety Poster Competition organised by the Central Institute for Labour Protection – National Research Institute, Poland.*



guideline [136]. A further step towards *in vitro* testing – a cell-based assay for assessing the skin sensitisation potential of chemicals – has been proposed [137]. All these tests contribute to reducing animal testing by applying *in vitro* techniques.

Much qualitative and quantitative information was gathered about dermal exposure conditions during a comprehensive European research project called RISKOFDERM. Determinants of dermal exposure such as ‘task done by the worker’ or ‘exposure control measure’ [138] as well as default dermal exposure values – particularly useful to small and medium enterprises (SMEs) – were defined [139]. Furthermore the available exposure information was classified [140] and integrated into a risk assessment toolkit, which is under further development [141] [142] [143].

The control banding approach of COSHH (Control of Substances Hazardous to Health) Essentials – a database which provides advice on controlling the use of chemicals for a range of common tasks such as mixing or drying – has been extended to dermal exposure [144]. A number of reviews have been published dealing with dermal exposure assessment [145] [146] [147] [148] [149]. However, better guidance from regulatory agencies directed at performance-based control of occupational skin hazards is needed [150].

### Occupational dermatology

Skin diseases are among the main occupational diseases in many industrial countries. In Germany, 16,165 suspected cases of occupational skin disease (OSD) were recorded in 2004. This constitutes 25% of all registered occupational diseases and, in 8,500 cases, the occupational origin was confirmed. More than 90% of the occupational skin disorders are hand eczema (allergic or irritative contact eczema or combination of both, forming a two-phase eczema) [151]. Other work-related skin diseases include contact urticaria, photodermatitis, contact leukoderma (Vitiligo), infectious dermatitis and skin cancer, as well as chemical burns ranging from rash through blister to full-thickness skin damage requiring grafts.

Not only the skin of the hands but also of other body parts can be affected in the case of indirect exposure of the skin with airborne substances (e.g. face, neck) or when contaminated hands touch other body parts (e.g. hand-to-face contact). Face, eyelids and neck dermatitis may be due to volatile epoxy resins (see Section 4.2.2.), fumes and airborne dusts (e.g. wood dust). The face and other uncovered areas are also the site of photodermatitis caused, for example, by plants (Ragweed, Compositae, Umbelliferae) or photoallergic substances such as phenothiazines, coal tar derivatives and Olaquinox. Farmworkers are the most likely group to be at risk of phytophotodermatitis and photoallergic dermatitis by Olaquinox. Connubial or consort contact dermatitis (e. g. due to fibreglass dust or owing to hair dyes and cosmetics) may also occur. A German (North Bavarian) study investigated dermatitis in many professions [152] [153] [154].

There are two different kinds of skin sensitisers:

- chemicals, (e.g. chromium, nickel, cobalt, resins and plastics, formaldehyde and other disinfectants and preservatives, dyes, rubber chemicals, and fragrances);
- proteins from natural materials, (e. g. natural rubber latex, animal proteins, plants, foodstuffs and enzymes).

Moreover, occupational acne can be caused by petroleum and coal tar products or by halogenated aromatic hydrocarbons (chloracne) [155] [156].

The actual incidence of work-related hand eczema is probably underreported [157].

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*More than 90% of the occupational skin disorders are hand eczema (allergic and/or irritative contact eczema).*

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*Not only the skin of the hands but also of other body parts can be affected in the case of indirect exposure of the skin with airborne substances (e.g. face, neck) or when contaminated hands touch other body parts.*

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Chromium in cement, courtesy of ILO.

### Identification of extrinsic risk factors

Frequent and prolonged exposure to weak skin irritants such as water and detergents has been identified as a risk resulting in high prevalence of occupational irritant contact dermatitis in wet work occupations (e. g. healthcare workers, hairdressers, cleaners, food handlers) [158] [159]. The German Code of Practice, TRGS 531 and TRGS 530, describes protection measures for wet work. Wearing moisture-resistant protective gloves also results in a wet atmosphere for the hands and the duration of wearing gloves therefore has

to be limited. The maximum continual time for wearing gloves should not exceed four hours [160].

Investigations in the German and British construction industry have shown that chromate is still the most important allergen, followed by epoxy resins and cobalt [161], [162]. In Germany, tile setters and terrazzo workers have an incidence of occupational hand eczema of 19.9 per 10,000 employees [161]. In Scandinavian countries, the prevalence of dichromate sensitisation declined as a consequence of the reduction of chromium (VI) levels in cement [163]. Since 2003, the use of cement with high contents of chromium (VI) has been restricted by an amendment to Directive 76/769/EEC.

Natural rubber protein (latex) is another main occupational allergen, particularly for healthcare workers with a history of atopy [164] [165] [166]. Multiple immunoglobulin-E-binding proteins in natural latex, which may be inhaled with cornstarch particles from powdered gloves [167], have been identified as the cause. In Germany, powdered latex gloves have not been considered to be state-of-the-art since 1998 [160].

In some cases, the risk from wearing gloves (allergens, occlusion, wet work) may outweigh the risk of not wearing gloves [168] [169]. It is often not clear how protective a glove is under working conditions since permeation testing does not consider parameters such as elevated temperature, flexing or pressure. In addition, the wet atmosphere inside the glove can evoke skin diseases [170].

The most frequent adverse reactions from wearing gloves are irritant contact dermatitis and allergic reactions (e.g. immunological contact urticaria in reaction to latex proteins or allergic contact dermatitis to rubber accelerators [165]) rhinitis and asthma [167]. The introduction of powder-free, low-allergen or synthetic gloves has been shown to significantly reduce the risk of sensitisation for healthcare workers [171] [172] [173].

In addition, any solvent can cause dermatitis by removing the surface lipids and dissolving the natural protective barrier of the skin. Indeed, an important function of the stratum corneum is to serve as a barrier and thus provide protection from the penetration of allergens, irritants, micro-organisms and loss of water. When the skin is dried and fissured, it is most likely to be affected by contact dermatitis or infections when immersing the hands in water, washing them with soap, or using detergents or solvents without adequate protection such as solvent-proof rubber gloves or solvent-resistant protective creams. Clothing on which solvent has been spilled should be removed as soon as possible to avoid any contact with the skin [174] [175] [176].

A growing number of allergic diseases resulting from dermal exposure to fragrances have been observed in recent years. In a multi-factorial analysis of health surveillance

*In some cases, the risk from wearing gloves may outweigh the risk of not wearing gloves.*

*Any solvent can cause dermatitis by removing the surface lipids and dissolving the natural protective barrier of the skin.*

*A growing number of allergic diseases resulting from dermal exposure to fragrances have been observed in recent years.*





data, the highest occupational risk of allergies from exposure to fragrances was observed among masseurs, physiotherapists and geriatric nurses [177].

### Prevention

Prevention of hand dermatitis can be achieved by reducing risk factors by:

- substituting with less dangerous substances;
- introducing closed systems or automation in industrial procedures to avoid exposure situations;
- reducing the amount of wet work.

Beyond this, skin care programmes which include skin protection, skin cleaning and skin care should be introduced with suitable instruction and information to workers. The benefit of skin care programmes has been demonstrated [178] [179] [180] [181].

Directive 89/656/EEC requires personal protective equipment to be assessed before its selection and use [169] [178] [182] [183]. The efficacy of barrier creams, together with regular training and awareness-raising of workers at risk, has been positively evaluated [184] [185] [186].



"Your skin, the most important 2 square meters in your life", Courtesy the skin protection campaign "Hautschutz Kampagne" of the Deutsche Gesetzliche Unfallversicherung (DGUV), Germany

#### 4.2.5. Dangerous substances in waste treatment

The amount of waste generated in the EU is growing [187]. In the 1990s, a number of EU governments adopted new waste management policies with the primary aim of decreasing the volume of waste sent to landfill and increasing the quantity of waste recycled. The EU Landfill Directive [188] requires that, no later than 2016, 'municipal waste going to landfills must be reduced to 30% of the total amount (by weight) of biodegradable municipal waste produced in 1995 or the latest year before 1995 for which standardised Eurostat data is available'. As a consequence, the recycling industry is a relatively new but expanding business, and the number of workers involved in waste treatment will continue to increase steadily [189] [190].

The lack of statistics available on this sector makes it difficult to describe it in terms of:

- numbers of workers and companies;
- specific indicators for occupational accidents and diseases.

In France, for example, it is estimated – probably underestimated – that around 100,000 workers are employed in a sector related to waste management, with about half of these involved in the collection and treatment of domestic waste [191]. In the UK, it is estimated that around 160,000 workers are employed in the waste industry, but with many more employed in other activities associated with specific recyclables and ancillary activities such as transportation.

Recent research estimates that around 45,000 new jobs could be created by 2010 [189] [192]. According to Eurostat, the recycling and water supply sector (NACE

*The amount of waste generated in the EU is growing. The recycling industry is a relatively new but expanding business, and the number of workers involved in waste treatment will continue to increase steadily.*



*The legislation related to waste was developed primarily for environmental purposes and thus does not integrate OSH aspects appropriately.*

*The HSE's Horizon Scanning expects an increase in the recycling of car components, plastics and electronic products, which could impact on the health and safety of operators and the public.*

*Workers in waste treatment activities may be exposed to complex mixtures of aerosols, bioaerosols and volatile organic compounds (VOCs).*

*Occupational health problems relevant to the work environment in waste treatment plants arise from the occurrence of dust, gases and VOCs.*

Divisions 37 and 41) generated EUR 24.0 billion of added value within the EU-25 in 2003, and employed some 400,000 people [193]. Between 2000 and 2005, recycling saw its output expand at an average annual rate of 4.0% – far ahead of the industrial average of 0.7% over the same period and the fastest growing industrial NACE division. This performance was confirmed by the employment index which grew by 4.5% per annum over the 10 years to 2005 and was, by far, the sector with the fastest growth rate [194].

The legislation related to waste was developed primarily for environmental purposes and thus does not integrate OSH aspects appropriately [191]. Indeed, in some cases, new waste handling and treating technologies have even increased risks for workers involved in waste collection, sorting, treatment and disposal activities [195]. Recycling is one of the new and changing occupational risks identified by Horizon Scanning<sup>(62)</sup> of the UK Health and Safety Executive (HSE) [196].

Municipal waste accounts for a relatively small proportion of total waste (around 15%), with the largest volume of waste being generated by mining, manufacturing, construction and demolition activities. Hazardous waste is mainly generated within the manufacturing sector [187]. The HSE's Horizon Scanning expects an increase in the recycling of car components, plastics and electronic products, which could impact on the health and safety of operators and the public [196].

Management of solid waste includes a multitude of activities such as [195] [197]:

- collection;
- reception;
- sorting;
- recycling of materials;
- biological treatment of organic material (e.g. composting);
- thermal treatment (including incineration with energy recovery);
- landfill.

Although the amount of landfilling is declining, it is still the most important type of waste treatment; in 2004 the amount of waste landfilled was over 2.5 times greater than the amount incinerated [187].

Workers in waste treatment activities may be exposed to complex mixtures of aerosols, bioaerosols and volatile organic compounds (VOCs); synergistic interactions among the agents may therefore be of importance [190]. The handling of medical waste presents extra challenges such as the risk of contamination with sharps [198] [199].

With regard to emerging chemical risks, the number of epidemiological studies on jobs related to waste treatment is scarce. This is in line with the fact that it is a recent activity from the point of view of generally accepted epidemiological criteria. This epidemiological gap is particularly important as far as the exposure to dioxins and furans from incineration processes is concerned.

### **Workers and workplaces most at risk**

Occupational health problems relevant to the work environment in waste treatment plants arise from the occurrence of dust, gases and VOCs. In incineration processes, the pollutants most often detected are dioxins and furans [200] [201] [202] [203] [204] [205].

<sup>(62)</sup> <http://www.hse.gov.uk/horizons/index.htm>



Workers facing major risks are those involved in the collection, processing and recycling of waste, especially those engaged in domestic waste collection or working at landfills, incinerators, resource recovery facilities and compost plants. These risks are considered below.

### Collection of domestic waste

The highest exposure level was found during the operation of loading of waste into compaction vehicles [206] [207].

### Landfills

All areas of the workplaces are potentially exposed to VOCs [190] [208].

### Incinerators

Maintenance of furnaces, electric dust collectors and wet scrubbers are the areas where workers have the highest potential exposure to dioxins [205].

### Resource recovery facilities

The maximum exposure to VOCs was observed in the waste processing room (manual sorting) [208].

### Compost plants

The work tasks with the high exposure levels in compost facilities are [190] [210] [211] [212]:

- loading waste;
- mill outlet;
- control room;
- stirring, pile creation and agitation;
- shedding;
- airing and feeding;
- hand-loading of compost;
- digging waste;
- turning compost;
- shaking conveyor (outdoor compost plants);
- loading containers from conveyor (pre- and post- composting);
- dismantling compost pile (indoor compost plants).



Recyclable waste sorting, INSHT, Spain.

### Exposure to chemical substances

A number of publications report VOC emissions during waste collection [206] [213], at compost plants [210] [211] [212] [214] [215] [216] [217], from landfills and at resource recovery facilities [208].

These VOCs are both inherent to the waste itself and produced by the micro-organisms present in the waste and degrading the organic material. Up to 110 organic compounds have been identified from windrow composting [213] [214]. Typical VOCs found in composting plants are:

*VOCs are both inherent to the waste itself and produced by the micro-organisms present in the waste and degrading the organic material. Up to 110 organic compounds have been identified from windrow composting.*



- carboxylic acids (e.g. acetic acid [190]) and their esters;
- some alcohols, ketones, aldehydes and terpenes [213] [216];
- trichloroethane;
- toluene, tetrachloroethylene and *p*-xylene [211];
- $\alpha$ -limonene [190] [211];
- dimethyl sulphide and siloxane [190];
- other hydrocarbons [190] [213].

Among 13 aromatic VOCs found during the composting of the organic fraction of municipal solid wastes, the highest levels have been found for toluene, ethylbenzene, 1,4-dichlorobenzene, *p*-isopropyl-toluene and naphthalene [215]. However, these levels were always lower than the OELs [210] [211] [213] [216].

During the first two weeks of storage of biodegradable domestic waste, up to 5.0 mg/m<sup>3</sup> methanol, 4.2 mg/m<sup>3</sup> ammonia and 2.8 mg/m<sup>3</sup> hydrogen sulphide have been measured [190]. Most VOCs are given off early during the composting process and their production rates decrease with time at thermophilic temperatures [211] [215].

The primary health hazards in landfill sites have been identified as methane gas and carbon dioxide produced from the waste. Landfill workers are also potentially exposed to high levels of dusts containing micro-organisms which can be spread during the dumping or moving of waste [192].

High airborne dust concentrations have also been found at waste collection sites (mean 7.7 mg/m<sup>3</sup>) and at composting units (mean 4.6 mg/m<sup>3</sup>) [206].

The health hazards to incinerator workers generally relate to the effects of dust inhalation and exposure to chemicals [218]. Acids such as nitrous oxide and sulphur dioxide have been found in the air at incineration plants [192]. In addition, polychlorinated dibenzo-*p*-dioxins (PCDDs, dioxins) and polychlorinated dibenzofurans (PCDFs, furans) have been detected during the incineration of both municipal solid waste and industrial waste [204]. PCDDs, PCDFs and polychlorinated biphenyls (PCBs) – as well as other toxic air pollutants – may be produced when:

- wastes are incinerated at temperatures below 800°C;
- incomplete combustion occurs (i.e. wastes are not completely incinerated);
- plastics containing polyvinyl chloride (PVC) are incinerated.

There has been growing controversy in recent years over the incineration of waste and particularly healthcare waste; the incineration of, for example, blood bags and fluid bags is a source of dioxins and furans [219]. The evaluation of occupational exposure to dioxins and furans in incineration plants is common practice and both types of chemicals are often detected [200] [201] [204]. Blood concentrations of PCDDs and PCDFs in incinerator workers can be significant [202] [205].

Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) [220] and Directive 2002/96/EC on waste electrical and electronic equipment (WEEE) [221] aim to tackle the rapid increase in WEEE. Increased recycling of electrical and electronic equipment is meant to limit the total quantity of waste going to final disposal. The directives make producers responsible for taking back and recycling their electrical and electronic equipment. Consumers are thus able to return their discarded equipment free of charge. This measure is meant to encourage producers to design electrical and electronic equipment in an environmentally more efficient way, which takes waste management aspects fully into account. In addition, and in order to prevent the generation of hazardous waste, the RoHS Directive requires the substitution of various heavy metals (lead, mercury,

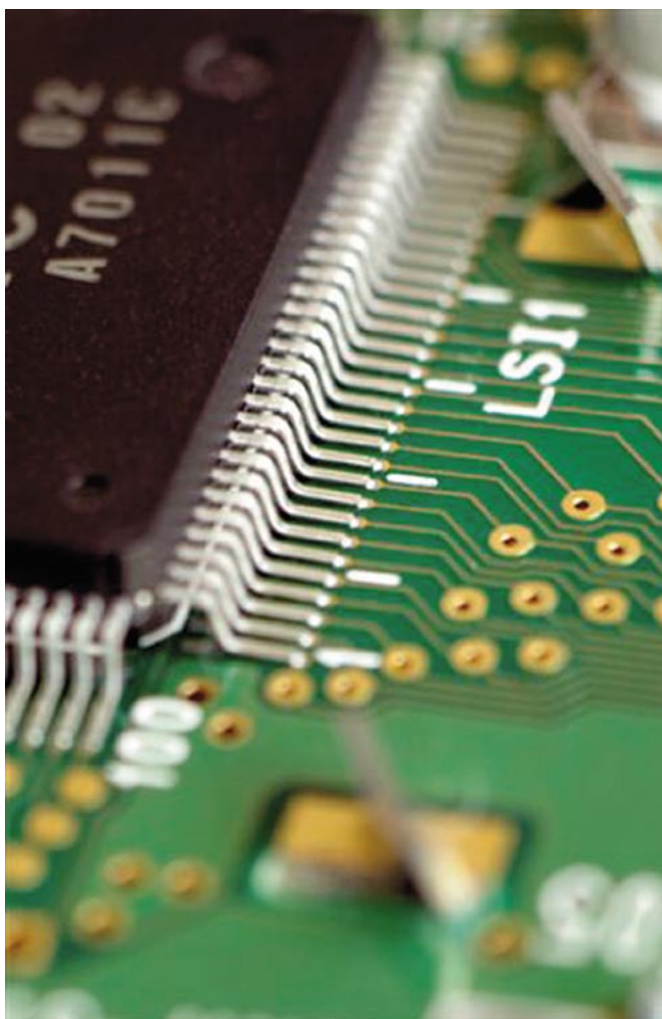


cadmium and hexavalent chromium) and brominated flame retardants – polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE) – in new electrical and electronic equipment put on the market after 1 July 2006 [222].

However, there are still concerns that WEEE and end-of-life vehicles (ELVs) being handled and disposed of contain hazardous materials which could pose health risks to the workers involved. For example [196]:

- CRT-based monitors and televisions contain significant quantities of lead and other hazardous compounds from their phosphor screens;
- personal computers can contain a variety of toxic metals including cadmium and mercury, together with PCBs;
- recycling batteries can lead to workers' exposure to lead, mercury, nickel and cadmium;
- fluorescent light fittings contain mercury (an estimated 4 tonnes/year are disposed of via landfill in the UK).

A French study characterised the potential chemical risks in the treatment of car waste, WEEE, industrial packaging, toxic waste in dispersed quantities (TWDQ), and feather and down [223]. Chemical agents were identified and estimations of potentially exposed workers calculated. The results show an important exposure to an inhalable dust composed of complex mixtures of metallic compounds, the synergetic effects of which are unknown (Table 6). Most treatment processes included at least one manual operation both before and after the waste crushing operation. During these operations, workers may be exposed to dangerous substances via dermal contact or via inhalation of airborne substances such as liquid waste vapours or solid waste dust. The activities where the potential exposure seems to be highest are the dismantling of ELVs and the gathering of TWDQ, which are both manual operations. In both cases, the hazardous wastes to which workers may be exposed are liquids, some of which are volatile. As for WEEE, it is unlikely to be possible to cope with the increasing amount of material to be dismantled using manual operations and the necessary mechanisation of waste treatment is likely to modify worker exposure to chemical agents in this sector [223].



*Increasing quantities of electronic equipment are recycled.*



**Table 6: Potential exposure depending on the type of waste treated in France (adapted from [223])**

Type of waste treated	Number of workers potentially exposed	Chemicals to which workers may be exposed	Intensity of potential exposure
Dismantling of ELVs	<20,000	Sulphuric acid PAH Benzene Hydrocarbons Heavy metals Asbestos	High
Gathering of TWDQ	< 1,000	Solvents Paints Pharmaceuticals Phytosanitary products	High
Recycling of industrial packaging	849	Chemicals contained in packaging Cleaning solvents Particles of paints Vapours of solvents contained in paints	Medium
Crushing of scrap ELVs	2,000	Metals Textile fibres Plastics Rubber Hydrocarbons	Medium
Recycling of tyres	< 160	Aromatic compounds Ketones Styrene Benzothiazole PAH	Medium
Treatment of oil filters	< 10	Oil mist Benzene PAH Phenols Phthalates	Medium
Treatment of cathode tubes	80	Metals Luminophore	Medium
Treatment of electronic cards	40	Precious metals Beryllium Lead	Medium
Preparation of feather and down	< 1,000	Dust Pathogen agents	Medium
Dismantling of WEEE	1,700	Metals Carbon black	Low
Treatment of cables	< 100	Aluminium Copper Plastics	Low

According to another recent study on carcinogenic, mutagenic and reprotoxic (CMR) substances in waste in France [224], over 73% of hazardous waste arising in 2004 (representing more than five million tonnes) came from six of the categories defined in the Waste Statistics Regulation [225]:

- wood wastes (2.47 million tonnes);
- slags and ashes from thermal treatments and combustion (1.352 million tonnes);



- chemical deposits and residues (880,000 tonnes);
- used oils (647,000 tonnes);
- chemical preparation wastes (624,000 tonnes);
- and spent solvents (505,000 tonnes).

The 17 CMR substances most commonly found were [224]:

- benzene
- toluene
- dichloromethane
- tetrachloroethylene
- formaldehyde
- polycyclic aromatic hydrocarbons (PAHs)
- dimethylformamide (DMF)
- chromium (VI)
- trichloroethylene
- lead and its compounds
- dichloroethane
- polychlorinated biphenyls (PCBs)
- phthalates
- cadmium
- arsenic and its compounds
- butadiene
- dimethylacetamide.

The presence of CMR substances for which OELs are available (e.g. lead) should encourage employers to monitor exposure levels at the workplace and to implement adapted prevention measures [223].

### Health effects

The health outcomes depend on the type of exposure. An increased incidence of upper airway inflammation and respiratory symptoms has been found in waste collectors. Exposure to organic dust probably underlies the inflammation mediated by neutrophils that result in respiratory symptoms [226]. Exposure to dust (organic dust) is associated with [208] [214] [227]:

- eye irritation;
- frequent respiratory tract infections;
- infections of the lungs;
- Organic Dust Toxic Syndrome (ODTS) characterised by cough, chest tightness, dyspnoea, influenza-like symptoms such as chills, fever, muscle ache, joint pain, fatigue and headache.

Primary health effects due to VOCs were not presumable, but unpleasant odour may cause secondary symptoms such as nausea and hypersensitivity reactions [212] [216]. Some sulphur-containing VOCs could contribute to the reported gastrointestinal problems of collection workers [207] [213]. A mixture of VOCs with a total of 25 mg/m<sup>3</sup> hydrocarbons has been found to cause irritations in the upper respiratory tract and inflammatory responses in the upper airways [212].

An increase of blood cadmium concentrations was noted in refuse handling workers in Denmark compared with controls. However, this increase was low enough so as not to cause any health effects on the workers [228]. High levels of arsenic were detected in the urine and hair of Mexican landfill workers, but no patterns of adverse effects were found [229].

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*An increased incidence of upper airway inflammation and respiratory symptoms has been found in waste collectors.*

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*Long-term, low-level exposure of humans to dioxins and furans may lead to impairment of the immune system and impairment of the development of the nervous system, endocrine system and reproductive functions.*

Workers at waste disposal sites in Mexico exhibited a significant increase in the frequencies of chromosomal aberrations [209]. The results of cytogenetic investigations on employees of two waste disposal sites in Germany confirmed a genotoxic hazardous potential. A highly significant increase of the frequencies of chromosomal aberrations was detected, particularly in dicentric chromosomes and acentric fragments [230].

Lung impairment has been identified in incineration workers compared with non-exposed workers, thus indicating likely obstructive disorders [231]. Skin irritation and coughs were more frequent in the exposed workers [232]. In addition, incineration plant workers were found to show a significant increase in urinary mutagenicity using the Ames assay with *Salmonella typhimurium* TA 100 with and without metabolic activation S9 [233].

With regard to the exposure of incinerator workers to dioxins and furans, there is evidence that long-term, low-level exposure of humans to dioxins and furans may lead to impairment of the immune system and impairment of the development of the nervous system, endocrine system and reproductive functions [219]. Short-term, high-level exposure may result in skin lesions and altered liver function. Exposure of animals to dioxins has resulted in several types of cancer.

The International Agency for Research on Cancer (IARC) classifies dioxins as a 'known human carcinogen'. However, most of the evidence documenting the toxicity of dioxins and furans is based on studies of populations exposed to high concentrations of dioxins either occupationally or through industrial accidents. There is insufficient evidence to prove that chronic low-level exposure to dioxins and furans causes cancer in humans. It has not yet been possible to estimate the worldwide burden of mortality and morbidity from exposure to dioxins and furans. The exposure and risk assessment still has many uncertainties and the data gaps are very large. In addition, the types of health effects that may result (e.g. cancer, impaired immune function) would show up only after long exposure periods and would be difficult to measure [219].

The World Health Organization (WHO) has established a Provisional Tolerable Monthly Intake (PTMI) for dioxins, furans and PCBs of 70 picograms per kilogram of body weight. The PTMI is an estimate of the amount of chemical per month that can be ingested over a lifetime without appreciable health risk. However, WHO has not established limits for emissions, which must be set within the national context. Some countries have defined emission limits, ranging from 0.1 ng TEQ/m<sup>3</sup> (Toxicity Equivalence) in Europe to 0.1–5 ng TEQ/m<sup>3</sup> in Japan, according to incinerator capacity [219]. The presence of dioxin in serum falls after the end of occupational dioxin exposure [203].

Despite a number of papers showing significant associations between waste incineration and lower male-to-female ratio, twinning, lung and laryngeal cancer and ischemic heart disease, other studies found no significant effects on respiratory symptoms, pulmonary function, twinning, cleft lip and palate, lung, laryngeal and oesophageal cancer. More hypothesis-testing epidemiologic studies are needed to clarify the potential effects of waste incineration on incineration workers [234].

### **Preventive measures**

Prevention should be adapted to the specificities of each waste sector and activities characterised by [191]:

- 'multi-task' workers often involved in several different activities – hence a multiple exposure;
- small enterprises often employing low skill and poorly trained workers;
- poor knowledge/complexity of the waste entering the treatment process;





- waste-related technologies and processes in permanent evolution;
- waste treatment activities often taking place in longstanding facilities in which it may be difficult to implement collective protection measures.

While it is not possible to completely eliminate the risks inherent to waste-related activities, the most efficient prevention measure is to reduce the generation of dust, bioaerosols and VOCs in the workplace [235] [236]. A number of Member States have already developed preventive measures including:

- replacement of manual sorting with, for example, mechanical pre-sorting;
- installation of sorting cabins with proper ventilation;
- local exhaust ventilation for sorting lines;
- closed vehicles equipped with air filters;
- use of adequate protective clothing including proper gloves.

Hygiene plans, regular cleaning and decontamination measures have also contributed to a considerable reduction in the exposure of workers [195].

A number of prevention and protection measures are described in the literature [206] [208] [210] [215] [216] [227] [235] [236] [237]. Priority is given to collective prevention measures rather than to personal protection measures:

### Technical protective measures

Reduction of dust in the workplace by means of local exhaust as well as general ventilation is needed. Closed cabins with controlled ventilation providing well-filtered air should be used in bulldozers, lorries and cranes. High-level maintenance of the ventilation systems is also a requirement [227].

Proper optimisation of the composting process, in addition to gas treatment units such as biofiltration, can help to reduce VOC emission levels and the offensive odours commonly found in facilities composting municipal solid waste [206]. Biofiltration has been found to reduce the concentration of ammonia, dimethyl disulfide, formic acid, acetic acid and sulphur dioxide (or carbonyl sulphide) by 99, 90, 32, 100, 34 and 100%, respectively [238]. The offensive odour was found to be caused by low molecular weight carboxylic acids. Adding wood chips, increasing turning frequency at the beginning of composting and constructing smaller windrows could solve the problems [214].

Even in high-temperature incinerators (>800°C), temperatures are not uniform and dioxins and furans can form in cooler pockets or during start-up or shutdown periods. Optimisation of the incineration process can reduce the formation of these substances by, for example, ensuring that incineration takes place only at temperatures above 800°C, and that flue gas temperatures in the range 250°C to 450°C are avoided. In the last 10 years, stricter emission standards for dioxins and furans in many countries have significantly reduced the release of these substances into the environment. In several European countries where tight emissions restrictions were adopted in the late 1980s, dioxin and furan concentrations in many types of food have fallen sharply [219].

### Work organisation

Organisational measures intended to reduce the number of exposed workers to an operational minimum by limiting the access to dust generation areas to the minimal

*While it is not possible to completely eliminate the risks inherent to waste-related activities, the most efficient prevention measure is to reduce the generation of dust, bioaerosols and VOCs in the workplace.*



By courtesy of INSHT, Spain.



required workers are highly pertinent as part of a general risk reduction policy [216] [239].

Regular information and training for workers is essential [208]. This also plays a crucial role in promoting safe working habits. For example, workers should be made aware of the importance of spending the minimum time in hazardous areas such as the composting hall [216] [239]. Programmes of medical monitoring and health surveillance should also be implemented insofar as chronic health effects and injuries are to be prevented [227].

### Hygienic measures

Cleaning must be considered an integral part of operations and should be carried out properly in order to minimise dust generation. Workplaces should be designed with easy-to-clean surfaces.

Eye, nose and mouth contact with unwashed hands should be avoided. Hands should be washed at the end of a shift, and before eating or drinking. Proper washroom facilities with specific washing products, including eye wash, should also be provided. Specific clothes, cap and footwear should be used during work and taken off when leaving the working area.

Regular cleaning and changing of working and protective clothes has to be scheduled. Workers should keep specific protective clothing apart from private clothes. Eating, drinking or smoking at the workplace should be avoided and clean, separated storage facilities for food and drinks should be provided [208] [210].

### Personal protective equipment

The use of personal protective equipment and clothing exchange after the work shift are vital and must be emphasised to workers.

Appropriate gloves to protect from dermal chemical contact, as well as specific masks FFP2 or FFP3 <sup>(63)</sup> against dust and VOCs, and goggles should be used [206] [216] [240].

## 4.2.6. Poor control of chemical risks in small and medium enterprises

Chemical agents are found in nearly all workplaces from farms and factories to hairdressers and car repair garages. They may be dangerous to human health and also to the environment. On the other hand, chemicals offer benefits that are indispensable to modern society, for example in food production, medicines, textiles and cars. They also make a vital contribution to the economic and social wellbeing of people in terms of trade and employment.

In 2001, the global production of chemicals was some 400 million tonnes and about 100,000 different substances were registered in the EU market [241].

Micro-, small- and medium-size enterprises (SMEs) are socially and economically important, representing 99.8% of all enterprises in EU-25 in 2003. They employ 66% of Europe's private sector workforce; 91.5% of these enterprises are micro (<9 workers), 7.3% are small (10–49 workers) and about 1% are medium size (50–249 workers) [246].

*SMEs represented 99.8% of all enterprises in EU-25 in 2003. They employ 66% of Europe's private sector workforce.*

<sup>(63)</sup> FFP = filtering face piece. FFP masks are available in three classes P1, P2 and P3 providing differing protection factors levels (efficiency: low, med, high). The classification of available filtering half masks is carried out according to European Norms (EN149).



Unfortunately, their situation with respect to OSH is worse than larger enterprises; 82% of all reported occupational injuries occur in SMEs [242] [243] [244] [245] [246]. In addition, the fatal accident rate in companies with less than 50 workers is around double that of larger companies [247].

The main reasons for less favourable OSH conditions in SMEs are [247]:

- lack of knowledge concerning occupational risks and the applicable regulations;
- lack of time and resources;
- absence of contact with representatives of OSH organisations and the labour inspectorate – or a certain suspicion regarding these bodies;
- absence of internal consultation structures;
- poor appreciation of the cost of an occupational injury or occupational disease;
- lack of information and training provided to workers.

In France, only 20% of workers in micro- and small enterprises declared in 2005 that they had received either OSH information or training compared with twice as many in many large companies of more than 1,000 workers [248].

Recent studies also indicate an increasing interdependency between enterprises, putting greater pressure on subcontractors and companies – often SMEs – to be productive [249]. This includes a tendency to outsource sometimes high-risk tasks to the increasing number of SMEs in the service sector. Larger companies are usually more able to organise an OSH infrastructure than the smaller ones. In addition, the existing infrastructure has difficulties in getting through to self-employed individuals [247].

In general, the involvement of SMEs in the prevention of occupational risks and the improvement of working conditions remains weak. The owner/manager of an SME plays a key role in determining the priority for implementing controls for hazardous substances [247] [250].

### **Chemicals in SMEs**

The chemical industry is Europe's third largest manufacturing industry. It employs 1.7 million people directly and up to three million indirectly – including the further processing or use of chemicals, for example, in the metal industry, food industry, cleaning activities, etc. [241].

However, exposure to dangerous chemicals may occur not only in chemical manufacturing SMEs but also in many workplaces outside the chemical industry where chemicals are further processed or used, or where they are by-products of work (e.g. wood dust in construction industry, VOCs in waste treatment).

There is little literature dealing specifically with workers' exposure to chemicals in SMEs, but workers may be exposed to dangerous substances in [244] [251] [252] [253] [254] [255] [256] [257] [258]:

- cleaning and disinfection services
- construction
- galvanisation
- health service activities
- hairdressing salons
- laundry services
- leather
- manufacture of metal construction elements
- manufacture of pottery, glass and fibreglass products

*82% of all reported occupational injuries occur in SMEs, and the fatal accident rate in companies with less than 50 workers is around double that of larger companies.*

*Exposure to dangerous chemicals may occur not only in chemical manufacturing SMEs but also in many workplaces outside the chemical industry where chemicals are further processed or used, or where they are by-products of work.*





- manufacture of pulp, paper and board
- manufacture of rubber and plastic items
- textiles
- transport
- waste disposal
- woodworking
- car repair, service station and car painting.

Construction workers are commonly exposed to numerous dangerous substances such as asbestos, solvents, paints, glue, epoxy resins, isocyanates, silica dust and other carcinogenic agents [259] [260] (see also Section 4.1.). Studies of furniture enterprises demonstrate higher exposure to wood dust and organic solvents in small factories than in larger ones [261]. Workers involved in

electroplating, vulcanisation, rubber and plastic processing, as well as manufacturing metal components are exposed to highly dangerous substances including carcinogenic and mutagenic compounds. For example, several studies have reported that workers in electroplating SMEs may be exposed both to chromium and nickel compounds, which are classified as carcinogens category 1 (confirmed human carcinogen), as well as to other chemical compounds such as mineral acids and organic solvents. Moreover, it has been found that chromium platers in SMEs are at increased risk of lung cancer, respiratory irritation and sensitisation, contact dermatitis and kidney damage [252].

### *Problems in controlling chemical risks in SMEs*

Although there is some information available on dangerous substances in the workplace, there is a complete lack of overview for particular work activities [262].

The Organisation for Economic Co-operation and Development (OECD) has attempted to draw up emission scenario documents (ESDs) describing the sources, production processes, pathways and use patterns of chemicals with the aim of quantifying the emissions of a chemical into the air and helping in the risk assessment [263]. Nevertheless, the exposure situations of workers who handle the substances in the workplace are often under-represented in this kind of research [258]. Moreover, exposure to dangerous substances in the workplace is difficult to assess – whether in SMEs or in larger companies – because workers are often exposed not to one single substance but to a mixture of substances, and because exposure routes might be multiple and difficult to determine (e.g. via inhalation, skin or eye contact).

While employers have to assess any risk to the safety and health of workers arising from any hazardous chemical agents present at the workplace, many SMEs experience difficulties in complying with this obligation [247]. SMEs have particular difficulty in implementing complex technical legislation as they often have only limited technical



expertise and often lack a dedicated OSH professional. Simple guidance is therefore needed to assist in the process of risk assessment and control [242].

In 2003, a UK study demonstrated that only 12% of EU enterprises complied with their regulatory duties in risk prevention with regard to dangerous substances according to EU Directive 98/24/EC and national regulations [264]. Only 1% of all companies measure exposure levels to dangerous substances [265]. This is all the more true for SMEs. SMEs lack the knowledge required to identify chemical risk and to choose and implement preventive measures for workers against hazardous substances [242] [251] [252] [266] [267] [268].

In France, an inspection campaign run in 2006 and focusing on carcinogenic, mutagenic and reprotoxic (CMR) substances revealed that only 40% of companies using such substances had assessed the risks linked to these substances – even though carrying out a risk assessment is compulsory. The proportion that had assessed the risks of CMR substances increased significantly with the size of the company [269]:

- 20% of micro-enterprises;
- 38% of small companies;
- 57% of companies with 40–199 workers;
- 67% of companies with more than 200 workers.

In 2005, a project undertaken for the Office of the Australian Safety and Compensation Council [250] attempted to determine the barriers, enablers and motivators in SMEs to control the following 10 hazardous substances selected by stakeholders:

- isocyanates
- welding fumes
- cytotoxic drugs
- styrene
- chromium (VI) compounds
- methyl bromide
- wood dust
- trichloroethylene
- silica dust
- methyl methacrylate and acrylates in general.

A total of 91 workplaces were surveyed. The findings revealed that elimination or substitution of the hazardous substance could have been considered by a greater number of SMEs. The reason given for a SME selecting a particular hazardous substance was usually that the substance and process were those normally used in the industry. Less than a quarter of the businesses surveyed had considered elimination of the substance. Most SMEs were aware of the hazard associated with the hazardous substance they were using but often only in very general terms. Both managers and workers placed emphasis on the immediate injuries arising from chemicals because they were less aware of the long-term or chronic health effects. There was a high level of acceptance of the risk of hazardous substances as being part of the job, partly because of the belief that an SME could not necessarily do a lot to eliminate or reduce the risk.

Less than half of SMEs had installed local exhaust ventilation which, in many cases, was insufficient or ineffective. One of the reasons was a lack of understanding of what constitutes a 'well-ventilated space' and an effective local exhaust ventilation. Personal protective equipment (PPE) was provided by 80% of the SMEs surveyed but there were many examples of incorrect PPE being supplied. There was also an excessive dependency on PPE in 30% of the SMEs surveyed. Monitoring of hazardous substances had been undertaken in only 46% of cases but did not take in consideration workers' exposure in many cases.

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*In France, only 40% of companies using CMRs assessed the risks linked to these substances, although compulsory (2006).*

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*Less than a quarter of the businesses surveyed had considered elimination of the substance.*

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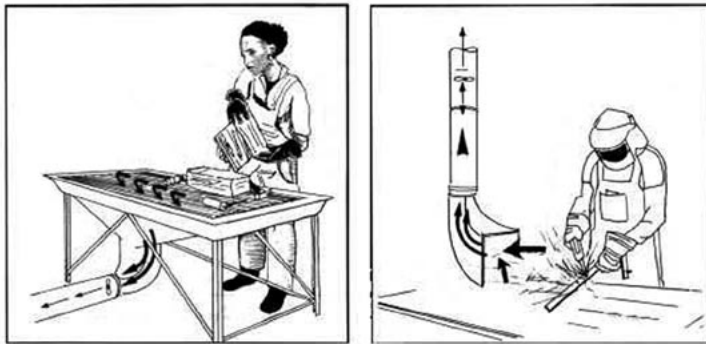


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*There was an excessive dependency on PPE in 30% of the SMEs surveyed.*

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Here are two methods of local ventilation. On the left, the contaminants are drawn into the work table before they can reach the breathing zone of the worker. On the right, fumes from welding are drawn into an exhaust system

Courtesy of ILO.

The cost of implementing controls was cited as a barrier by more than half of the businesses surveyed. About three-quarters of SMEs said they were familiar with the relevant regulations but most of them had only a limited understanding of the details. Larger SMEs were more likely to have assigned responsibility for day-to-day management of occupational safety and health to a manager, supervisor or occupational safety and health co-ordinator. They were also more likely to have undertaken risk assessments,

developed safe operating procedures and to have effective supervision of occupational safety and health requirements. Smaller SMEs frequently had an ad hoc OSH management framework or none at all. Only three-quarters of businesses provided their workers with information and training on the hazardous substance being used. Less than two-thirds of businesses consulted with workers about the implementation of controls for the hazardous substance and less than half had elected health and safety representatives.

*SMEs lack the simplified, validated and appropriate tools to make a thorough evaluation of chemical risks.*

In particular, SMEs lack the simplified, validated and appropriate tools to make a thorough evaluation of chemical risks [242] [251] [252] [266] [267] [268] [270] [271] [272] [273]. They need ready-made tools for identifying and mapping out the various risks [247] [275] [276].

In the UK [242][274], the Health and Safety Executive (HSE) discovered that, in spite of introducing the Control of Substances Hazardous to Health (COSHH) Regulations and Occupational Exposure Limits (OELs), very few SMEs knew about COSHH but relied heavily on label information and product safety sheets. It was also shown that SMEs see the distinctions government makes between health, safety and environment as irrelevant to them; what they want is to know exactly how to control chemicals so as to meet all regulatory requirements. To address this need, HSE developed 'COSHH Essentials' – an interactive website that takes users through a number of easy steps and provides integrated guidance for SMEs on controlling health, safety and environmental risks from chemicals.

Further tools have been developed in some Member States to assist SMEs in their risk assessment. For example BGIA in Germany has produced The Column Model [277] – an aid to risk identification and to substitution. The Instituto Nacional de Seguridad e Higiene en el Trabajo [278] in Spain provides guidance on the evaluation of conditions of work in SMEs. The simplified methodologies for assessing the risk of exposure to hazardous chemical agents are based on three variables [272] [273] [274] [277] [278]:

- intrinsic hazard of the substance (defined by R-phrases <sup>(64)</sup>);
- tendency to pass into the environment (e.g. volatility or tendency to form dust);
- quantity of substance used in each operation.

<sup>(64)</sup> Risk-phrases – referred to as R-phrases – are warning sentences by which producers have to label products containing dangerous substances. R-phrases indicate the specific danger of the product to health or the environment. They are stated in EU as well as in national chemical legislation. European Commission, COM(98)745 final. Brussels, 1998



A number of helpful checklists are also available [279] [280] [281] [282] [283].

Although many organisations have developed easy-to-use instruments based on a stepwise approach to the assessment of chemical risks, a number of issues still remain to be addressed. Among others, these tools should be shared among Member States and made available to SMEs in national language versions [284]. Moreover, in order to bring about changes in attitude and improved safety outcomes, it is essential to use a range of interventions with owners of SMEs that are aimed at reinforcing the belief that occupational safety and health is important [250].

### *Protecting workers*

SMEs can find many recommendations for choosing and implementing preventive measures against workers' exposure to hazardous chemical agents in the literature [272] [279] [280] [285] [286] [287].

However, the choice of preventive measures should be based on the results of chemical risk assessment and should follow the general principles for the prevention of OSH risks and the hierarchy of prevention measures laid down in the Framework Directive 89/391/EEC [288] and refined for the protection of workers from the risks related to chemical agents by Directive 98/24/EC [289]:

- substitution and elimination of hazardous substances and processes;
- design of appropriate work processes and engineering controls, and use of adequate equipment and materials, to avoid or minimise the release of dangerous substances to the workplace;
- application of collective protection measures at the source of the risk, giving the priority to technical measures such as adequate ventilation, and appropriate organisational measures (e.g. reducing the number of workers exposed to the minimum operational, reducing the duration of exposure to a minimum [272]);
- use of individual protection measures including personal protective equipment (e.g. respiratory protection equipment, gloves [278]) where exposure cannot be prevented or reduced to a minimum acceptable by other means.

While large and innovative companies in the main recognise occupational safety and health management not just as a cost, but also as a benefit, assistance to SMEs for matters of occupational health and safety is a challenging task. The challenge is also to make occupational safety and health a benefit for them [247]. The Agency's European Campaign 2008-2009 will be focused on risk assessment. Helpful information and material on the assessment of dangerous substances and for SMEs will be produced and made available on the Agency's website <sup>(65)</sup>.

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*The choice of preventive measures should be based on the results of chemical risk assessment and should follow the general principles laid down in the Framework Directive 89/391/EEC, and refined by Directive 98/24/EC.*

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*Helpful information and material on the assessment of dangerous substances and for SMEs are available on the Agency's website.*

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<sup>(65)</sup> <http://osha.europa.eu/en/campaigns/hw2008>

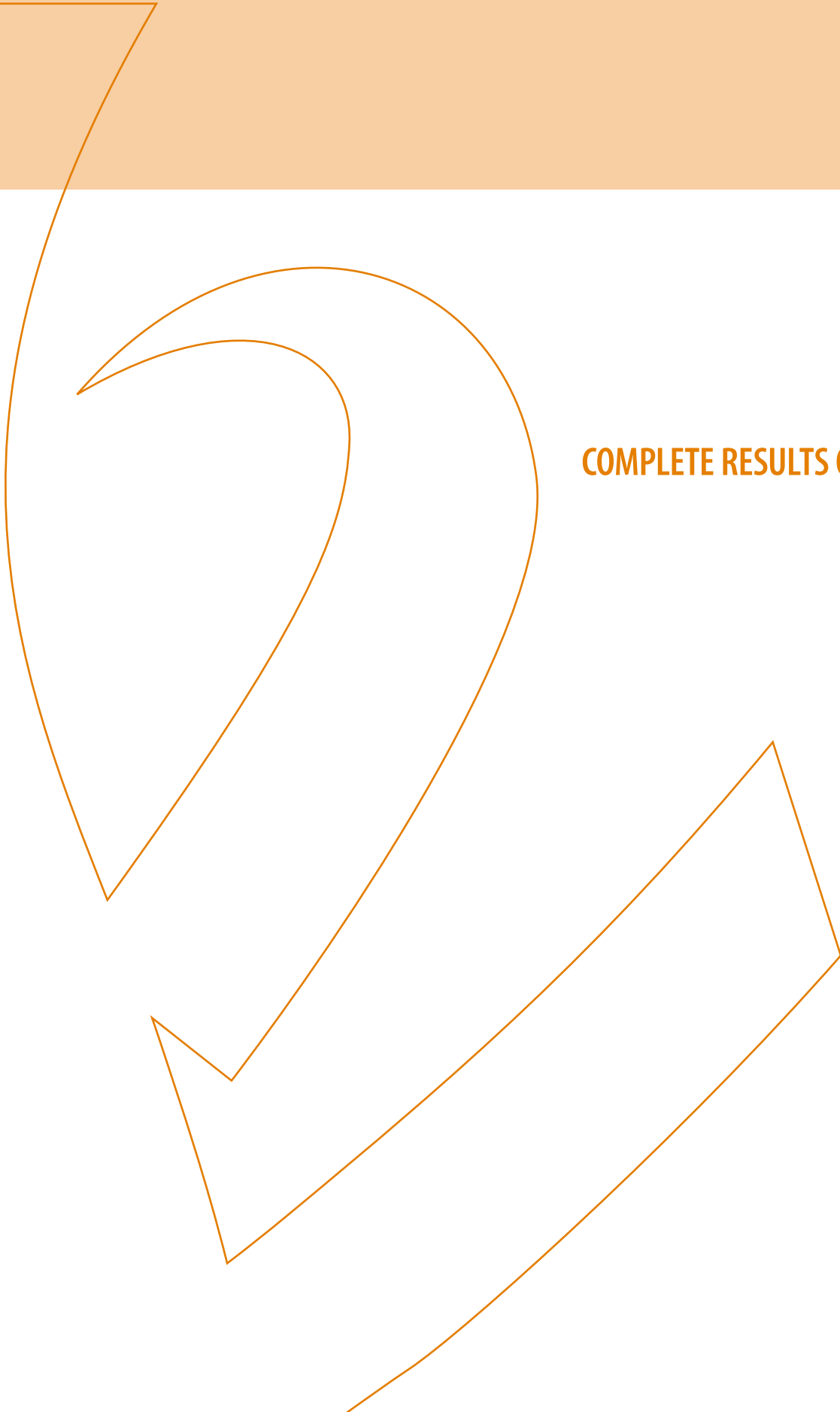


European Agency for Safety and Health at Work

*EUROPEAN RISK OBSERVATORY REPORT*

# 5.

**COMPLETE RESULTS OF THE SURVEY**



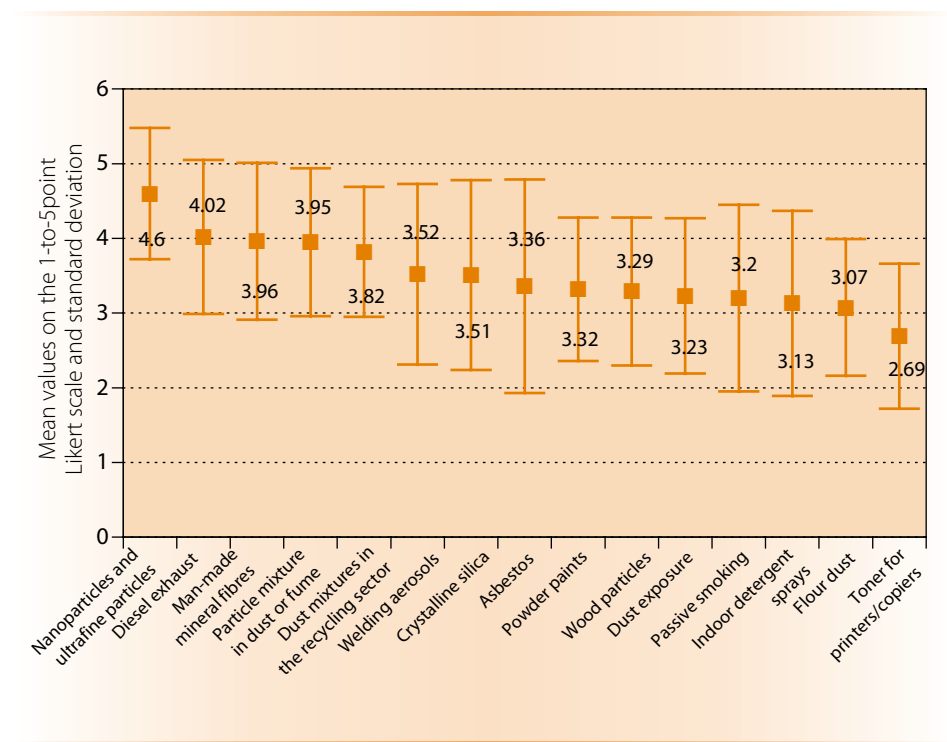


In the following sections, the exact descriptions of the risks rated by the experts are listed in tables together with the number of respondents, the mean value (MV) of the ratings and the standard deviation (SD). These figures are also compiled in diagrams. When available, the comments added by the respondents to the items are listed to provide some context and support to the ratings.

# 5.1. PARTICLES, DUSTS AND AEROSOLS

Diagram 6 summarises the risk rating by the survey respondents for particles, dusts and aerosols.

**Diagram 6: Chemical risks due to particles, dusts and aerosols identified in the survey**



Among the 15 items related to particles, dusts and aerosols mentioned by the respondents:

- two are strongly agreed as emerging risks (MV > 4);
- eight as emerging (3.25 < MV ≤ 4);
- four as undecided (2.75 ≤ MV ≤ 3.25);
- one as not emerging (2 ≤ MV < 2.75).

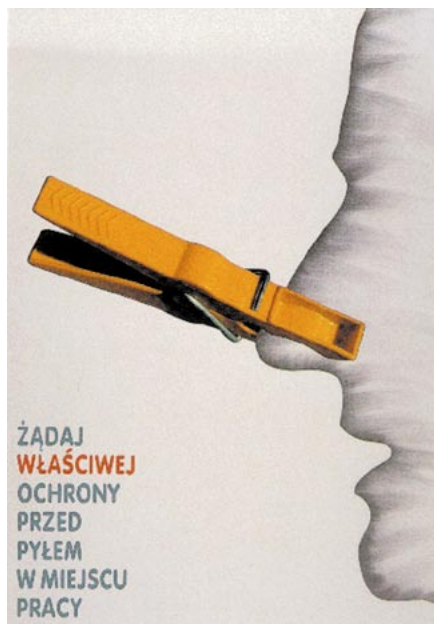


According to the Fourth European Working Conditions Survey <sup>(66)</sup>, 19.1% of the EU-27 workforce reported in 2005 that they 'breathe in smoke, fumes, powders or dust'.

The risks posed by '**nanoparticles and ultrafine particles**' are by far the strongest agreed as emerging risks by the experts, with an acceptable degree of consensus among the respondents (SD=0.876). Nanoparticles and ultrafine particles have also been identified as one of the main occupational safety and health priorities in a review of various national, EU and international resources carried out by the Agency to identify future EU research needs in the field of occupational safety and health <sup>(67)</sup>. In addition, in 2005, the Agency organised the first seminar of the series 'Promoting occupational safety and health research in the EU' where the results of the expert forecast on emerging risks as well as the occupational safety and health priority review report were discussed with representatives from:

- major European occupational safety and health research institutes
- UNICE
- ILO
- Research DG
- Employment, Social Affairs and Equal Opportunities DG
- the Agency.

19.1% of the EU-27 workforce reported in 2005 that they 'breathe in smoke, fumes, powders or dust.'



'Adequate protection needed against dust', Artist: Witold Kubicha. Courtesy of the Occupational Safety Poster Competition organised by the Central Institute for Labour Protection – National Research Institute, Poland

'Nanoparticles and ultrafine particles' were included in the summary list of top occupational safety and health research priorities drawn up at the seminar and consolidated in a broader consultation process among the Agency's stakeholders. More information on nanoparticles is available in Section 4.2.1.

Diesel exhaust (MV=4.02), crystalline silica (MV=3.51), asbestos (MV=3.36) and wood dust (MV=3.29) were all identified as emerging risks in this forecast and also figure among the main carcinogens identified in the CAREX database <sup>(68)</sup>. According to CAREX, 32 million workers (23% of the workforce) were exposed to 139 carcinogens (this includes all agents in IARC Groups 1 and 2A, and selected agents in Group 2B of in the EU-15 in 1990-1993). The most common exposures were:

<sup>(66)</sup> Parent-Thirion, A., Fernández Macías, E., Hurley, J., Vermeylen, G., *Fourth European Working Conditions Survey*, European Foundation for the Improvement of Living and Working Conditions, Luxembourg, 2007. <http://eurofound.europa.eu/pubdocs/2006/98/en/2/ef0698en.pdf>

<sup>(67)</sup> European Agency for Safety and Health at Work, *Priorities for occupational safety and health research in the EU-25*, Office for Official Publications of the European Communities, Luxembourg, 2005. <http://osha.europa.eu/en/publications/reports/6805648/view>

<sup>(68)</sup> Kauppinen, T. et al., *CAREX – International Information System on Occupational Exposure to Carcinogens. Occupational exposures to carcinogens in the European Union in 1990-1993*, Finnish Institute of Occupational Health, Helsinki, 1998. [http://www.ttl.fi/NR/rdonlyres/4444380F-B1FB-4D01-A974-0B6A9E663CFA/0/1\\_description\\_and\\_summary\\_of\\_results.pdf](http://www.ttl.fi/NR/rdonlyres/4444380F-B1FB-4D01-A974-0B6A9E663CFA/0/1_description_and_summary_of_results.pdf)



- solar radiation (9.1 million workers exposed at least 75% of working time);
- environmental tobacco smoke (7.5 million workers exposed at least 75% of working time);
- crystalline silica (3.2 million exposed);
- diesel exhaust (3.1 million);
- radon (2.7 million);
- wood dust (2.6 million).

In France, the results of the SUMER survey 2003 also indicate that diesel exhaust, crystalline silica, asbestos and wood dust are among the main occupational carcinogens. About two-thirds of the occupational exposures to carcinogenic chemicals were linked to eight substances and substance groups which include mineral oils, benzene, tetrachloroethylene and trichloroethylene, as well as asbestos, wood dust, diesel exhaust and crystalline silica; 2,260,000 workers (13.5% of the workforce) were exposed to these eight products <sup>(69)</sup>.

*The International Agency for Research on Cancer has classified diesel engine exhaust as 'probably carcinogenic to humans'.*

*A positive association between diesel exhaust emissions and lung cancer is suspected but is still controversial. A link with non-cancer damage to the lung has been found.*

Exposure to '**diesel exhaust**' is the second most emerging risk highlighted in the forecast (MV=4.02). Hazardous levels of diesel exhaust can be found in occupations ranging from mining to driving diesel-fuelled trucks or forklifts.

Diesel exhaust is made up of a complex mixture of thousands of gases, vapours, and fine particles; its the major components are carbon dioxide, carbon monoxide, nitrogen dioxide, nitric oxide, particulate matter and sulphur dioxide <sup>(70)</sup>. The International Agency for Research on Cancer has classified diesel engine exhaust as 'probably carcinogenic to humans' (Group 2A) <sup>(71)</sup>. More specifically with regard to lung cancer, a positive association between diesel exhaust emissions and lung cancer is suspected but is still controversial, and many aspects of this complex topic remain unclear <sup>(72)</sup>. In addition to cancer, a link between emissions from diesel-fuelled engines and non-cancer damage to the lung has been found <sup>(73)</sup>.

In order to reduce occupational exposure to diesel exhaust, companies should increase the use of:

- modern, low emission engines;
- low sulphur fuel;
- appropriate exhaust after-treatment devices such as filters and oxidation catalysts;
- ventilation;
- closed, environmentally conditioned cabs.

<sup>(69)</sup> Ministère de l'emploi, de la cohésion sociale et du logement, DARES, *Huit produits cancérigènes parmi les plus fréquents*, Premières Synthèses Informations, Annex 28.1, July 2005. [http://www.travail.gouv.fr/IMG/pdf/publication\\_pips\\_annexe\\_200507\\_n-28-1\\_huit-produits-cancerogenes.pdf](http://www.travail.gouv.fr/IMG/pdf/publication_pips_annexe_200507_n-28-1_huit-produits-cancerogenes.pdf)

<sup>(70)</sup> US Department of Labor, Occupational Safety and Health Administration, *Partial list of chemicals associated with diesel exhaust*. <http://www.osha.gov/SLTC/dieselexhaust/chemical.html>

<sup>(71)</sup> International Agency for Research on Cancer (IARC) and World Health Organization (WHO), *Diesel and gasoline engine exhausts and some nitroarenes. Overall evaluations of carcinogenicity to humans*, Volume 46, IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, IARC and WHO, Lyon, 1989. <http://monographs.iarc.fr/ENG/Monographs/vol46/volume46.pdf>

<sup>(72)</sup> Nold, A., Bochmann, F., *Epidemiological results on diesel exhaust and lung cancer: a synopsis*, *Gefahrstoffe Reinhaltung der Luft*, Vol. 59, No. 7/8, 1999, pp. 289-298.

<sup>(73)</sup> California Environmental Protection Agency, Air Resources Board, *The toxic air contaminant identification process: toxic air contaminant emissions from diesel-fueled engines*, Factsheet, Air Resources Board, Sacramento, CA, 1998. <http://www.arb.ca.gov/toxics/dieseltac/factsht1.pdf>



Diesel engines should be appropriately operated and maintained <sup>(74)</sup>. Additional information and research are needed on methods to monitor diesel particulates and to determine the level of risk from such particulates.

Occupational exposure to **'man-made mineral fibres'** (MV=3.96) is explored in more depth in this report through a literature review (see Section 4.2.3.).

The issue of **combined exposures to multiple risk factors** was highlighted as an emerging risk in several items of the four expert forecasts on emerging physical, psychosocial, biological and chemical risks. In this survey on chemical risks, the respondents highlighted as emerging risks the combined exposure to different types of particles, and more particularly together with gaseous substances (MV=3.95); they mentioned the example of welding fumes. Welding aerosols were also emphasised as emerging risks in a separate item (MV=3.52).

With regard to the item 'dust mixtures in the recycling sector' (MV=3.82), occupational exposure to **'dangerous substances in the waste treatment'** sector is mentioned in another item 'strongly agreed as an emerging risk' in the survey, i.e. 'Exposure to dangerous substances in the treatment of domestic, clinical and industrial waste' (MV=4.11). In addition, the same issue with a specific mention of biological agents in waste treatment activities was rated as an 'emerging risk' (MV=3.89) in a similar expert survey on emerging biological risks <sup>(75)</sup>.

**'Crystalline silica'** (MV=3.51) is abundant in nature. It constitutes about 12% of the Earth's crust and is also contained naturally in other minerals and mineral products. In the industry, two forms of crystalline silica – quartz and cristobalite – are intensively used in the form of sand, which is a granular material, or of silica flours, which consist of particles finer than 0.1 mm.

Crystalline silica and materials or products containing crystalline silica are used across many industries such as extractive, cement, foundry, glass, ceramic, industrial minerals, mineral wool, natural stone, mortar, pre-cast concrete and metalliferous minerals, chemicals, construction, cosmetics, detergents, electronics, metal and engineering, and pharmaceutical. They are also found in coatings including paint and are used as filtration media in several applications <sup>(76)</sup>.

In 1997, the IARC classified occupational exposure to crystalline silica as a Group 1 human lung carcinogen <sup>(77)</sup>. However, IARC recognised the lack of consistency and noted that the carcinogenicity of crystalline silica 'may be dependent on inherent characteristics of the crystalline silica or on external factors affecting its biologic activity'. Crystalline silica is not classified as carcinogen under European legislation. The European Chemical Bureau (ECB) last addressed the issue of crystalline silica in

*Combined exposures to multiple risk factors was highlighted as an emerging risk in several items of the four expert forecasts on emerging physical, psychosocial, biological and chemical risks.*

*In 1997, the IARC classified occupational exposure to crystalline silica as a Group 1 human lung carcinogen.*

<sup>(74)</sup> US Department of Labor, Mine Safety and Health Administration, *Practical ways to reduce exposure to diesel exhaust in mining – a toolbox*, <http://www.msha.gov/S&HINFO/TOOLBOX/DTBFINAL.HTM>

<sup>(75)</sup> European Agency for Safety and Health at Work, *Expert forecast on emerging biological risks related to occupational safety and health at work*, Office for Official Publications of the European Communities, Luxembourg, 2007. [http://riskobservatory.osha.europa.eu/risks/forecasts/biological\\_risks/](http://riskobservatory.osha.europa.eu/risks/forecasts/biological_risks/)

<sup>(76)</sup> European Network on Silica, *Agreement on workers health protection through the good handling and use of crystalline silica and products containing it*. <http://www.nepsi.eu/agreement.aspx>

<sup>(77)</sup> International Agency for Research on Cancer (IARC) and World Health Organization (WHO), *Silica and some silicates*, IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans, Volume 68, IARC and WHO, Lyon, 1997. <http://monographs.iarc.fr/ENG/Monographs/vol68/volume68.pdf>



1998 <sup>(78)</sup> and decided that crystalline silica was not to be regarded as a priority for classification under Annex 1 of Directive 67/548/EEC. However, the European Commission's Scientific Committee for Occupational Exposure Limits (SCOEL) <sup>(79)</sup> concluded in 2003:

'that the main effect in humans of the inhalation of respirable crystalline silica is silicosis. There is sufficient information to conclude that the relative lung cancer risk is increased in persons with silicosis [...]. Therefore, preventing the onset of silicosis will also reduce the cancer risk. Since a clear threshold for silicosis development cannot be identified, any reduction of exposure will reduce the risk of silicosis'.

*Silicosis is an irreversible, but preventable, disease.*

Silicosis is an irreversible, but preventable, disease where scar tissue develops in the lungs and reduces the ability to extract oxygen from the air. However, a review of epidemiological investigations on silica exposure in 2005 concluded that the carcinogenic role of silica *per se* in the absence of silicosis is still unclear <sup>(80)</sup>. The dose-effect relationship and causality are still unclear and need more research <sup>(81)(82)(83)</sup>, but a number of recent studies have shown strong evidence for a causal association between crystalline silica exposure and risk of lung cancer <sup>(84)(85)(86)(87)</sup>.

*Lung cancer is one of the three main occupationally-induced cancers. 24% of deaths due to lung/bronchial cancers are attributable to work exposure.*

Lung cancer is one of the three main occupationally-induced cancers. Of deaths due to lung/bronchial cancers, 2.7% are estimated to be attributable to occupational exposure to crystalline silica in men and 0.2% in women; in total, 24% of deaths due to lung/bronchial cancers are attributable to work exposure. In addition, 100% of pneumoconiosis (called silicosis when silica-induced) is attributable to occupational

<sup>(78)</sup> European Chemicals Bureau (ECB), *Summary record. Meeting of the Commission Working Group on the Classification and Labelling of Dangerous Substances, held Ispra, 7–9 October 1998*, ECBI/55/98 – Rev. 2, ECB, Ispra, 1999. [http://ecb.jrc.it/documents/Classification-Labelling/ADOPTED\\_SUMMARY\\_RECORDS/5598r2\\_cmr1098.pdf](http://ecb.jrc.it/documents/Classification-Labelling/ADOPTED_SUMMARY_RECORDS/5598r2_cmr1098.pdf)

<sup>(79)</sup> Scientific Committee for Occupational Exposure Limits (SCOEL), *SUM Doc 94-final on respirable crystalline silica*, June 2003.

<sup>(80)</sup> Pelucchi, C., Pira, E., Piolatto, G., Coggiola, M., Carta, P., La Vecchia, C. *Occupational silica exposure and lung cancer risk: a review of epidemiological studies 1996-2005*, *Annals of Oncology*, Vol. 17, No. 7, 2006, pp. 1039-1050.

<sup>(81)</sup> Peretz, A., Checkoway, H., Kaufman, J.D., Trajber, I., Lerman, Y., *Silica, silicosis and lung cancer*, *Israeli Medical Association Journal*, Vol. 8, No. 2, 2006, 114-118.

<sup>(82)</sup> Cocco, P., Dosemeci, M., Rice, C., *Lung cancer among silica-exposed workers: the quest for truth between chance and necessity*, *La Medicina del Lavoro*, Vol. 98, No. 1, 2007, pp. 3-17.

<sup>(83)</sup> Bellia, M., Ferrara, A., Bellia, S., Serafino, L., Milana, F., Farruggia, E., [Silica carcinogenicity: description of a clinical case]. *La Medicina del Lavoro*, Vol. 98, No. 4, 2007, pp. 312-319.

<sup>(84)</sup> Cassidy, A., 't Mannetje, A., van Tongeren, M., Field, J.K., Zaridze, D., Szeszenia-Dabrowska, N., Rudnai, P., Lissowska, J., Fabianova, E., Mates, D., Bencko, V., Foretova, L., Janout, V., Fevotte, J., Fletcher, T., Brennan, P., Boffetta, P., *Occupational exposure to crystalline silica and risk of lung cancer: a multicenter case-control study in Europe*, *Epidemiology*, Vol. 18, No. 1, 2007, pp. 36-43.

<sup>(85)</sup> Pukkala, E., Guo, J., Kyyrönen, P., Lindbohm, M-L., Sallmén, M., Kauppinen, T., *National job-exposure matrix in analyses of census-based estimates of occupational cancer risk*, *Scandinavian Journal of Work, Environment and Health*, Vol. 31, No. 2, 2005, pp. 97-107.

<sup>(86)</sup> Steenland, K., Mannetje, A., Boffetta, P., et al., *Pooled exposure-response analyses and risk assessment for lung cancer in 10 cohorts of silica-exposed workers: an IARC multicentre study*, *Cancer Causes and Controls*, Vol. 12, 2001, pp. 773-784.

<sup>(87)</sup> Stayner, L., *Silica and lung cancer: when is enough evidence enough? Commentary*, *Epidemiology*, Vol. 18, No. 1, 2007, pp. 23-24.



exposures and silica is one of the factors involved <sup>(88)</sup>. The risk of developing lung cancer when exposed to crystalline silica is approximately as high as when exposed to diesel exhaust (i.e. the risk of workers exposed to crystalline silica of having lung cancer increases by 33% compared with the non-exposed population) <sup>(89)</sup>.

According to estimates from CAREX from 1990-1993, crystalline silica was the third most common carcinogen in the workplace in the EU-15 after solar radiation and tobacco smoke, with 3.2 million workers exposed at least 75% of their working time <sup>(90)</sup>. National estimates are available for 19 EU Member States <sup>(91)</sup>.

A more recent survey (SUMER survey) carried out in France indicates that 1.5% of the workforce was exposed to crystalline silica in 2003 – mainly male workers (95%). Crystalline silica was among the main eight occupational carcinogens, which also included mineral oils, benzene, tetrachloroethylene, trichloroethylene, asbestos, wood dust and diesel exhaust <sup>(92)</sup>. According to Spanish data from 2004, 1,223,146 Spanish workers were exposed to crystalline silica in 2004, which was the second most common carcinogen (after solar radiation) <sup>(93)</sup>.

In the EU, mining and construction are the sectors exposing the most workers to crystalline silica: about 23% of workers in the mining sector and 18% in the construction sector. Silica is regarded as the main lung carcinogen in these sectors <sup>(94)</sup>. According to the SUMER survey, the three main sectors in France in 2003 where workers are exposed were (without counting temporary workers):

- construction (102,700 workers exposed, representing 9% of workers in this sector);
- minerals industry (25,900 workers exposed, i.e. 20% of the workers in this sector);
- metallurgical industry (25,400 workers exposed, corresponding to 6% of the workforce in this sector).

Thirty-eight percent of the exposure situations were shorter than two hours a week, while 24% reached over 20 hours a week. The intensity of exposure was regarded as high in 55% of cases. Only in 14% of cases was there a ventilation system at the source of the hazard. Personal protective equipment was provided to 39% of the workers exposed <sup>(92)</sup>. According to a WHO factsheet on silicosis from 2000, it is

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*The risk of developing lung cancer when exposed to crystalline silica is approximately as high as when exposed to diesel exhaust.*

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*In the EU, 23% of workers in the mining sector and 18% in the construction sector are exposed to crystalline silica, the main lung carcinogen in these sectors.*

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<sup>(88)</sup> Nurminen, M., Karjalainen, A., *Epidemiologic estimate of the proportion of fatalities related to occupational factors in Finland*, *Scandinavian Journal of Work, Environment and Health*, Vol. 27, No. 3, 2001, pp. 161-213.

<sup>(89)</sup> Driscoll, T. Nelson, D.I., Steenland, K., Leigh, J., Concha-Barrientos, M., Fingerhut, M., Prüss-Ustün, A., *The global burden of disease due to occupational carcinogens*, *American Journal of Industrial Medicine*, Vol. 48, No. 6, 2005, pp. 419-431.

<sup>(90)</sup> Kauppinen, T. et al., *CAREX – International Information System on Occupational Exposure to Carcinogens. Occupational exposures to carcinogens in the European Union in 1990-1993*, Finnish Institute of Occupational Health, Helsinki, 1998. [http://www.ttl.fi/NR/rdonlyres/4444380F-B1FB-4D01-A974-0B6A9E663CFA/0/1\\_description\\_and\\_summary\\_of\\_results.pdf](http://www.ttl.fi/NR/rdonlyres/4444380F-B1FB-4D01-A974-0B6A9E663CFA/0/1_description_and_summary_of_results.pdf)

<sup>(91)</sup> CAREX database, <http://www.ttl.fi/Internet/English/Organization/Collaboration/CAREX/>

<sup>(92)</sup> Ministère de l'emploi, de la cohésion sociale et du logement, DARES, *Huit produits cancérigènes parmi les plus fréquents*, Premières Synthèses Informations, Annexe 28.1, July 2005. [http://www.travail.gouv.fr/IMG/pdf/publication\\_pips\\_annexe\\_200507\\_n-28-1\\_huit-produits-cancerogenes.pdf](http://www.travail.gouv.fr/IMG/pdf/publication_pips_annexe_200507_n-28-1_huit-produits-cancerogenes.pdf)

<sup>(93)</sup> Draft report of the European Agency for Safety and Health at Work on carcinogens to be published in 2008 (data provided by the Topic Centre Risk Observatory).

<sup>(94)</sup> Driscoll, T. Nelson, D.I., Steenland, K., Leigh, J., Concha-Barrientos, M., Fingerhut, M., Prüss-Ustün, A., *The global burden of disease due to occupational carcinogens*, *American Journal of Industrial Medicine*, Vol. 48, No. 6, 2005, pp. 419-431.





Dust in mines and quarries, INSHT, Spain.

estimated that more than one million workers in the USA are occupationally exposed to free crystalline silica dusts (more than 100,000 of these workers are sandblasters), of whom some 59,000 will eventually develop silicosis<sup>(95)</sup>. It is reported that each year in the USA about 300 people die from silicosis, but the true number is not known. Under-diagnosis and under-reporting are frequent. The statistical and epidemiological data on silicosis are very poor – especially in SMEs and the construction industry, where many workers are not registered.

Respirable quartz levels exceeding 0.1 mg/m<sup>3</sup> have been reported in many

industries worldwide and are most frequently found in<sup>(96)</sup>:

- metal, non-metal and coal mines and mills;
- granite quarrying and processing, crushed stone and related industries;
- foundries;
- ceramics industry;
- construction and sandblasting operations.

The WHO factsheet on silicosis recommends silica-free sandblasting as one measure to reduce exposure to crystalline silica; sandblasting is one of the major, very high exposures<sup>(95)</sup>.

There is currently no Occupational Exposure Limit (OEL) for respirable crystalline silica at an EU level. National OELs have been established in some countries but vary from 0.05 mg/m<sup>3</sup> in, for example, Denmark, Spain, Sweden or Canada (Quebec) to 0.15 mg/m<sup>3</sup> in, for example, Austria and Switzerland (eight hour limit value)<sup>(97)</sup>. In its draft report of 14 September 2007 on the Community Strategy 2007-2012 on health and safety at work<sup>(98)</sup>, the Committee on Employment and Social Affairs of the European Parliament considered the establishment of a Binding Occupational Exposure Limit value (BOELV) for crystalline silica to be a priority in the context of the revision of the Directive

*There is currently no Occupational Exposure Limit (OEL) for respirable crystalline silica at an EU level. National OELs have been established in some countries.*

<sup>(95)</sup> World Health Organization (WHO), *Silicosis*, Factsheet No. 238, WHO, Geneva, 2000. <http://www.who.int/mediacentre/factsheets/fs238/en/>

<sup>(96)</sup> International Agency for Research on Cancer (IARC) and World Health Organization (WHO), *Silica and some silicates*, IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans, Volume 68, IARC and WHO, Lyon, 1997. <http://monographs.iarc.fr/ENG/Monographs/vol68/volume68.pdf>

<sup>(97)</sup> Berufsgenossenschaftliches Institut für Arbeitsschutz (BGI), *GESTIS international limit values for chemical agents – Occupational Exposure Limits (OELs)*. [http://www.hvbg.de/e/bia/gestis/limit\\_values/index.html](http://www.hvbg.de/e/bia/gestis/limit_values/index.html)

<sup>(98)</sup> Committee on Employment and Social Affairs, European Parliament, *Draft report on the Community strategy 2007-2012 on health and safety at work*, Provisional 2007/2146(INI), 14 September 2007. [http://www.europarl.europa.eu/registre/commissions/empl/projet\\_rapport/2007/393990/EMPL\\_PR\(2007\)393990\\_EN.doc](http://www.europarl.europa.eu/registre/commissions/empl/projet_rapport/2007/393990/EMPL_PR(2007)393990_EN.doc)

2004/37/EC<sup>(99)</sup> – the carcinogens directive. However, this proposal was rejected by a vote of the European Parliament in January 2008.

A European multi-sector agreement – the first of its kind – aimed at reducing workers' exposure to crystalline silica dust through good practice in the workplace was signed in 2006 by the social partners (trade unions and employers' representatives) in the presence of the EU Commissioner for Employment, Social Affairs and Equal Opportunities<sup>(100)</sup>. It came into force at the end of 2006 for four years and should be renewed automatically for consecutive two-year periods. The agreement covers more than two million workers in many different sectors across Europe. The fact that the negotiations on the agreement started in September 2005 may have influenced the high average rating given to the item 'crystalline silica' (MV=3.51). However, there was a low level of consensus between the respondents (SD=1.272), which perhaps reflects the conflicting interpretations of 'emerging risk' that the respondents might have had in mind when completing the questionnaire, i.e. 'priority' versus 'new and increasing' risk.

Rated as an emerging risk (MV=3.36) in the forecast more particularly with regard to removal work, '**asbestos**' remains the primary carcinogen in the workplace in many countries. If inhaled, asbestos fibres can have serious health effects, including asbestosis, lung cancer and mesothelioma. These are among the most costly occupational diseases.

There is no known safe exposure level to asbestos; the more one is exposed, the greater the risk of developing an asbestos-related disease. This is why occupational exposure to airborne asbestos fibres should be prevented<sup>(101)</sup>. European legislation has sought to prohibit the use of asbestos and to set strict standards for the protection of workers. Directive 1999/77/EC<sup>(102)</sup> banned all types of utilisation of asbestos from 1 January 2005. In addition, Directive 2003/18/EC<sup>(103)</sup> banned the extraction of asbestos and the manufacture and processing of asbestos products.

This legislation stopped the exposure of the primary users of asbestos-containing products and materials to asbestos. However, exposure to asbestos in the course of removal, demolition, servicing and maintenance activities still occurs. In fact, 600,000

*A European multi-sector agreement – the first of its kind – aimed at reducing workers' exposure to crystalline silica dust through good practice in the workplace was signed in 2006 by the social partners.*

*Exposure to asbestos in the course of removal, demolition, servicing and maintenance activities still occurs.*

*SLIC has published a guide on best practice to prevent or minimise asbestos risks in work that involves (or may involve) asbestos.*

<sup>(99)</sup> Directive 2004/37/EC on the protection of workers from the risks related to exposure to carcinogens or mutagens at work, *Official Journal*, L158, 30 April 2004, p. 50 plus correction in *Official Journal*, L229, 29 June 2004, pp.23-34. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:229:0023:0034:EN:PDF>

<sup>(100)</sup> European Network on Silica, *Agreement on workers health protection through the good handling and use of crystalline silica and products containing it*, <http://www.nepsi.eu/agreement.aspx>

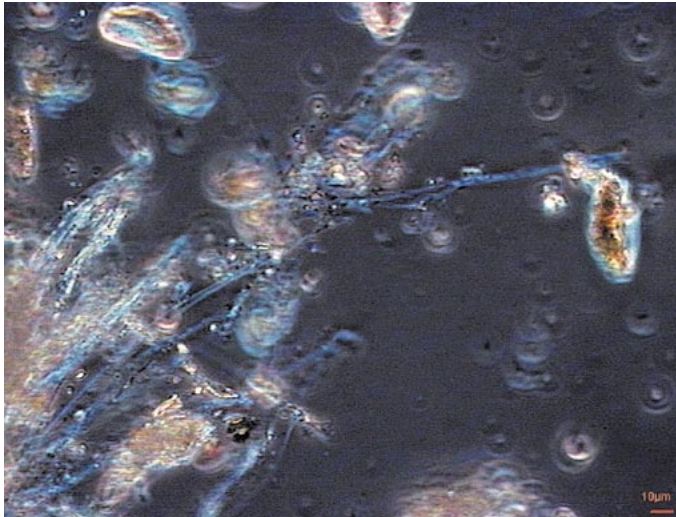
<sup>(101)</sup> European Agency for Safety and Health at Work, *Facts 51: Asbestos in construction*, Factsheet 51, Office for Official Publications of the European Communities, Luxembourg, 2004. <http://osha.europa.eu/en/publications/factsheets/51/view>

<sup>(102)</sup> Commission Directive 1999/77/EC of 26 July 1999 adapting to technical progress for the sixth time Annex I to 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 (asbestos), *Official Journal*, L207, 6 August 1999, pp. 18-20. [http://eur-lex.europa.eu/smartapi/cgi/sga\\_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=EN&numdoc=31999L0077&mode!guichett](http://eur-lex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=EN&numdoc=31999L0077&mode!guichett)

<sup>(103)</sup> 'Directive 2003/18/EC of the European Parliament and of the Council of 27 March 2003 amending Council Directive 83/477/EEC on the protection of workers from the risks related to exposure to asbestos at work', *Official Journal*, L97, 15 April 2003, pp. 48-52. [http://eur-lex.europa.eu/smartapi/cgi/sga\\_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=EN&numdoc=32003L0018&model=guichett](http://eur-lex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=EN&numdoc=32003L0018&model=guichett)







Phase contrast microscopy of chrysotile (white asbestos) from asbestos-cement board (line amplitude ca. 300 micro meters), BGIA, Germany.

*Workers exposed to 'wood particles' may develop irritation and inflammation of the respiratory tract, asthma and cancer (particularly sino-nasal cancer).*

construction workers are still exposed to asbestos each year <sup>(104)</sup>. The Senior Labour Inspectors Committee (SLIC) has published a non-binding practical guide on best practice in order to help employers, workers and labour inspectors to prevent or minimise asbestos risks in work that involves (or may involve) asbestos <sup>(105)</sup>.

Last, but not least, as the time between exposure to asbestos and the first signs of disease can be as much as 30 years, the effects of past exposure are only now apparent. As the use of asbestos increased until the late 1970s in Europe, the annual number of malignant diseases will continue to increase – even in those countries that were first to cease the use of asbestos – and

will only reach its peak around the year 2030 in some Member States <sup>(106)</sup>.

It has been observed that workers exposed to '**wood particles**' – considered an emerging risks by respondents (MV=3.29) – may develop various health disorders, including irritation and inflammation of the respiratory tract, asthma and cancer (particularly sino-nasal cancer). While epidemiological studies of workers exposed to oak and beech dusts have confirmed their carcinogenicity, other types of hardwood dusts are also suspected to cause cancers <sup>(107)</sup>. However, the carcinogenic mechanisms of cancers related to wood dust are still poorly understood and require more investigation. Council Directive 2004/37/EC <sup>(108)</sup> sets an Occupational Exposure Limit (OEL) value of 5mg/m<sup>3</sup> (inhalable fraction) over a reference period of eight hours for all types of hardwood dusts. According to the WOODDEX database <sup>(109)</sup>, about 3.6 million workers in the EU-25 (2% of the active workforce) in 2002-2003 were exposed to inhalable wood dust at work. About 560,000 workers (16% of the exposed) may be exposed to a level exceeding the OEL (5 mg/m<sup>3</sup>) and about 1.5

<sup>(104)</sup> Kauppinen, T. et al., CAREX – International Information System on Occupational Exposure to Carcinogens. Occupational exposures to carcinogens in the European Union in 1990-1993, Finnish Institute of Occupational Health, Helsinki, 1998. [http://www.ttl.fi/NR/rdonlyres/4444380F-B1FB-4D01-A974-0B6A9E663CFA/0/1\\_description\\_and\\_summary\\_of\\_results.pdf](http://www.ttl.fi/NR/rdonlyres/4444380F-B1FB-4D01-A974-0B6A9E663CFA/0/1_description_and_summary_of_results.pdf)

<sup>(105)</sup> Senior Labour Inspectors Committee (SLIC), 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, European Commission, Employment, Social Affairs and Equal Opportunities DG, Brussels, 2006. [http://ec.europa.eu/employment\\_social/health\\_safety/docs/final\\_guide\\_en.pdf](http://ec.europa.eu/employment_social/health_safety/docs/final_guide_en.pdf)

<sup>(106)</sup> European Agency for Safety and Health at Work, SLIC European Asbestos Campaign 2006: Asbestos Deadly Serious – Prevent Exposure! <http://osha.europa.eu/campaigns/asbestos/>

<sup>(107)</sup> EU Fifth Framework Programme, WOOD-RISK. Research project on risk assessment of wood dust: assessment of exposure, health effects and biological mechanisms, Project No. QLK4-2000-00573. <http://www.ttl.fi/NR/rdonlyres/98D74781-98B5-440A-8474-5C3160D58EB8/1983/Woodrisk1.pdf>

<sup>(108)</sup> Directive 2004/37/EC on the protection of workers from the risks related to exposure to carcinogens or mutagens at work, Official Journal, L158, 30 April 2004, p. 50 plus correction in Official Journal, L229, 29 June 2004, pp.23-34. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:229:0023:0034:EN:PDF>

<sup>(109)</sup> Kauppinen, T. et al., Occupational exposure to inhalable wood dust in the Member States of the European Union, Annals of Occupational Hygiene, 2006, Vol. 50, No. 6, pp. 549-561.



million<sup>(110)</sup> (41%) to a level >2 mg/m<sup>3</sup>. The sector distribution of the workers exposed is as follows:

- 1.2 million (33%) in the construction industry – mostly carpenters;
- 700,000 (20%) in the furniture industry;
- 300,000 (9%) in the manufacture of builders' carpentry items;
- 200,000 (5%) in sawmilling;
- 150,000 (4%) in forestry;
- <100,000 in other wood industries.

In addition, 700,000 (20%) were exposed in miscellaneous industries employing carpenters, joiners and other woodworkers. The highest exposure levels were estimated to occur in the construction and furniture industries. Mixed exposure to more than one species of wood and dust from wooden boards was found to be very common, but reliable data on exposure to different species of wood could not be retrieved.

According to a Green Paper published on 30 January 2007 by the European Commission to launch a broad public consultation on the best way to promote smoke-free environments in the EU<sup>(111)</sup>, **'tobacco'** is the single largest cause of avoidable death in the EU. About 650,000 people die each year because of smoking and it is estimated that a further 80,000 people die from passive smoking each year.

Tobacco smoke is a complex toxic mixture of more than 4,000 substances, including poisons such as hydrogen cyanide, ammonia and carbon monoxide, as well as 50 substances proven to be carcinogenic<sup>(112)</sup>. Exposure to tobacco smoke, in general, or in the workplace is proven to substantially increase the risk of lung cancer; for example, workers in catering establishments where smoking is permitted are 50% more likely to develop lung cancer than workers not exposed to tobacco smoke.

While 70% of Europeans are non-smokers, 86% are in favour of a ban on smoking at work, 84% in other public places, 61% in bars and pubs, and 77% in restaurants<sup>(112)</sup>. But, according to the Fourth European Survey on Working Conditions, one in five workers (20%) in 2005 reported being exposed to tobacco smoke from other people in their workplace at least a quarter of the time, and 7% all or nearly all of the time<sup>(113)</sup>.

In the present study, workers' exposure to 'passive tobacco smoke' in the workplace was rated as undecided (MV=3.20). However, the mean value is close to the limit between the 'undecided' and the 'emerging risk' areas (arbitrarily) set at 3.25 (see Section 2.1.) and the standard deviation is high (SD=1.254), reflecting a poor consensus among the respondents.

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*'Tobacco' is the single largest cause of avoidable death in the EU.*

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*Workers in catering establishments where smoking is permitted are 50% more likely to develop lung cancer.*

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<sup>(110)</sup> European Commission, *The WOOD-RISK Project: Risk assessment of wood dust: assessment of exposure, health effects and biological mechanisms*, in *EU Research on Environment and Health: Results from project funded by the Fifth Framework Programme*, Office for Official Publications of the European Communities, Luxembourg, 2007, pp. 128-129. [http://ec.europa.eu/research/environment/pdf/env\\_health\\_projects/chemicals/c-woodrisk.pdf](http://ec.europa.eu/research/environment/pdf/env_health_projects/chemicals/c-woodrisk.pdf)

<sup>(111)</sup> European Commission, Health and Consumer Protection Directorate General, Directorate C - Public Health and Risk Assessment C6 - Health measures, *Green Paper. Towards a Europe free from tobacco smoke: policy options at EU level*, COM(2007)27 final, European Commission, Brussels, 2007. [http://ec.europa.eu/health/ph\\_determinants/life\\_style/Tobacco/Documents/gp\\_smoke\\_en.pdf](http://ec.europa.eu/health/ph_determinants/life_style/Tobacco/Documents/gp_smoke_en.pdf)

<sup>(112)</sup> European Parliament resolution of 24 October 2007 on the Green Paper *Towards a Europe free from tobacco smoke: policy options at EU level*, 2007/2105(INI). <http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P6-TA-2007-0471+0+DOC+XML+V0//EN&language=EN>

<sup>(113)</sup> Parent-Thirion, A., Fernández Macías, E., Hurley, J., Vermeylen, G., *Fourth European Working Conditions Survey*, European Foundation for the Improvement of Living and Working Conditions, Luxembourg, 2007. <http://eurofound.europa.eu/pubdocs/2006/98/en/2/ef0698en.pdf>



One explanation may be the discrepancies between the different national legislation restricting or banning smoking in the workplace in the Member States. Following Council Recommendation 2003/54/EC <sup>(114)</sup> which called on Member States to implement effective protection measures against exposure to environmental tobacco smoke in indoor workplaces – as well as in enclosed public places and public transport – comprehensive bans on smoking in all workplaces, including bars and restaurants, have been introduced in Ireland (March 2004), Scotland (March 2006) and Northern Ireland, England and Wales (summer 2007) <sup>(115)</sup>. Smoke-free legislation with exemptions introduced in Italy (January 2005), Malta (April 2005), Sweden (June 2005) and Finland (June 2007) permits employers to create special sealed-off smoking rooms with separate ventilation systems. Similar measures came into effect in France in February 2007 with a transition period for hospitality venues until January 2008. Lithuania became smoke-free (with the exception of specially equipped ‘cigar and pipe clubs’) as of January 2007. Other Member States such as Belgium, Cyprus, Estonia, Finland, the Netherlands, Slovenia and Spain have banned smoking in all workplaces, with the exception of the hospitality sector where partial restrictions apply.

In its first response to the Green Paper, the European Parliament <sup>(116)</sup> urged the Commission to designate environmental tobacco smoke a category 1 carcinogen so as to bring environmental tobacco smoke under the scope of the carcinogens and mutagens Directive 2004/37/EC <sup>(117)</sup>. It also recommended that, within two years, Member States should impose smoking bans in all enclosed workplaces, including catering establishments, as well as in all enclosed public buildings and transport. If these objectives are not attained, the Commission was urged to submit a proposal for rules on the protection of non-smokers in the field of employment protection by 2011.

The exposure to dangerous substances emitted by ‘**toners for printers and copiers**’ (MV=2.69) is the only item related to ‘particles, dusts and aerosols’ not rated as emerging risks. The use of printers at the workplace has raised concerns and, in recent years, a number of studies have been initiated to determine whether these may cause harm to workers’ health.

Studies performed in standardised testing chambers show that there is an increase in the number of airborne particles emitted at the beginning of the printing process. However, there is still some uncertainty as to whether these particles are actually insoluble dust particles from the toner itself or from other sources – for instance, soluble particles from the paper being printed or volatile organic compounds

<sup>(114)</sup> Council Recommendation of 2 December 2002 on the prevention of smoking and on initiatives to improve tobacco control (2003/54/EC), Official Journal, L22, 25 January 2003, pp. 31-34. [http://eur-lex.europa.eu/LexUriServ/site/en/oj/2003/l\\_022/l\\_02220030125en00310034.pdf](http://eur-lex.europa.eu/LexUriServ/site/en/oj/2003/l_022/l_02220030125en00310034.pdf)

<sup>(115)</sup> European Commission, Health and Consumer Protection Directorate General, Directorate C - Public Health and Risk Assessment C6 - Health measures, *Green Paper. Towards a Europe free from tobacco smoke: policy options at EU level*, COM(2007)27 final, European Commission, Brussels, 2007. [http://ec.europa.eu/health/ph\\_determinants/life\\_style/Tobacco/Documents/gp\\_smoke\\_en.pdf](http://ec.europa.eu/health/ph_determinants/life_style/Tobacco/Documents/gp_smoke_en.pdf)

<sup>(116)</sup> European Parliament resolution of 24 October 2007 on the Green Paper *Towards a Europe free from tobacco smoke: policy options at EU level*, 2007/2105(INI). <http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P6-TA-2007-0471+0+DOC+XML+V0//EN&language=EN>

<sup>(117)</sup> Directive 2004/37/EC on the protection of workers from the risks related to exposure to carcinogens or mutagens at work, Official Journal, L158, 30 April 2004, p. 50 plus correction in Official Journal, L229, 29 June 2004, pp.23-34. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:229:0023:0034:EN:PDF>



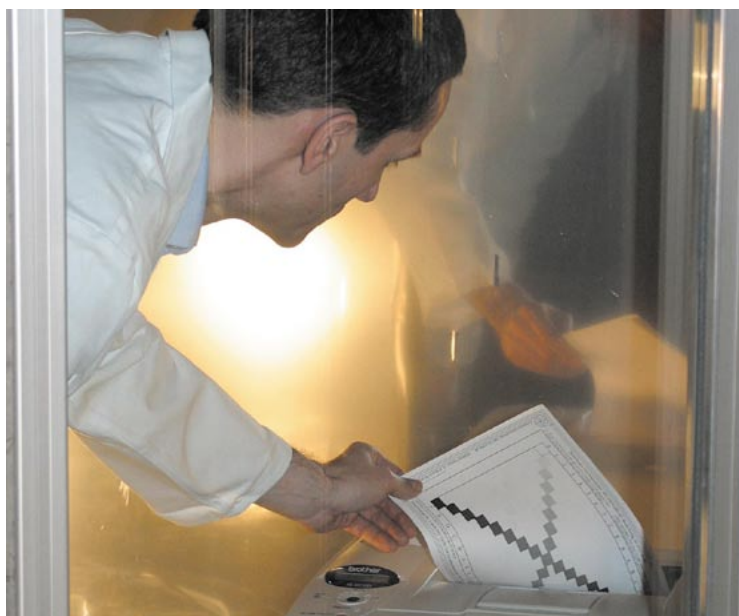
(VOCs) such as benzene, styrene or toluene – produced when the toner powder is heated to fix it to the paper. In addition, the emission depends on factors such as the printer characteristics, printer use (e.g. numbers of pages printed and toner coverage), cartridge model and the age of the cartridge <sup>(118)</sup><sup>(119)</sup><sup>(120)</sup><sup>(121)</sup>. In any case, the concentrations of particles and VOCs measured in these studies were very low and remained one or even two orders of magnitude below the German workplace limit values.

Moreover, the level of particles emitted by a printer does not provide any information on the concentration level under real conditions in the workplace. Indeed this concentration depends on factors such as:

- the size of the room;
- its ventilation and air exchange rate;
- the concentration of other ultrafine particles emanating from indoor material and equipment or drawn in from outdoors;
- moulds spread for example by poorly-maintained air-conditioning systems.

The measurements performed in testing chambers correspond to the 'worse case' situation of a very small room without any air circulation with the outside. Some measurements performed at workplaces indicate that the number of airborne particles emitted by printers actually contribute a very low proportion of the total number of indoor particles.

At the time of preparing this report, there is no scientific-based evidence that exposure to fine particles from toner is hazardous to health. Cases of reported sensitisation allegedly linked to exposure to printers could not be confirmed. The German Bundesinstitut für Risikobewertung (BfR) has carried out further research on these exposures <sup>(122)</sup> and has compiled information on its website <sup>(123)</sup>.



Laser printer in test room, BGIA, Germany.

*There is no scientific-based evidence that exposure to fine particles from toner is hazardous to health.*

<sup>(118)</sup> Verwaltungsberufsgenossenschaft (VBG), *Laserdrucker – Sicher betreiben*, Berufsgenossenschaftlichen Information BGI 820, VBG, Hamburg, 2006. <http://www.vbg.de/imperia/md/content/produkte/downloads/laserdrucker.pdf>

<sup>(119)</sup> Bake, D., Moriske, H-J., *Untersuchung zur Freisetzung feiner und ultrafeiner Partikel beim Betrieb von Laserdruck-Geraeten*, Umwelt Bundes Amt (UBA), Berlin, 2006.

<sup>(120)</sup> Bundesinstitut für Risikobewertung (BfR), *Gesundheitliche Beschwerden durch Toner*, Aktualisierte Information No. 021/2007 des BfR, December 2006. [http://www.bfr.bund.de/cm/252/gesundheitliche\\_beschwerden\\_durch\\_toner.pdf](http://www.bfr.bund.de/cm/252/gesundheitliche_beschwerden_durch_toner.pdf)

<sup>(121)</sup> He, C., Morawska, L., Taplin, L., *Particle emission characteristics of office printers*, *Environmental Science and Technology*, Vol. 41, No. 17, 2007, pp. 6039-6045.

<sup>(122)</sup> Bundesinstituts für Risikobewertung (BfR), *Ultrafeinstäube aus Laserdruckern und Fotokopierern enthalten offenbar keine Tonerpartikel*. Press release 18/2007, 16 October 2007. <http://www.bfr.bund.de/cd/10150>

<sup>(123)</sup> <http://www.bfr.bund.de/cd/8644>



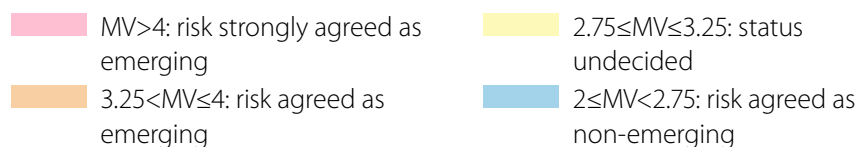
Although regular users are rarely in direct contact with toners, those maintaining printers – for example those who carry out repair work, those who change toner cartridges, or those who remove paper jams and clean printers – do and should receive appropriate health and safety training. Practical guidance and recommendations for preventive measures are available <sup>(124)</sup><sup>(125)</sup>. The German Berufsgenossenschaftliche Institut für Arbeitsschutz (BGI), for instance, gives a certificate (BG-Prüfzert schadstoffgeprüft) for printers that emit low levels of dangerous substances.

Last, but not least, it should be noted that the consensus among the experts is especially low for the following items:

- ‘asbestos’ (SD=1.433),
- ‘passive smoking’ (SD=1.254),
- ‘indoor use of detergent sprays, room deodorants and cosmetic sprays’ (SD=1.236)
- ‘crystalline silica’ (SD=1.272)
- ‘welding aerosols’ (SD=1.206).

The prioritised list of risks due to particles, dusts and aerosols identified in the survey is given in Table 7.

**Table 7: Prioritised list of chemical risks due to particles, dusts and aerosols**



NB: None of the risks was strongly agreed as non-emerging (MV<2).

Chemical risks due to particles, dusts and aerosols	N	Mean Value (MV)	Standard Deviation (SD)
Nanoparticles and ultrafine particles: emerging risks due to increasing (new) industrial applications creating ultrafine particles (e.g. laser treatment of material) and nanoparticles, to lack of knowledge on toxicity of ultrafine particles leading to inappropriate or insufficient protective measures, to poor risk assessment and to unfavourable workplace design and environment. Health effects of ultrafine particles in general may have been underestimated so far. Potential health effects: inflammatory lung diseases, secondary effects on cardiovascular system (e.g. heart attack, stroke), tumours.	47	4.60	0.876
Diesel exhaust.	45	4.02	1.033
Man-made mineral fibres (e.g. refractory ceramic fibres, carbon/graphite fibres or composites): lack of knowledge on health effects of (new) fibre substitutes for asbestos, the use of which is increasing and for which exposure levels seem high enough for concern in certain areas. Potential health effects: respiratory diseases, cancer.	46	3.96	1.053

<sup>(124)</sup> Verwaltungsberufsgenossenschaft (VBG), *Laserdrucker – Sicher betreiben*, Berufsgenossenschaftlichen Information BGI 820, VBG, Hamburg, 2006. <http://www.vbg.de/imperia/md/content/produkte/downloads/laserdrucker.pdf>

<sup>(125)</sup> Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA), *Kopiergeräte und Drucker im Büro*, BAuA, Dortmund-Dorstfeld. [http://www.baua.de/nn\\_27840/de/Publikationen/Faltblaetter/F44,xv=vt.pdf](http://www.baua.de/nn_27840/de/Publikationen/Faltblaetter/F44,xv=vt.pdf)



Chemical risks due to particles, dusts and aerosols	N	Mean Value (MV)	Standard Deviation (SD)
Combinations of different types of particles in dust or fume, especially in combination with gaseous substances, are not known sufficiently (for instance in welding fumes).	44	3.95	0.987
Dust mixtures in the recycling sector.	44	3.82	0.870
Welding aerosols produced at welding- and flame-cutting workplaces.	46	3.52	1.206
Crystalline silica.	45	3.51	1.272
Asbestos (removing asbestos in facilities and buildings).	45	3.36	1.433
Powder paints used in painting/coating installations.	44	3.32	0.959
Wood particles	45	3.29	0.991
Increasing dust exposure leading to inflammatory diseases such as heart infarct or rheumatoid arthritis.	43	3.23	1.043
Passive smoking at the workplace.	45	3.20	1.254
Increased use of detergent sprays, room deodorants and cosmetics sprays leading to an increased indoor concentration of dangerous substances.	45	3.13	1.236
Flour dust.	45	3.07	0.915
Toners for printers/copiers.	45	2.69	0.973

Note: N = number of experts answering the specific item.

### 5.1.1. Experts' comments

When available, the comments added by the respondents to the items are listed below to provide some context and support to the ratings.

#### *Risks strongly agreed as emerging (MV > 4)*

##### **Nanoparticles and ultrafine particles**

According to one respondent, it is because nanoparticles are new that the item is mentioned as the first emerging risk in the survey. However, it cannot be considered as a characterised risk in terms of 'hazard × probability' as neither the hazards of nanoparticles nor the probably of exposure based on measurement and exposure assessment are well-defined. In addition, it is not a risk widespread among workers – only 25,000 workers may be affected in a population of hundreds of millions.

But according to other respondents, nanoparticles and ultrafine particles present many new chemical compositions and possess new, different properties than the very same materials at the macro scale. There is a need for well-established methods to assess workers' exposure and for more research into the effects of nanoparticles on workers' health – including reproductive health – in order to allow for risk assessment. The precautionary principle should be followed whenever there is any doubt about the potential risks posed by nanoparticles and nanotechnologies.

One respondent reminded us that exposure to ultrafine particles is not only an occupational safety and health issue as, for instance, diesel engines are used in daily life and create such particles.



Last, but not least, it was mentioned that the potential damage caused by new technologies to reproductive health, which is particularly vulnerable, should in general be investigated more.

### **Diesel exhaust**

Workers are particularly exposed to diesel exhaust in mining activities and where diesel-driven loaders and trucks are used. Evidence from animal studies indicates that diesel exhaust may harm the foetus; risks include post-natal occurrence of allergies, reduced male fertility, hormone-like effects and even degradation of cognitive functions in the future child. It is underlined that modern diesel engines with high pressure injection are not only used in the workplace, and are hence not only a risk to occupational safety and health but also to public health.

One respondent added that diesel exhaust is also an emerging problem in Denmark as a consequence of increasing road transport of goods, as well as a consequence of new technology of diesel engines resulting in smaller diesel particles. The number and percentage of privately owned diesel cars is also increasing in Denmark, which leads to a higher level of emissions of diesel particles in the environment and in the work environment.

Another respondent was of the opinion that diesel exhaust is an 'old risk' which should perhaps better be considered as a public health issue as, according to the respondent, most of the engines used in industry are electrically powered, while it is the ambient air in cities that is the most polluted by diesel exhaust.

### **Risks agreed as emerging ( $3.25 < MV \leq 4$ )**

#### **Man-made mineral fibres**

Man-made mineral fibres are broadly used in modern composite materials, which are thus a source of occupational exposure. According to some experts, the properties of such fibres are well-known and are acknowledged by scientists and regulators. Most of these fibres have a diameter big enough not to present a major health hazard to humans. According to an employers' association, there has been an "over-reaction of the authorities based on fear that man-made mineral fibres could have similar properties as asbestos. But their properties are very different. There is no new scientific evidence for an increase of the risk." According to the same employers' association there is new scientific evidence that shows that the animal studies which served to classify aluminium silicate wools (ASW) known as RCFs in category 2 were misinterpreted because of the overload of particles in the samples tested, which would have led to lung cancers with any other fibre type or nuisance dust <sup>(126)</sup>.

The risk is not 'increasing' either: there are no new hazards and exposure of people. Exposure to ASW/RCFs is decreasing. The ECFIA, representing the European high-temperature insulation industry, has a long-lasting programme called CARE that aims to control and reduce exposure; this shows exposure levels have been falling over the years. Furthermore, in France, 70% of ASW/RCFs have been substituted by alkaline earth silicate wools, which have been widely tested and are exonerated from classification. ASW/RCFs have been used for more than 50 years and have not shown to cause any disease in workers. But, according to other respondents, their properties

<sup>(126)</sup> Brown, R.C., Bellmann, B., Muhle, H., Davis, J.M.G., Maxim, L.D., *Survey of the biological effects of refractory ceramic fibres: overload and its possible consequences*, *Annals of Occupational Hygiene*, Vol 49, No. 4, 2005, pp. 295-307.



have not yet been studied adequately. They also highlighted the fact that new types of fibres potentially harmful to health are always being synthesised.

### **Combinations of different types of particles in dust or fume**

There is a need for more research into the effects on health of (mixtures) of dusts and fumes, which contain different types of particles. More particularly, there is a lack of knowledge on combined mixed phase aerosols and vapours.

### **Dust mixtures in the recycling sector**

In the recycling sector, the risks to workers' health depend on the type of waste being handled and on the recycling process. However, some respondents deplored the fact that, in many cases, the hierarchy of prevention measures in waste recycling industries is not respected and that the level of workers' risk awareness is low. Moreover, the workforce in recycling activities is often socially vulnerable. Again, the need for more knowledge about the health effects of mixtures of different types of dusts is highlighted.

### **Welding aerosols**

Welding aerosols produced at welding- and flame-cutting workplaces are considered as an emerging risk due to new materials processed (e.g. polymers) and new technologies used. In addition, there is often a lack of proper ventilation systems removing the aerosols from the workplace, which increases the risk of workers' exposure. According to the respondents, the risk of lung cancer caused by welding aerosols is hard to estimate.

### **Crystalline silica**

Crystalline silica is used in many applications. Construction workers in particular are exposed to crystalline silica, including workers involved in renovation, maintenance and pavement activities. Workers performing dry-cutting of stone or concrete, for example, are extremely exposed. What is more, according to some respondents, workers are rarely protected against the exposure. One expert reminded us that it is only the exposure to the respirable fraction of crystalline silica which is critical.

Some Member States have legislation and OELs for crystalline silica such as the Technische Regeln für Gefahrstoffe 906 (TRGS 906) in Germany, though some experts are of the opinion that a European OEL is needed. The need for more knowledge on the risk of cancer linked to crystalline silica was underlined.

### **Asbestos**

Workers' exposure to asbestos is regarded as a high risk. The remediation and renovation industry, where workers may be exposed, is growing. Respondents emphasised the need for strict enforcement of the law.

### **Powder paints**

Powder paints used in painting and coating installations contain many new allergens. The experts mentioned that new substances are being developed to substitute for the allergenic and mutagenic substance, triglycidyl isocyanurate (TGIC) – the only mutagen classified as Muta Cat 2 without simultaneous classification as a carcinogen in the EU system (it was formerly tested as an anti-cancer drug, hence its mutagenic properties). The need for good ventilation systems in powder painting workplaces was also underlined.



*Welding fumes*





**Wood particles**

It is particularly the ultrafine particles of wood dust which, according to the respondents, put workers at risk. Adverse health outcomes include inflammatory diseases, such as rheumatoid arthritis, and heart infarct. It was mentioned that the exposure of carpenters is often underestimated. Moreover, it was underlined that the effects of dust mixtures are not known sufficiently and that more attention should be paid to combined effects of dust with substances in the gaseous or solid states such as aerosols.

*Undecided (2.75 ≤ MV ≤ 3.25)*

**Passive smoking**

The experts generally welcomed the legislation banning tobacco in the workplace introduced in some Member States and the support for such a ban at EU level. Some respondents underlined the negative impact of passive smoking on foetal development. One Austrian respondent emphasised that passive smoking at the workplace is currently considered a high priority at a European level as well as in Austria.

**Detergent sprays, room deodorants and cosmetics sprays leading to an increased indoor concentration of dangerous substances**

One respondent commented that the normal use of detergent sprays, room deodorants and cosmetics sprays does not increase indoor concentration of dangerous substances.

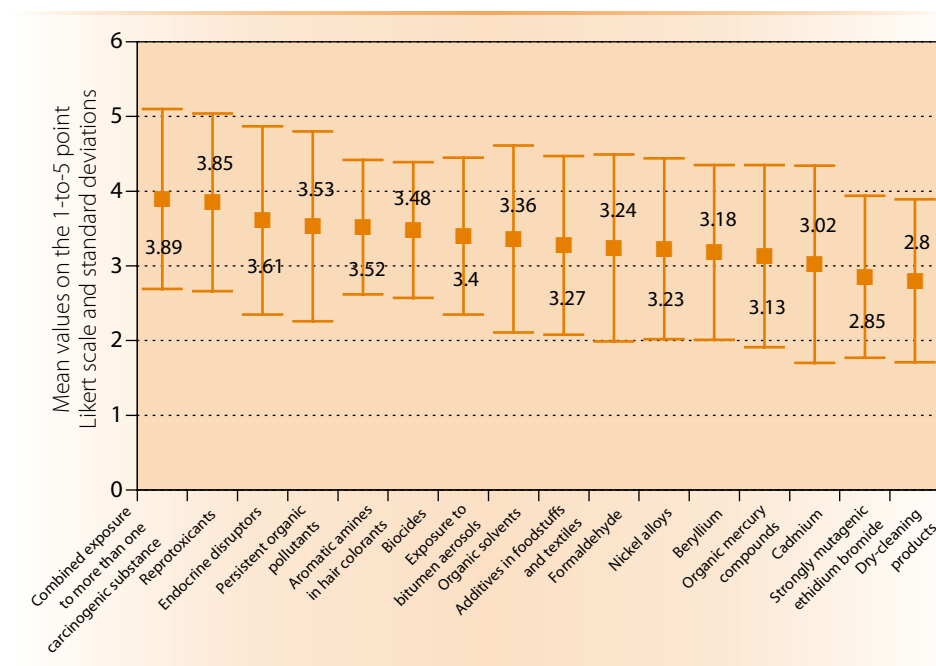
## 5.2. RISKS DUE TO CARCINOGENIC, MUTAGENIC AND REPROTOXIC SUBSTANCES (CMRs)

Diagram 7 summarises the risk rating by the survey respondents for carcinogenic, mutagenic and reprotoxic substances.

Nine of 16 of the risks due to carcinogenic, mutagenic and reprotoxic (CMR) substances are agreed as emerging risks, though none of them is 'strongly agreed as emerging'.

Besides the CMR substances mentioned in this part of the survey, other carcinogens were mentioned and rated as 'emerging' or even 'strongly emerging' in other parts of the survey with regard to another of their characteristics – for instance with regard to their physical state as particles, dust or aerosols in the case of diesel exhaust, asbestos, crystalline silica and wood dust (see Section 5.1). In addition, the limits for distinguishing between the different areas for the interpretation of the mean values was set arbitrarily (see Section 2.1.) and that the mean value of the item 'formaldehyde' (MV=3.24) – the first item rated as 'undecided' in this part of the survey – is extremely close to the limit set arbitrarily at 3.25 to differentiate between 'emerging' risks and 'undecided' items.



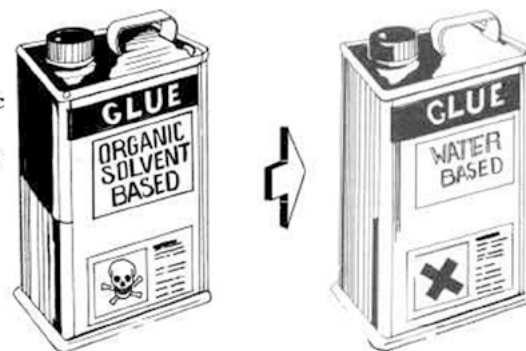
**Diagram 7: Chemical risks due to carcinogenic, mutagenic and reprotoxic substances identified in the survey**

Work-related cancers were also agreed as a top research priority in the seminar on occupational safety and health research priorities organised by the Agency which brought together EU policy-makers, social partners and experts <sup>(127)</sup>.

In relation to the item 'organic solvent' rated as an emerging risk (MV=3.36), it can be added that 11.2% of the workforce in the EU-27 reported in 2005 that they 'breathe in vapours such as solvents and thinners' <sup>(128)</sup>.

Exposure to the dangerous substances associated with dry-cleaning were rated as undecided in this forecast (MV=2.80). But, according to the SUMER survey 2003, tetrachloroethylene, which is widely used for the dry cleaning of fabric as well as for metal degreasing, is among the eight most common occupational carcinogens found in France <sup>(129)</sup>.

Wherever possible, hazardous substances should be replaced by less hazardous ones. For example, an organic solvent-based glue should be replaced by a water-based one



Courtesy of ILO.

The consensus among the respondents is especially low for the following items:

- 'cadmium' (SD=1.320);

<sup>(127)</sup> European Agency for Safety and Health at Work, *Promoting occupational safety and health research in the EU*, Forum 15, Office for Official Publications of the European Communities, Luxembourg, 2006. <http://osha.europa.eu/en/publications/forum/15/view>

<sup>(128)</sup> Parent-Thirion, A., Fernández Macías, E., Hurley, J., Vermeylen, G., *Fourth European Working Conditions Survey*, European Foundation for the Improvement of Living and Working Conditions, Luxembourg, 2007. <http://eurofound.europa.eu/pubdocs/2006/98/en/2/ef0698en.pdf>

<sup>(129)</sup> Ministère de l'emploi, de la cohésion sociale et du logement, DARES, *Huit produits cancérigènes parmi les plus fréquents*. Premières Synthèses Informations, Annexe 28.1, July 2005. [http://www.travail.gouv.fr/IMG/pdf/publication\\_pips\\_annexe\\_200507\\_n-28-1\\_huit-produits-cancerogenes.pdf](http://www.travail.gouv.fr/IMG/pdf/publication_pips_annexe_200507_n-28-1_huit-produits-cancerogenes.pdf)



*The worldwide global burden of lung cancer, leukaemia and malignant mesothelioma arising from occupational exposures to carcinogens has been estimated at 152,000 deaths.*

*According to EU estimates, 32 million people are exposed to carcinogens at levels which exceed what is considered as safe.*

- 'persistent organic pollutants' (SD=1.272);
- 'endocrine disruptors' (SD=1.256);
- 'formaldehyde' (SD=1.251);
- 'organic solvents' (SD=1.246);
- 'organic mercury compounds' (SD=1.217);
- 'nickel alloys' (SD=1.212).

In terms of outcomes, the worldwide global burden of lung cancer, leukaemia and malignant mesothelioma arising from occupational exposures to carcinogens has been estimated at 152,000 deaths (102,000 cases of lung cancers, 7,000 leukaemias and 43,000 malignant mesothelioma) and nearly 1.6 million DALYs <sup>(130)</sup> (969,000 DALYs for lung cancer, 101,000 for leukaemia and 564,000 for malignant mesothelioma) <sup>(131)</sup>. According to EU estimates, 32 million people are exposed to such carcinogens at levels which exceed what is considered as safe, and between 35,000 and 45,000 cancer deaths per year are due to exposures occurring in the workplace <sup>(132)</sup>. However, new studies <sup>(133)</sup> suggest that the magnitude of the work-related cancers and subsequent deaths is higher than earlier estimates and that, in the EU-27, 95,581 deaths caused each year by cancer could be work-related. This figure can be compared with the estimated 8,900 fatal occupational accidents in the EU-27. This would mean that 9.6% of all cancer deaths are attributable to work. One occupational death from cancer costs an average of EUR 2.14 million and the total cost of occupational deaths from cancer across the European Union is over EUR 70 billion per year.

According to CAREX <sup>(134)</sup>, there were about 32 million workers (23% of the employed) in the EU-15 in 1990-1993 exposed to the 139 carcinogenic agents covered by CAREX – this includes all agents in Groups 1 and 2A, and selected agents in Group 2B of the classification by the International Agency for Research on Cancer (IARC). Altogether these workers received about 42 million exposures (1.3 exposures by exposed worker on average). At least 22 million workers were exposed to IARC Group 1 carcinogens.

In France <sup>(135)</sup>, the Institut National de Recherche et de Sécurité (INRS) estimates that 4.8 million tonnes of CMR substances are used. The SUMER survey 2003 indicates that 2.3 million workers (13.5% of the workforce) are exposed to carcinogens and 370,000

<sup>(130)</sup> Disability Adjusted Life Years

<sup>(131)</sup> Driscoll, T., Takala, J., Steenland, K., Corvalan, C. Fingerhut, M., *Review of estimates of the global burden of injury and illness due to occupational exposures, American Journal of Industrial Medicine*, Vol. 48, No. 6, 2005, pp. 491-502.

<sup>(132)</sup> *Commission consults workers and employers on reducing exposure to substances that cause cancer and reduce fertility, Press release*, Reference IP/04/391, Brussels, 26 March 2004. <http://europa.eu/rapid/pressReleasesAction.do?reference=IP/04/391&format=HTML&aged=0&language=EN&guiLanguage=en>

<sup>(133)</sup> A study by Hämäläinen P., Takala J. of Tampere University of Technology (Finland) for the International Labour Office available in: J. Takala, ILO, *Introductory Report – Decent work, Safe work*. XVIIth World Congress on Safety and Health at Work, Orlando, 18-22 Sep. 2005, <http://www.ilo.org/public/english/protection/safework/wdcongrs17/intrep.pdf>; European Agency for Safety and Health at Work, *Work-related cancers*, [http://osha.europa.eu/OSH\\_world\\_day/occupational\\_cancer](http://osha.europa.eu/OSH_world_day/occupational_cancer)

<sup>(134)</sup> Kauppinen, T. et al., 'CAREX – International Information System on Occupational Exposure to Carcinogens. Occupational exposures to carcinogens in the European Union in 1990-1993', Finnish Institute of Occupational Health, Helsinki 1998. [http://www.ttl.fi/NR/rdonlyres/4444380F-B1FB-4D01-A974-0B6A9E663CFA/0/1\\_description\\_and\\_summary\\_of\\_results.pdf](http://www.ttl.fi/NR/rdonlyres/4444380F-B1FB-4D01-A974-0B6A9E663CFA/0/1_description_and_summary_of_results.pdf)

<sup>(135)</sup> Larcher, G., *Bilan des campagnes de contrôles 2006 de l'inspection du travail sur les produits cancérigènes et lamiante*, Ministère de l'emploi, de la cohésion sociale et du logement, Paris, 2007. <http://www.inrs.fr/espacepresse/dossiercampagne2006.html>



workers (2% of the workforce) to mutagens and reprotoxicants <sup>(129)</sup>. According to the Institut de Veille Sanitaire (InVS), there are between 11,000 and 23,000 new cases of work-related cancers each year, with half of them being fatal <sup>(136)</sup>.

In the UK, the number of cancer registrations in 2003 attributable to occupational causes was 13,338. In 2004, the proportion of cancer deaths attributable to occupation was estimated to be 4.9% (7,317 deaths) – 8% in men (6,259 deaths) and 1.5% in women (1,058 cases) <sup>(137)</sup>. Asbestos contributed the largest numbers of deaths and registrations (mesothelioma and lung cancer), followed by mineral oils (mainly non-melanoma skin cancer (NMSC)), solar radiation (NMSC), silica (lung cancer) and diesel engine exhaust (lung and bladder cancer). Large numbers of workers were potentially exposed to several carcinogenic agents over the risk exposure periods, particularly in construction and agriculture, and as workers in land transport, metal working, painting, welding, the textile industry and the manufacture of machinery and other equipment, and of wood products.

With regard to gender differences, the cancer incidence rate has risen across the EU-25 for both men and women. From 1995 to 2002, the rise was 12.1% for men and 13.7% for women. According to the data analysed, cancer occurs more commonly in men than women in almost all countries but the gender differences vary significantly between countries <sup>(138)</sup>.

However, occupational causes of cancer have not been well-evaluated among women. Estimates that 1% of cancer among women is attributable to occupation are based on research conducted mainly in the 1970s among men only. But women may respond differently to occupational exposures because of anatomic, metabolic, genetic or other differences. The inability to evaluate occupational causes of female gynaecologic tumours in studies of men underlines the need for investigations focused specifically on women.

Women may also have different workplace exposures to those of men. In past decades, there has been a considerable increase in the number of women in jobs with potentially hazardous exposures (e.g. in electronics) where cancer risks have not yet been fully evaluated <sup>(139)</sup><sup>(140)</sup><sup>(141)</sup>. With the increasing participation of women in the labour force,



Courtesy of ILO.

*Occupational causes of cancer have not been well-evaluated among women.*

*Women may respond differently to occupational exposures because of anatomic, metabolic, genetic or other differences.*

<sup>(136)</sup> Sécurité sociale, Assurance Maladie, Risques professionnels, *Cancers professionnels : Agir aujourd'hui pour prévenir les cancers de demain*, Paris, 30 January 2007. <http://www.risquesprofessionnels.ameli.fr/media/Dossier%20de%20presse%20cancers%20professionnels.pdf>

<sup>(137)</sup> Health and Safety Executive (HSE), *The burden of occupational cancer in Great Britain*, Research Report 595, HSE, Sudbury, UK, 2007. <http://www.hse.gov.uk/research/rrhtm/rr595.htm>

<sup>(138)</sup> Eurostat, *Living conditions in Europe – data 2002-2005*, European Commission Pocketbooks, Office for Official Publications of the European Communities, Luxembourg, 2007. [http://epp.eurostat.ec.europa.eu/cache/ITY\\_OFFPUB/KS-76-06-390/EN/KS-76-06-390-EN.PDF](http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-76-06-390/EN/KS-76-06-390-EN.PDF)

<sup>(139)</sup> National Occupational Research Agenda (NORA) team, *Priorities for development of research methods in occupational cancer*, *Environmental Health Perspectives*, Vol. 111, No. 1, 2003, <http://www.ehponline.org/members/2003/5537/5537.html>

<sup>(140)</sup> Blair, A., Zahm, S.H., Silverman, D.T., *Occupational cancer among women: research status and methodologic considerations*, *American Journal of Industrial Medicine*, Vol. 36, No. 1, 1999, pp. 6-17.

<sup>(141)</sup> Zahm, S., Blair, A., *Occupational cancer among women: where have we been and where are we going?* *American Journal of Industrial Medicine*, Vol. 44, No. 6, 2003, pp. 565-575.



*With the increasing participation of women in the labour force, the exposure of women has potentially increased.*

the exposure of women has potentially increased<sup>(142)</sup>. To assess the occupational safety and health situation of women, the Agency will conduct a project in 2009-2010 which will include occupational cancers and exposure to carcinogens of women at work.

With regard to European legislation, Directive 93/21/EEC<sup>(143)</sup> (adapting Council Directive 67/548/EEC) illustrates the general principles of the classification of substances and gives criteria for the classification of respectively carcinogens, mutagens and reprotoxicants in three categories:

Category 1: substances known to be respectively carcinogenic, or mutagenic, or to impair fertility or developmental toxicity in humans, i.e. for which there is sufficient evidence to establish a causal association.

Category 2: substances that should be regarded as if they are respectively carcinogenic, or mutagenic, or as if they impair fertility, or cause developmental toxicity to humans. There is sufficient evidence to provide a strong presumption that human exposure to those may result in the development of cancer, or heritable genetic damage, or impaired fertility, or developmental toxicity.

Category 3: substances that cause concern for humans owing to possible carcinogenic, or mutagenic effects, or effects on human fertility, or developmental toxic effects but where the evidence is insufficient to place the substance in Category 2.

A list of chemicals classified as carcinogens, mutagens or toxic to reproduction is published by the European Chemicals Bureau<sup>(144)</sup>.

Directive 2004/37/EC<sup>(145)</sup> on the protection of workers from the risks related to exposure to carcinogens or mutagens at work – including substances that are generated by work processes such as wood dust – places the responsibility on employers to assess and manage the risks of carcinogens and mutagens in the workplace. It lays down OELs only for benzene, vinyl chloride monomer and hardwood dust.

In its draft report of 14 September 2007 on the Community strategy 2007-2012 on health and safety at work, the Committee on Employment and Social Affairs of the European Parliament states that it is waiting for:

‘the outcome of the second phase of consultation of the social partners on the revision of the 2004 carcinogens directive and considers that the preferred option should be to amend that directive to include mutagens and substances toxic for reproduction and to propose a revision of the binding occupational exposure limit values (BOELVs) for carcinogens listed in the directive and to establish new BOELVs for some carcinogens,

<sup>(142)</sup> European Agency for Safety and Health at Work, *Gender issues in safety and health at work – a review*, Office for Official Publications of the European Communities, Luxembourg, 2003. <http://osha.europa.eu/en/publications/reports/209/view>

<sup>(143)</sup> Commission Directive 93/21/EEC of 27 April 1993 adapting to technical progress for the 18th time Council Directive 67/548/EEC on the approximation of the laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances. *Official Journal*, L110, 4 May 1993, pp. 20-0021. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31993L0021:EN:HTML>

<sup>(144)</sup> <http://ecb.jrc.it/>

<sup>(145)</sup> *Directive 2004/37/EC on the protection of workers from the risks related to exposure to carcinogens or mutagens at work*, *Official Journal*, L158, 30 April 2004, p. 50 plus correction in *Official Journal*, L229, 29 June 2004, pp.23-34. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:229:0023:0034:EN:PDF>







mutagens and reprotoxins not yet included in the directive with crystalline silica being a priority' <sup>(146)</sup>.

However, the proposal to include crystalline silica as a priority substance was rejected by a vote of the European Parliament in January 2008.

Further European legislation also includes provisions related to carcinogens, mutagens and reprotoxicants such as Directive 92/85/EEC <sup>(147)</sup> on the health and safety of pregnant workers and workers who have recently given birth or are breastfeeding.

The prioritised list of risks due to carcinogenic, mutagenic and reprotoxic substances identified in the survey is given in Table 8.

**Table 8: Prioritised list of chemical risks due to carcinogenic, mutagenic and reprotoxic substances identified in the survey**

 MV>4: risk strongly agreed as emerging	 2.75≤MV≤3.25: status undecided
 3.25<MV≤4: risk agreed as emerging	 2≤MV<2.75: risk agreed as non-emerging

NB: None of the risks was strongly agreed as non-emerging (MV<2).

Chemical risks due to carcinogenic, mutagenic and reprotoxic substances	N	Mean Value (MV)	Standard Deviation (SD)
Combined exposure to more than one carcinogenic substance.	44	3.89	1.205
Reprotoxicants, to which women are increasingly exposed (because of the increasing female participation in the workforce) leading to an increasing number of reproductive health effects.	46	3.85	1.192
Endocrine disruptors (PCBs, dioxins, styrene, pesticides, etc.).	46	3.61	1.256
Persistent organic pollutants (POPs) (pesticides, polychlorinated biphenyls (PCBs) and terphenyls (PCTs), dioxins, furans, etc.).	45	3.53	1.272
Aromatic amines in hair colorants leading to cancer and allergies.	44	3.52	0.902
Biocides (e.g. chlorothalonil, tributyltin compounds, acrolin): exposure increases and the carcinogenicity is still uncertain.	46	3.48	0.913
Exposure to bitumen aerosols on, for example, construction sites.	45	3.40	1.053
Organic solvents with carcinogenic, mutagenic and reprotoxic effects.	42	3.36	1.246
Additives in foodstuffs and textiles (e.g. azo dyes).	45	3.27	1.195

<sup>(146)</sup> European Parliament Committee on Employment and Social Affairs, *Draft report on the Community strategy 2007-2012 on health and safety at work*, Provisional 2007/2146(INI), 14 September 2007. [http://www.europarl.europa.eu/registre/commissions/empl/projet\\_rapport/2007/393990/EMPL\\_PR\(2007\)393990\\_EN.doc](http://www.europarl.europa.eu/registre/commissions/empl/projet_rapport/2007/393990/EMPL_PR(2007)393990_EN.doc)

<sup>(147)</sup> Council Directive 92/85/EEC of 19 October 1992 on the introduction of measures to encourage improvements in the safety and health at work of pregnant workers and workers who have recently given birth or are breastfeeding, *Official Journal*, L348, 28 November 1992, pp. 1-8. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31992L0085:EN:HTML>



Chemical risks due to carcinogenic, mutagenic and reprotoxic substances	N	Mean Value (MV)	Standard Deviation (SD)
Formaldehyde: suspected carcinogenic effects (lung, nasopharyngeal and nasal squamous cell cancer); acute (short-term) and chronic (long-term) inhalation exposure to formaldehyde in humans can result in respiratory symptoms, and eye, nose and throat irritation.	46	3.24	1.251
Nickel alloys are (potential) carcinogens.	43	3.23	1.212
Beryllium. Potential health effects: suspected human carcinogen; chronic beryllium disease (CBD) (an irreversible and sometimes fatal scarring of the lungs).	45	3.18	1.173
Organic mercury compounds with carcinogenic, mutagenic and reprotoxic effects.	45	3.13	1.217
Cadmium as a component of various alloys and compounds (e.g. nickel–cadmium batteries, cadmium pigment, zinc smelting, plastic stabiliser).	44	3.02	1.320
Strongly mutagenic ethidium bromide used in laboratories for separation of nucleic acids.	41	2.85	1.085
Dry cleaning products (tetrachloroethylene).	44	2.80	1.091

Note: N = number of experts answering the specific item.

### 5.2.1. Experts' comments

When available, the comments added by the respondents to the items are listed below to provide some context and support to the ratings.

#### *Risks agreed as emerging ( $3.25 < MV \leq 4$ )*

##### **Combined exposure to more than one carcinogenic substance**

Diesel exhaust is listed as an example of the combined exposure to more than one carcinogenic substance. The respondents deplore the fact that the effects of mixtures are not known sufficiently.

##### **Reprotoxicants**

The state of knowledge on reprotoxicants was reported to be very low by the respondents, who emphasised that women are increasingly exposed. According to the respondents, only few chemicals are tested for reprotoxicity. They also emphasised that reprotoxicity does not only affect women but also men.

##### **Persistent organic pollutants**

Effects of persistent organic pollutants (POPs) in humans are not well-known. One respondent stressed that the concern about POPs originally emerged in the 1990s from an environmental point of view and that this is not only an occupational safety and health issue.



## Biocides

The use of biocides is increasing as a consequence of hygiene standards requiring the replacement of some dangerous substances with water-based mixtures. In addition, the use of biocides as solvents is also increasing. For instance, mineral oils are often replaced by water-based biocides. Thanks to the introduction of Directive 98/8/EC on the placing of biocidal products on the market, there is now more knowledge on biocides available. It was also added that the risks posed by biocides are not only an occupational safety and health issue but also an environmental issue.



Courtesy of INSHT, Spain.

## Organic solvents

The effects on health of mixtures of organic solvents with CMR effects are not sufficiently known. Workers in small and medium enterprises (SMEs) are particularly at risk. Cheap, low-quality, solvent-based paints, for instance, put painters at risk.

## Additives in foodstuffs and textiles

More and more additives (e.g. aromatic amines) are used in textiles to meet the demand for new fashion products. In addition, the risks posed by the use of such additives is not only an occupational safety and health issue, but also a consumer protection concern and even a public health matter.

## Undecided ( $2.75 \leq MV \leq 3.25$ )

### Formaldehyde

Formaldehyde may induce irritation of the eyes, nose and throat, allergies and cancers (in particular naso-pharyngeal cancers). There are also suspicions that it may cause leukaemia. Last, but not least, there is an increasing concern that formaldehyde may have carcinogenic effects even below the OEL.

### Beryllium

Exposure to beryllium is found, for example, in the recycling industry. Two respondents commented that beryllium is not widely used, but that the exposures may be high and also difficult to assess. In most cases, the presence of beryllium is not even known.

### Organic mercury compounds

Organic mercury compounds with CMR effects are not commonly used. Nevertheless, some studies indicate that even exposure to low levels of organic solvents may impair female fertility.





**Cadmium**

The use of cadmium is low as a consequence of strict regulations. However, exposure to cadmium may be a growing problem in the recycling and waste treatment industry. Moreover, accidental exposure may occur due to a lack of awareness.

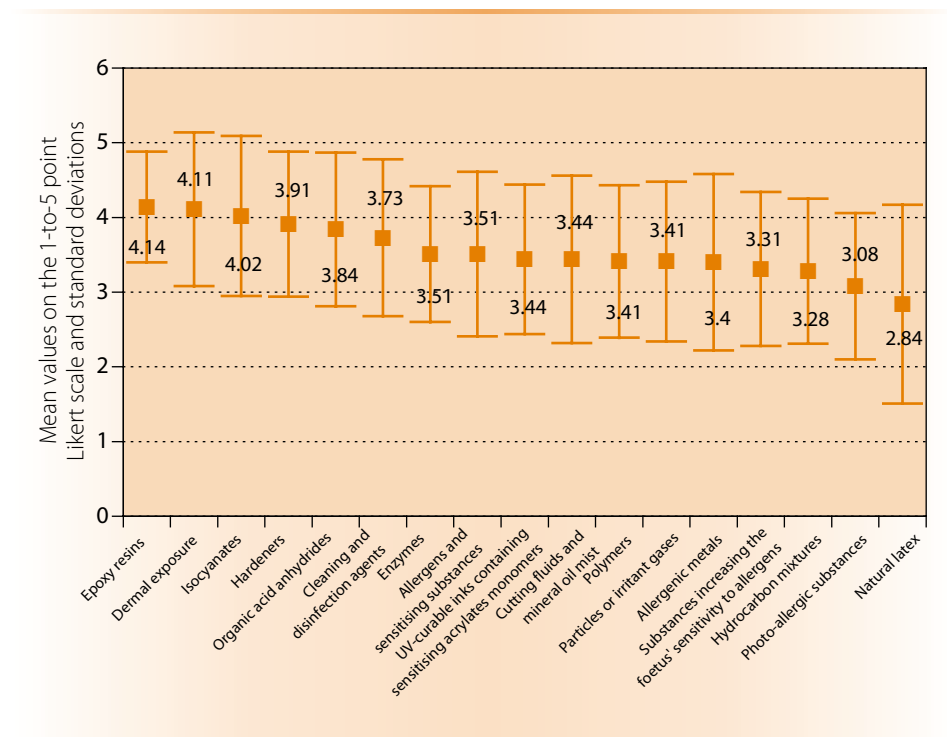
**Strongly mutagenic ethidium bromide**

The use of strongly mutagenic ethidium bromide in laboratories for the separation of nucleic acids is minor. In addition, one respondent commented that the risk of exposure to this substance in such laboratories is low as its vapour pressure is low.

# 5.3. RISKS OF ALLERGIES AND SENSITISATION

Diagram 8 summarises the risk rating by the survey respondents of allergies and sensitisation.

**Diagram 8: Risks of allergies and sensitisation identified in the survey**



Globally, risks of allergies and sensitisation are an important concern; 15 of the 17 items mentioned in the survey were rated as emerging by the experts. More particularly, the risks related to ‘epoxy resins’ (MV=4.14) (see Section 4.2.2.), ‘dermal exposure’ (MV=4.11) (see Section 4.2.4) and ‘isocyanates’ (MV= 4.02) (see Section 4.1.) were ‘strongly agreed as emerging risks’ by the experts.



Skin diseases as well as 'allergens and sensitising substances' were also identified as two of the main occupational safety and health priorities in a review carried out by the Agency of various national, EU and international resources aimed at identifying future EU research needs in the field of occupational safety and health <sup>(148)</sup>.

Innate hypersensitivity reactions can be the result of an abnormal natural sensitivity in certain individuals to certain products. They may appear at first contact. Allergic reactions, which are more frequent, require prior sensitisation to a substance and only develop after this induction period where there is further contact with the substance.

Thousands of products may trigger sensitisation and cause allergic contact dermatitis <sup>(149)</sup>. Nearly 150 substances are classified in the EU as 'skin sensitisers' R 43 – 'May cause sensitisation by skin contact' according to Annex 1 of Directive 67/548/EC <sup>(150)</sup>.





A report by the Agency and its Topic Centre Risk Observatory giving an overview of dermal exposures and skin diseases in the EU will be published in 2008. It will contain the principal policies in relation to recognition and recording of skin diseases as well as recognition, assessment and control of dermal exposure to chemical, biological and physical risk factors in the EU-25.

With regard to the item 'Cleaning and disinfection agents', which is rated as emerging risk (MV=3.73), a further report on the occupational safety and health risks faced by cleaning workers will be published in autumn 2008.

There is a good level of consensus among the respondents regarding the rating of the item 'epoxy resins' (SD=0.743). However, the consensus is low for the item 'natural latex' (SD=1.328).

The prioritised list of risks of allergies and sensitisation identified in the survey is given in Table 9.

**Table 9: Prioritised list of risks of allergies and sensitisation identified in the survey**

 MV>4: risk strongly agreed as emerging	 2.75≤MV≤3.25: status undecided
 3.25<MV≤4: risk agreed as emerging	 2≤MV<2.75: risk agreed as non-emerging

NB: None of the risks was strongly agreed as non-emerging (MV<2).

Nearly 150 substances are classified in the EU as 'skin sensitisers' R 43 – 'May cause sensitisation by skin contact'.

<sup>(148)</sup> European Agency for Safety and Health at Work, *Priorities for occupational safety and health research in the EU-25*, Office for Official Publications of the European Communities, Luxembourg, 2005. <http://osha.europa.eu/en/publications/reports/6805648/view>

<sup>(149)</sup> European Foundation for the Improvement of Living and Working Conditions, *Allergies liées au travail*, *Eurorevue sur la recherche en SST*, European Foundation for the Improvement of Living and Working Conditions, Dublin, 1996.

<sup>(150)</sup> Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances, Official Journal, L196, 16 August 1967, pp. 1-98. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31967L0548:EN:HTML>



Chemical risks due to allergens and sensitising substances	N	Mean Value (MV)	Standard Deviation (SD)
Increasing use of epoxy resins on construction sites in general and, for example, for the construction of the wings of wind mills used as power generators or in the cabin of large aircraft.	43	4.14	0.743
Dermal exposure leading to skin diseases.	45	4.11	1.027
Isocyanates leading to allergic reactions: exposure does not only occur at the production stage but also during further processing (e.g. thermal or chemical degradation of polyurethane, grinding and welding of products containing polyurethane in, for example, car repair shops).	44	4.02	1.067
Hardeners such as acrylates and isocyanates used in polymer production.	43	3.91	0.971
Organic acid anhydrides (new applications, for example, in epoxy resins and paints) leading to skin and airways irritation and allergies.	44	3.84	1.033
Cleaning and disinfection agents (e.g. where hydrocarbons have been replaced by glycols and esters, which are skin resorptive and have a 'carrier' function) leading to asthma, irritation of skin and mucous membranes, and sensitisation.	45	3.73	1.053
Enzymes leading to conjunctivitis, rhinitis, asthma and parenchymal disease.	43	3.51	0.910
The increasing number of allergens and sensitising substances contained in the growing number of chemicals produced and used results in new form of diseases.	41	3.51	1.098
Increasing use of UV-curable inks containing sensitising acrylate monomers in the printing industry.	41	3.44	1.001
Cutting fluids and mineral oil mist resulting from cutting fluids in metal processing and other workplaces leading to cutaneous diseases.	43	3.44	1.119
Polymers which can reach the respiratory tract and lead to acute and chronic respiratory diseases.	41	3.41	1.024
Particles or irritant gases leading to chronic obstructive pulmonary disease (COPD).	41	3.41	1.072
Allergenic metals (ions of nickel, cobalt, chromium).	43	3.40	1.178
Substances likely to increase the foetus' sensitivity to allergens, leading to an increase in allergies after birth (e.g. diesel exhausts).	39	3.31	1.030
Increasing industrial use of hydrocarbon mixtures leading to skin diseases.	39	3.28	0.972
Photo-allergenic substances in the workplace, the health effects of which are increasing due to the thinning of the ozone layer.	39	3.08	0.984
Natural latex.	44	2.84	1.328

Note: N = number of experts answering the specific item.



### 5.3.1. Experts' comments

When available, the comments added by the respondents to the items are listed below to provide some context and support to the ratings.

#### *Risks strongly agreed as emerging ( $MV > 4$ )*

##### **Epoxy resins**

One respondent mentioned that, in Denmark, there is compulsory training for workers who use epoxy resins (and isocyanates) at work. One objective is to train workers on how to work safely with these products. Although not all workers using epoxy resins (and isocyanates) have actually completed the training and the problems with these products have not been completely solved in Denmark, the respondent's view is that the risks linked to these products are not emerging risks in Denmark; according to the respondent, this was confirmed in a Nordic report on the subject a few years ago. According to the same respondent, the use of epoxy (and isocyanates), which is expected to increase, must be continually monitored.

##### **Dermal exposure**

Health effects resulting from dermal exposure to dangerous substances are underestimated. Such exposures can lead not only to allergies but to many other adverse, cumulative effects. In Spain, the Social Security has supported a study on occupational diseases conducted by the main mutual insurance companies, including Mutua Universal. The study carried out by Mutua Universal covering the period 2005-2007 demonstrated clearly that work-related dermal diseases are increasing in absolute as well as in relative numbers.

In addition, three of the items identified as emerging risks – epoxy resins, isocyanates and dermal exposure – are interrelated at the level of the effects on workers. Indeed, epoxy resins and isocyanates are chemical sensitisers for which dermal exposure is the main way of penetration into the human body. The three items are all of concern in the construction sector, SMEs and self-employed workers.

##### **Isocyanates**

Exposure to isocyanates is more common than generally believed. Another respondent mentioned that, in Denmark, there is a compulsory training for workers who use isocyanates and epoxy resins at work. One objective is to train workers on how to work safely with these products. Although not all workers using isocyanates (and epoxy resins) have actually completed the training, and the problems with these products have not been completely solved in Denmark, the respondent's view is that the risks linked to these products are not emerging risks in Denmark; according to the respondent, this was confirmed in a Nordic report on the subject a few years ago. According to the same respondent, the use of isocyanates (and epoxy) is expected to increase and should be continually monitored (see same comment above by this respondent under epoxy resins).

#### *Risks agreed as emerging ( $3.25 < MV \leq 4$ )*

##### **Cleaning and disinfection agents**

Cleaning and disinfection agents used to clean metalworking machines and dirty cutting fluids, or those present in water-based cleaning products and in barrier creams, have negative health effects on workers.





*Chemicals and skin protection in cleaning, Courtesy of the skin protection campaign "Hautschutz Kampagne" of the Deutsche Gesetzliche Unfallversicherung (DGUV), Germany*

In addition, the use of enzymes in cleaning products increasingly leads to conjunctivitis, rhinitis, asthma and parenchymal diseases in workers. One expert added that there is an increasing use of cleaning and disinfection agents in the form of sprays.

### **Cutting fluids and mineral oil mist**

Cutting fluids and mineral oil mist – used, for example, in metal processing – contain many sensitizers and lead to many negative health effects such as cutaneous and respiratory diseases, as well as many not yet well-diagnosed problems.

### **Polymers**

Polymers – more particularly added hardeners such as acrylates and

isocyanates – and paint mist can reach the respiratory tract and lead to acute and chronic respiratory diseases.

### **Particles or irritant gases**

More research on particles and irritant gases leading to chronic obstructive pulmonary disease (COPD) is needed.

### **Hydrocarbon mixtures**

The increasing use of hydrocarbon mixtures in industrial applications is not only responsible for skin diseases but also for respiratory diseases.

### **Undecided ( $2.75 \leq MV \leq 3.25$ )**

### **Photo-allergic substances**

Workers are increasingly exposed to photo-allergic substances as a consequence of the increasing use of (photo-)printing equipment and ultraviolet radiation curing substances.

### **Natural latex**

One Dutch respondent felt that the risk of workers' exposure to natural latex is well controlled. Another one commented that it is mainly low-quality latex that puts workers at risks, hence the need for better quality control.

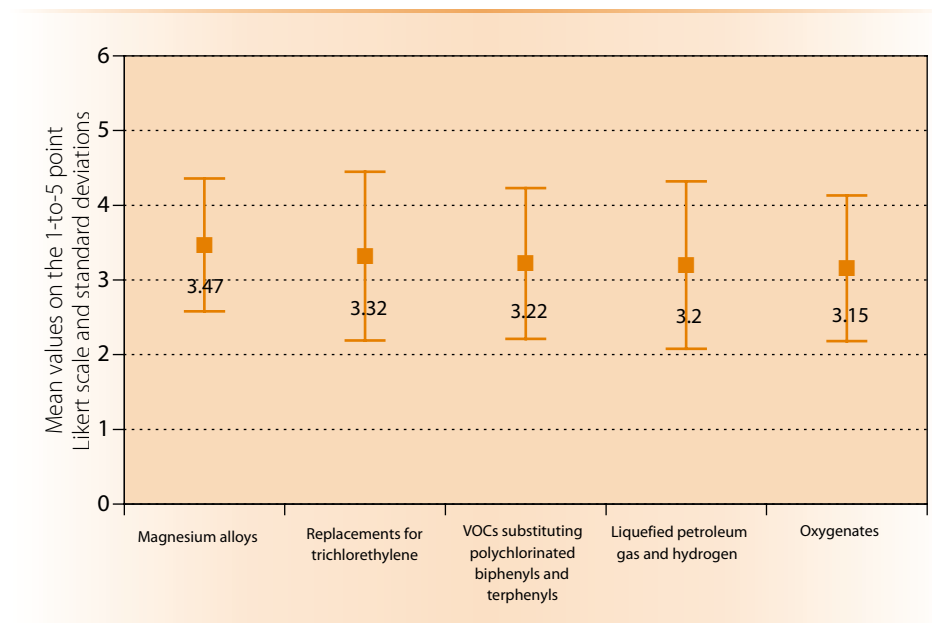
# 5.4.

## FLAMMABLE AND EXPLOSIVE SUBSTANCES

Diagram 9 summarises the risk rating by the survey respondents for flammable and explosive substances.

Two of the five flammable and explosive substances mentioned in the survey were perceived as emerging by the experts – none of them as strongly emerging.

**Diagram 9: Flammable and explosive substances identified in the survey**



The prioritised list of risks due to flammable and explosive substances identified in the survey is given in Table 10.

**Table 10: Prioritised list of chemical risks due to flammable and explosive substances identified in the survey**

	MV > 4: risk strongly agreed as emerging		2.75 ≤ MV ≤ 3.25: status undecided
	3.25 < MV ≤ 4: risk agreed as emerging		2 ≤ MV < 2.75: risk agreed as non-emerging

NB: None of the risks was strongly agreed as non-emerging (MV < 2).

Chemical risks due to flammable and explosive substances	N	Mean Value (MV)	Standard Deviation (SD)
Increasing use of magnesium alloys in the construction of cars, railway coaches and other machinery which makes them highly flammable and very difficult to extinguish, thus enhancing the risks not only for the fire brigades but for everybody involved.	38	3.47	0.893



Chemical risks due to flammable and explosive substances	N	Mean Value (MV)	Standard Deviation (SD)
Replacements for trichloroethylene in degreasing with flammable liquids.	41	3.32	1.128
Volatile organic compounds (VOCs): substitutes for polychlorinated biphenyls (PCBs) and terphenyls (PCTs) such as esters.	41	3.22	1.013
Liquefied petroleum gas (LPG) and hydrogen in the future – as substitutes for chlorofluorocarbons (CFCs), petrol, etc.).	41	3.20	1.123
Oxygenates used as additives in petrol (e.g. methyl tert-butyl ether (MTBE), di-tert-butyl ether).	40	3.15	0.975

Note: N = number of experts answering the specific item.

### 5.4.1. Experts' comments

When available, the comments added by the respondents to the items are listed below to provide some context and support to the ratings.

#### Undecided (2.75 ≤ MV ≤ 3.25)

##### Oxygenates

One expert commented that oxygenates used as additives in petrol are rather new and are widely used.

## 5.5. SUBSTANCES AND MIXTURES WITH UNKNOWN OR NEWLY RECOGNISED HEALTH EFFECTS

Diagram 10 summarises the risk rating by the survey respondents for substances and mixtures with newly recognised or unknown health effects.

Six out of the 10 items related to substances and mixtures with unknown or newly recognised adverse health effects were rated as 'strongly emerging' by the experts.

'Complex mixtures' is the item agreed as the emerging risk with the highest score in this part of the survey (MV=3.76). As occupational exposures to chemical mixtures and multiple stressors are the rule rather than the exception, both mixed exposures and exposure assessment methods are among the 21 research priorities of the US National Occupational Research Agenda (NORA) programme. NORA is committed to finding ways to tackle the complex area of health effects of such mixed exposures. It has found that the current substance-by-substance or stressor-by-stressor approach to hazard

*Occupational exposures to chemical mixtures and multiple stressors are the rule rather than the exception.*

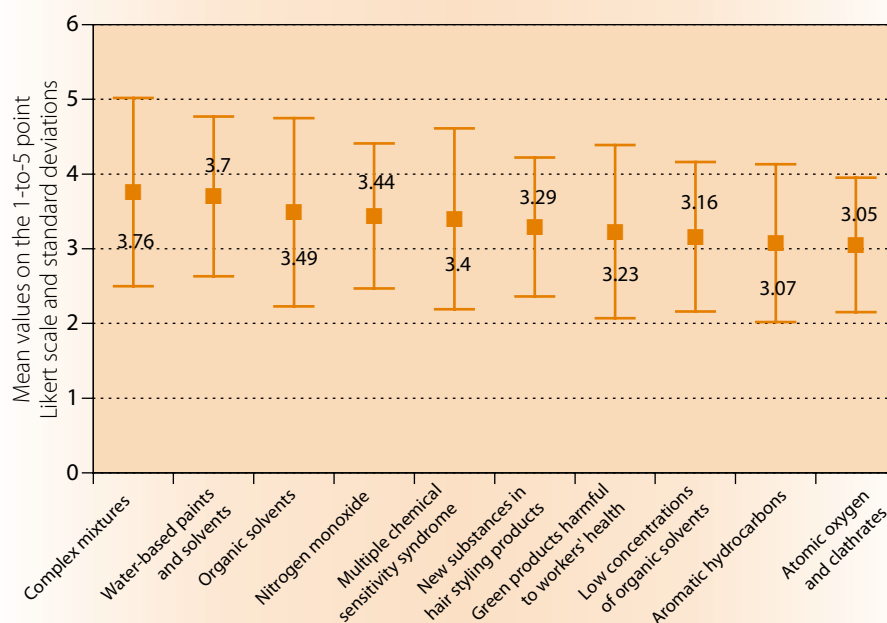


control is inadequate. The true risk for workers is likely to be underestimated when considering each stressor independently. The NORA mixed exposures team <sup>(151)</sup><sup>(152)</sup>

- has grouped these exposures into the following groups:
- complex mixtures such as combustion exhausts;
- mixtures with identifiable composition;
- mixed stressor exposures such as noise and chemicals;
- mixtures associated with particular workplaces or processes such as coal mine dust.

*The current substance-by-substance or stressor-by-stressor approach to hazard control is inadequate. The true risk for workers is likely to be underestimated when considering each stressor independently.*

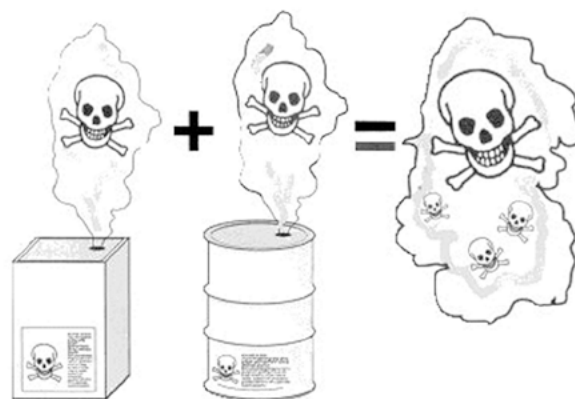
**Diagram 10: Chemical risks due to substances and mixtures with newly recognised or unknown health effects identified in the survey**



Although research can be directed at various specific mixtures in each of these categories, the NORA team recommends priority is given to those studies that yield a broader understanding of how mixed exposures increase the effect of the health response and, as far as possible, to simultaneously carry out the research with 'real world' mixtures which affect large numbers of workers.

Mixed exposures to dangerous substances and toxicology of combined mixtures were also identified as two of the main occupational safety and health priorities in a review carried out by the Agency of

**The toxic effect of a combination of two chemicals may be far greater than the sum of the toxic effects of each**



Combined exposures to dangerous substances, Courtesy of ILO.

<sup>(151)</sup> National Institute for Occupational Safety and Health (NIOSH), *Mixed exposure research agenda – a report by the NORA mixed exposures team*, DHHS (NIOSH) No. 2005-106, NIOSH, Washington DC, 2004.

<sup>(152)</sup> National Institute for Occupational Safety and Health (NIOSH), *NORA – mixed exposure team*. <http://www.cdc.gov/niosh/00-143ff.html>





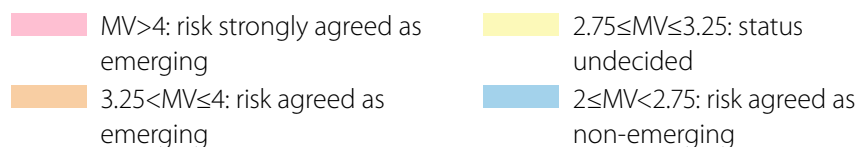
various national, EU and international resources aimed at identifying future EU research needs in the field of occupational safety and health <sup>(153)</sup>. The Agency will include a more detailed literature review exploring the issue of combined exposures to mixed dangerous substances in its work programme for 2008.

The level of consensus among the respondents was especially weak for the items:

- ‘complex mixtures’ (SD=1.264);
- ‘increasing use of organic solvents’ (SD=1.261);
- ‘multiple chemical sensitivity syndrome’ (SD=1.214).

The prioritised list of risks due to substances and mixtures with newly recognised or unknown health effects identified in the survey is given in Table 11.

**Table 11: Prioritised list of chemical risks due to substances and mixtures with newly recognised or unknown health effects identified in the survey**



NB: None of the risks was strongly agreed as non-emerging (MV < 2).

Chemical risks due to substances and mixtures with newly recognised or unknown health effects	N	Mean Value (MV)	Standard Deviation (SD)
Complex mixtures: unknown or toxic effects of the mixture although each compound separately is not toxic.	45	3.76	1.264
Water-based paints and solvents including different cellosolves (glycol ethers and derivates) containing preservative and antimicrobial agents. Potential health effects: skin allergies, nervous system damage, reproductive and mutagenic effect (cellosolves).	46	3.70	1.072
Increasing use of (new) organic solvents (e.g. glycol ether).	43	3.49	1.261
Exposure to nitric oxide (NO) (e.g. in processes involving diesel engines, warehouses, tunnel construction, etc.): The Scientific Committee for Occupational Exposure Limits (SCOEL) has reviewed the health effects of NO and recommends lowering the OEL for NO to 0.2 ppm.	45	3.44	0.967
Combined exposures leading to multiple chemical sensitivity syndrome (MCS): sensitisation to several substances characterised by a great variety of clinical symptoms (respiratory diseases, neurological diseases, musculoskeletal disorders, etc.).	45	3.40	1.214
New types of substances contained in hairstyling products (hair dyes, hair sprays, etc.) which could lead to new combined health effects.	41	3.29	0.929

<sup>(153)</sup> European Agency for Safety and Health at Work, *Priorities for occupational safety and health research in the EU-25*, Office for Official Publications of the European Communities, Luxembourg, 2005. <http://osha.europa.eu/en/publications/reports/6805648/view>



Chemical risks due to substances and mixtures with newly recognised or unknown health effects	N	Mean Value (MV)	Standard Deviation (SD)
'Green products': substitution of substances damaging the environment by substances which protect the environment but endanger workers' health.	44	3.23	1.159
Exposure to low concentrations of organic solvents, e.g. to low concentration of toluene or styrene suspected to lead to impairment of the visual function and to changes in neurobehavioral and neurochemical functions which are potential precursors of more serious adverse effects.	45	3.16	0.999
Aromatic hydrocarbons (e.g. styrene) leading to damage to airways and of the nervous system.	43	3.07	1.055
Atomic oxygen and clathrates used in air purification systems.	40	3.05	0.904

Note: N = number of experts answering the specific item.

### 5.5.1. Experts' comments

When available, the comments added by the respondents to the items are listed below to provide some context and support to the ratings.

#### *Risks agreed as emerging ( $3.25 < MV \leq 4$ )*

##### **Complex mixtures**

Complex mixtures – for example in technical mineral oil products, paint removers, water-based paints and solvents embracing different cellosolves (glycol ethers) – may have unknown dangerous (toxic) effects, although each individual compound may not be toxic on its own.

##### **Organic solvents**

The increasing use of (new) organic solvents, such as *n*-propyl bromide, which is used as a replacement for trichloroethylene ('trike') in degreasing tanks, may put workers at risk.

##### **Nitric oxide**

One expert noted that, in Poland, concentrations of nitric oxide (NO) in outdoor air are higher than 0.2 ppm.

##### **Combined exposures leading to multiple chemical sensitivity (MCS) syndrome**

One expert commented that the MCS cannot be regarded as a disease or a syndrome, and it is not an occupational safety and health issue.

##### **Substances in hairstyling products**

While one respondent commented that workers' exposure to new types of substances contained in hairstyling products is very limited, another reckoned that hairdressers are exposed



when they prepare hairstyling products by mixing some components in the form of powder more than when applying the final product to the client's hair.

*Undecided (2.75 ≤ MV ≤ 3.25)*

### **Green products**

Compounds such as chlorofluorocarbons (CFCs) are often substituted by liquefied petroleum gas (LPG) and hydrogen, polychlorinated biphenyls (PCB) by esters, and fuels by hydrogen or LPG. The health effects of these substitution products are not well-known and exposure may harm workers.

### **Low concentrations of organic solvents**

The exposure to low concentrations of ototoxic substances such as some organic solvents may harm the hearing. This is especially true for workers who are exposed to noise due to the synergistic interaction between the effects of noise and the exposure to organic solvents.

### **Aromatic hydrocarbons**

The exposure to aromatic hydrocarbons such as styrene is prevalent, for instance in the production of ship hulls and wind turbine blades. Styrene is a potential ototoxic substance and may harm the hearing, especially in combination with exposure to noise.

### **Atomic oxygen and clathrates**

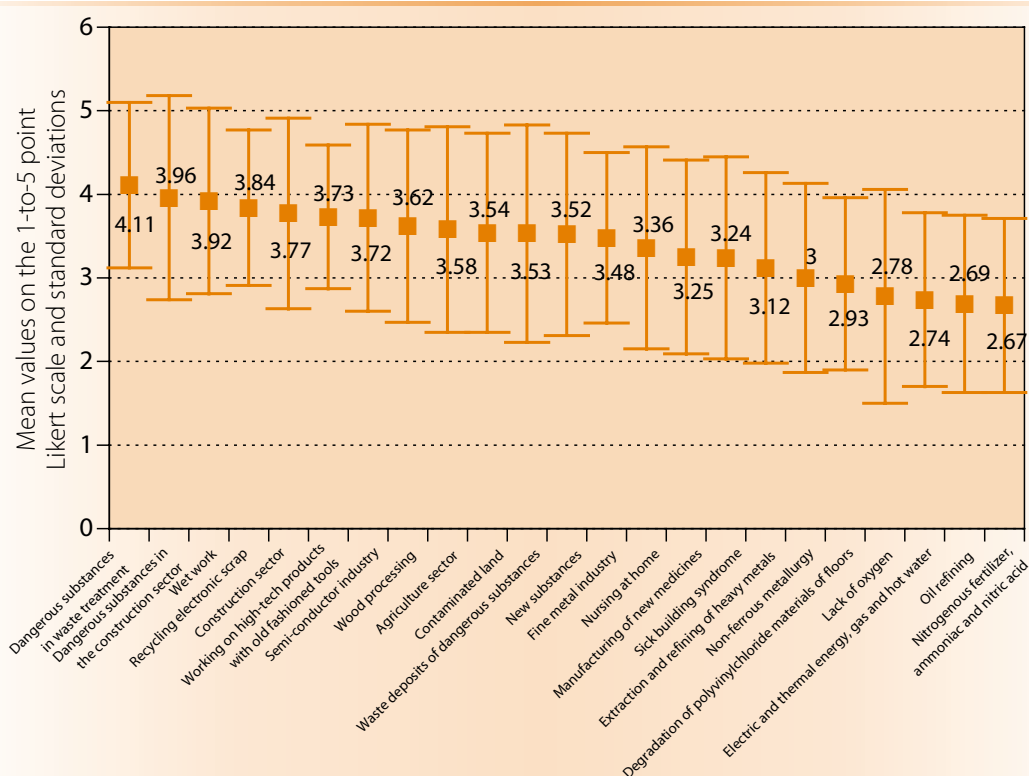
The exposure of workers to atomic oxygen and clathrates used in air purification systems is very limited.



# 5.6. CHEMICAL RISKS SPECIFIC TO WORK PROCESSES AND WORKPLACES

Diagram 11 summarises the risk rating by the survey respondents specific to work processes and workplaces.

**Diagram 11: Chemical risks specific to work processes and workplaces identified in the survey**



Only one item in this part of the survey was 'strongly agreed as emerging' risks (MV>4). This was 'dangerous substances in waste treatment' (MV=4.11) (see Section 4.2.5.).

'Dangerous substances in waste treatment' activities were also agreed to pose emerging risks to workers in another expert survey on emerging biological risks<sup>(154)</sup> with a view to determining workers' exposure to airborne micro-organisms.

Waste management is considered as one of the most hazardous occupations with an illness rate 50% higher and an infectious diseases rate six times higher than in other workers<sup>(155)</sup>. Another two items rated as emerging risks here also relate to waste management, i.e. the exposure to dangerous substances in the 'recycling of electronic scrap' (MV=3.84) and 'uncontrolled waste deposits of dangerous substances' (MV=3.53). A fourth item, which explicitly mentions the exposure to 'dust mixtures in the recycling

*Waste management is considered as one of the most hazardous occupations with an illness rate 50% higher and an infectious diseases rate six times higher than in other workers.*

<sup>(154)</sup> European Agency for Safety and Health at Work, *Expert forecast on emerging biological risks related to occupational safety and health*, Office for Official Publications of the European Communities, Luxembourg, 2007. [http://riskobservatory.osha.europa.eu/risks/forecasts/biological\\_risks/](http://riskobservatory.osha.europa.eu/risks/forecasts/biological_risks/)

<sup>(155)</sup> Bomel Limited, *Mapping health and safety standards in the UK waste industry*, Research Report 240, Health and Safety Executive (HSE), Sudbury, UK, 2004. <http://www.hse.gov.uk/research/rrpdf/rr240.pdf>



sector' (MV=3.82), is identified as an emerging risk in the section of the survey on particles, dusts and aerosols (see Section 5.1.). This confirms the survey participants' concern for the risks in the relatively new industry of waste management.

Furthermore, 14 items out of the 23 chemical risks specific to work processes and workplaces identified were rated as emerging risks ( $3.25 < MV \leq 4$ ). It is interesting to note that none of these items are in the chemical industry or in industries where chemicals are used intentionally in the work process (except the two items linked to cleaning work and nursing, where the use of the chemicals in question is necessary for proper performance of the work), but rather where dangerous substances are incidental products of the work.

*The construction sector is one of Europe's largest industries but also one with the worst occupational safety and health record.*

*Construction workers may be exposed to dust generated from cutting or handling crystalline silica-based products.*

*The social partners signed a European multi-sector agreement aimed at reducing workers' exposure to crystalline silica dust through good practice in the workplace in 2006.*

The **construction sector** is one of Europe's largest industries but also one with the worst occupational safety and health record <sup>(156)</sup><sup>(157)</sup>. Construction workers are exposed to a wide range of dangerous substances in addition to noise, vibrations, falls from height and musculoskeletal disorders.

Respiratory problems are widespread, not least due to **asbestos** <sup>(156)</sup>. Although the use of asbestos is now virtually banned in the European Union, 600,000 construction workers are still exposed to asbestos each year <sup>(158)</sup>.

In addition, construction workers may be exposed to dust generated from cutting or handling **crystalline silica-based products** such as sand <sup>(156)</sup>. According to CAREX, 3.2 million of the 32 million workers exposed to carcinogens in the EU-15 between 1990 and 1993 were exposed at least 75% of their working time to crystalline silica <sup>(158)</sup>. There is currently no OEL for respirable crystalline silica at an EU level <sup>(159)</sup>. Although the Committee on Employment and Social Affairs of the European Parliament in its draft report on the Community strategy 2007-2012 on health and safety at work <sup>(160)</sup> considered the establishment of a binding occupational exposure limit value (BOELV) for crystalline silica to be a priority <sup>(161)</sup>, the proposal was rejected in a vote of the European Parliament in January 2008. The social partners signed a European multi-sector agreement aimed at reducing workers' exposure to crystalline silica dust through good practice in the workplace in 2006 <sup>(159)</sup>. The agreement covers more than two million workers in many different sectors across Europe.

<sup>(156)</sup> European Agency for Safety and Health at Work, *European Week 2004: Building in Safety*. <http://ew2004.osha.europa.eu/static/about2004>

<sup>(157)</sup> European Construction Industry Federation (FIEC), *Construction in Europe – key figures*. <http://www.fiec.org/Content/Default.asp?PageID=5>

<sup>(158)</sup> Kauppinen, T. et al., *CAREX – International Information System on Occupational Exposure to Carcinogens. Occupational exposures to carcinogens in the European Union in 1990-1993*, Finnish Institute of Occupational Health, Helsinki, 1998. [http://www.ttl.fi/NR/rdonlyres/4444380F-B1FB-4D01-A974-0B6A9E663CFA/0/1\\_description\\_and\\_summary\\_of\\_results.pdf](http://www.ttl.fi/NR/rdonlyres/4444380F-B1FB-4D01-A974-0B6A9E663CFA/0/1_description_and_summary_of_results.pdf)

<sup>(159)</sup> European Network on Silica, *Agreement on Workers Health Protection through the Good Handling and Use of Crystalline Silica and Products containing it*. <http://www.nepsi.eu/agreement.aspx>

<sup>(160)</sup> European Parliament Committee on Employment and Social Affairs, *Draft report on the Community strategy 2007-2012 on health and safety at work*, Provisional 2007/2146(INI), 14 September 2007. [http://www.europarl.europa.eu/registre/commissions/empl/projet\\_rapport/2007/393990/EMPL\\_PR\(2007\)393990\\_EN.doc](http://www.europarl.europa.eu/registre/commissions/empl/projet_rapport/2007/393990/EMPL_PR(2007)393990_EN.doc)

<sup>(161)</sup> *Directive 2004/37/EC on the protection of workers from the risks related to exposure to carcinogens or mutagens at work*, Official Journal, 30 April 2004, L158, p. 50 plus correction in Official Journal, 29 June 2004, L229, pp.23-34. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:229:0023:0034:EN:PDF>



Workers of the construction sector are also exposed to **solvents** and other dangerous substances that heighten their health risks. Frequent contact with liquid-based substances such as **oils, resins and cement-based products containing chromium (VI)** exacerbate the likelihood of skin problems. Excessive contact with **lead** – for example when working with old lead piping or removing lead-based paints – can damage the central nervous system producing nausea, headaches, tiredness and other symptoms. Studies have also shown an increased risk of early retirement among floor layers and painters due to **'solvent syndrome'** – the neuro-psychiatric symptoms associated with excessive exposure to organic solvents such as glycol ethers and esters. These symptoms can include memory loss, severe fatigue and other problems of the central nervous system <sup>(162)</sup>.

In the EU-25 at the beginning of the 21st century, the construction industry employed 1.2 million workers exposed to **wood dust** – mostly carpenters. They have an elevated risk of contracting nasal cancer as a result of breathing in wood dust <sup>(163)</sup>. See Section 4.1. for more detailed information on dangerous substances in the construction industry.

In addition, exposure to hardwood dust was specifically mentioned as an emerging risk in a separate item (MV=3.62).

The experts rated as 'non-emerging risks' the exposure to dangerous substances in three types of workplaces:



- in the 'production of electric and thermal energy, and gas and hot water';
- in 'oil refining';
- in the 'production of nitrogenous fertiliser, ammonia and nitric acid'.

Nevertheless, the consensus among the experts was especially low for the following items:

- 'uncontrolled waste deposits of dangerous substances' (SD=1.297);
- 'confined workplaces' (SD=1.277);
- 'agriculture sector' (SD=1.234);
- exposure to chemical agents in the construction sector' (SD=1.224);
- 'nursing at home' (SD=1.209);
- 'indoor workplaces: sick building syndrome' (SD=1.209);
- 'processing and use of new substances' (SD=1.206).

The prioritised list of risks specific to work processes and workplaces identified in the survey is given in Table 12.

<sup>(162)</sup> European Agency for Safety and Health at Work, *Building in Safety – European Week 18–22 October 2004*. [http://ew2004.osha.europa.eu/static/whyconstruction/index.htm#bmk\\_yawc\\_30](http://ew2004.osha.europa.eu/static/whyconstruction/index.htm#bmk_yawc_30)

<sup>(163)</sup> Kauppinen, T. et al., *Occupational exposure to inhalable wood dust in the Member States of the European Union, Annals of Occupational Hygiene*, Vol. 50, No. 6, 2006, pp. 549-561.



**Table 12: Prioritised list of chemical risks specific to work processes and workplaces identified in the survey**

- $MV > 4$ : risk strongly agreed as emerging
- $2.75 \leq MV \leq 3.25$ : status undecided
- $3.25 < MV \leq 4$ : risk agreed as emerging
- $2 \leq MV < 2.75$ : risk agreed as non-emerging

NB: None of the risks was strongly agreed as non-emerging ( $MV < 2$ ).

Chemical risks specific to work processes and workplaces	N	Mean Value (MV)	Standard Deviation (SD)
Industrial, medical and domestic waste treatment: exposure to dust, microbes and endotoxins.	46	4.11	0.994
Construction sector (civil and industrial sector, including demolition, rebuilding and renovation activities): exposure to chemical agents (crystalline silica dust, asbestos, wood dust, diesel engine exhaust, welding fumes) leading to occupational cancers.	45	3.96	1.224
Wet work (in hospitals, cleaning, catering, metal work, hairdressing) leading to skin diseases: increasing numbers of sensitised workers due to an increase in atopic dermatitis.	48	3.92	1.108
Recycling electronic scrap involving dangerous metals and chemicals: increasing activity due to the rising trend of manufacturing always newer technologies to replace older electronic devices.	45	3.84	0.928
Construction sector: exposure of poorly qualified workers to isocyanates.	44	3.77	1.138
Working on high-tech products with old fashioned tools (e.g. removing catalytic converters from cars, recycling computer equipment, dismantling of rare non-ferrous metals) leading to skin sensitisation and respiratory diseases.	45	3.73	0.863
Semi-conductor industry: exposure to metal fumes and dust leading to skin sensitisation and respiratory diseases.	43	3.72	1.120
Wood processing: exposure to hardwood dust, solvents and formaldehyde in glue and surface coatings leading to occupational cancers.	45	3.62	1.154
Agriculture sector: exposure to farm dust, fungi and pesticides leading to allergies and poisoning.	45	3.58	1.234
Handling and treatment of contaminated land (e.g. former wood impregnation sites, lead foundries, petrol stations): new exposure to old 'buried' chemicals with high toxic potential.	46	3.54	1.187
Uncontrolled/unmaintained waste deposits of dangerous substances where the risks are difficult to identify and to control.	43	3.53	1.297
Processing and use of new substances.	46	3.52	1.206
Fine metal industry: widespread use of specialised tools at poorly monitored workplaces (e.g. welding non-ferrous metals) leading to respiratory diseases.	44	3.48	1.023



Chemical risks specific to work processes and workplaces	N	Mean Value (MV)	Standard Deviation (SD)
Nursing at home: exposure of (less trained) self-employed medical staff to chemical agents (e.g. cytostatic agents involved in cancer therapy) in a working environment where the safety conditions are less easy to control than in hospitals.	45	3.36	1.209
Manufacturing of new medicines, which is a continuously renewing area.	44	3.25	1.164
Sick Building Syndrome at indoor workplaces due to indoor emissions and/or poor heating ventilation and air conditioning (HVAC).	45	3.24	1.209
Extraction and refining of heavy metals.	43	3.12	1.138
Non-ferrous metallurgy (metallurgy of lead, copper, manganese).	43	3.00	1.134
Indoor workplaces: degradation of polyvinylchloride (PVC) materials of floors due to moisture and ageing of the material causing airway diseases (infections and asthma).	43	2.93	1.033
Confined workplaces: lack of oxygen leading to death and invalidity.	45	2.78	1.277
Production of electric and thermal energy, of gas and hot water: exposure to the dangerous substances involved (e.g. fuel combustion exhausts) leading to occupational cancers.	42	2.74	1.037
Oil refining.	45	2.69	1.062
Production of nitrogenous fertiliser, ammonia and nitric acid.	43	2.67	1.040

Note: N = number of experts answering the specific item.

### 5.6.1. Experts' comments

When available, the comments added by the respondents to the items are listed below to provide some context and support to the ratings.

#### *Risks agreed as strongly emerging (MV > 4)*

#### **Exposure to dangerous substances in industrial, medical and domestic waste treatment activities**

Hygiene conditions in the field of industrial, medical and domestic waste treatment are often poor. In addition to hazardous chemicals, workers are exposed most of the time to dust, microbes and endotoxins. Another respondent added that dangerous substances in waste treatment could indeed be an emerging problem since new environmental legislation with respect to recycling of materials from used cars and electronics will result in more workers in dismantling jobs. According to the same respondent, the demand for electronics and hence the production of electronic waste is also increasing in Denmark, as in most other countries.





### *Risks agreed as emerging ( $3.25 < MV \leq 4$ )*

#### **Exposure to chemical agents in the construction sector**

Although one respondent reckoned that the exposures to dangerous substances in the construction industry and how to deal with these are well-known, another commented that multiple exposures to dangerous substances are not well-assessed in this industry and difficult to control. The exposure to isocyanates was specifically mentioned and the exposure to wood dust in the construction industry was said to be higher than previously thought. The respondents added that the construction industry employs many poorly qualified workers who are generally not aware about the risks from dangerous substances. However, dangerous substances in the construction industry are not seen as a new or increasing problem in Denmark according to one respondent.

#### **Wet work**

There are an increasing number of sensitised workers as a consequence of performing wet work and the prevalence of atopic dermatitis, irritant dermatitis or contact sensitisation is rising. The cumulative effects of exposure to wet work in the metal industry were noted.

#### **Exposure of poorly qualified workers to isocyanates in the construction sector**

Although the properties of isocyanates and how to deal with them are well-known, the level of workers' awareness is low and there is a need for workers' information.



#### **Agriculture sector: exposure to farm dust, fungi and pesticides leading to allergies and poisoning**

Workers are rarely aware of these risks.

#### **Handling and treatment of contaminated land (e.g. former wood impregnation sites, lead foundries, petrol stations): new exposure to old 'buried' chemicals with high toxic potential**

One expert commented that workers involved in the handling and treatment of contaminated land are also exposed to vinyl chloride emissions from landfill sites.

#### **Processing and use of new substances**

This risk is seen as increasing especially in relation to carcinogenic, mutagenic and reprotoxic substances (CMRs), man-made mineral fibres and persistent organic pollutants (POPs). Workers in university laboratories are particularly at risk as the work organisation is poor. Respondents also deplored the fact that new substances are not assessed with respect to their reprotoxicity until used in large amounts.



**Undecided ( $2.75 \leq MV \leq 3.25$ )****Manufacturing of new medicines, which is a continuously renewing area**

Some experts were of the opinion that occupational safety and health standards and hygiene practices are usually very good in the pharmaceutical industry and that, as a consequence, workers' exposure to dangerous substances is usually low. Other experts reported that medical staff could be exposed via contamination on the outside surface of drug vials or as a result of drug leakage.

**Extraction and refining of heavy metals**

The extraction and refining of heavy metals mainly takes place during the treatment of electric and electronic waste in the recycling industry. One expert felt the health hazards of this kind of work were well-known and controlled.

**Non-ferrous metallurgy (metallurgy of lead, copper, manganese)**

One respondent commented that the properties of these substances are well-known and it is known how to deal with them.

**Indoor workplaces: degradation of polyvinylchloride (PVC) materials of floors due to moisture and ageing of the material causing airway diseases (infections and asthma):**

The degradation of polyvinylchloride (PVC) materials of floors may cause respiratory diseases (infections and asthma) at indoor workplaces. However, another expert reckoned that this is a broader issue not only related to occupational safety and health.

**Confined workplaces: lack of oxygen leading to death and invalidity**

The lack of oxygen (e.g. in confined workplaces where there are diesel exhausts) may even lead to death. Workers must be made aware of the risk and wear the appropriate respiratory protection including air supply.

**Risks agreed as non-emerging ( $2 \leq MV < 2.75$ )****Production of electric and thermal energy, of gas and hot water: exposure to the dangerous substances involved in the process (e.g. fuel combustion exhausts) leading to occupational cancers**

The exposure to dangerous substances in this area is regarded as rather low.





**Oil refining**

The occupational safety and health standards in the oil industry are high and the risks are well known and controlled.

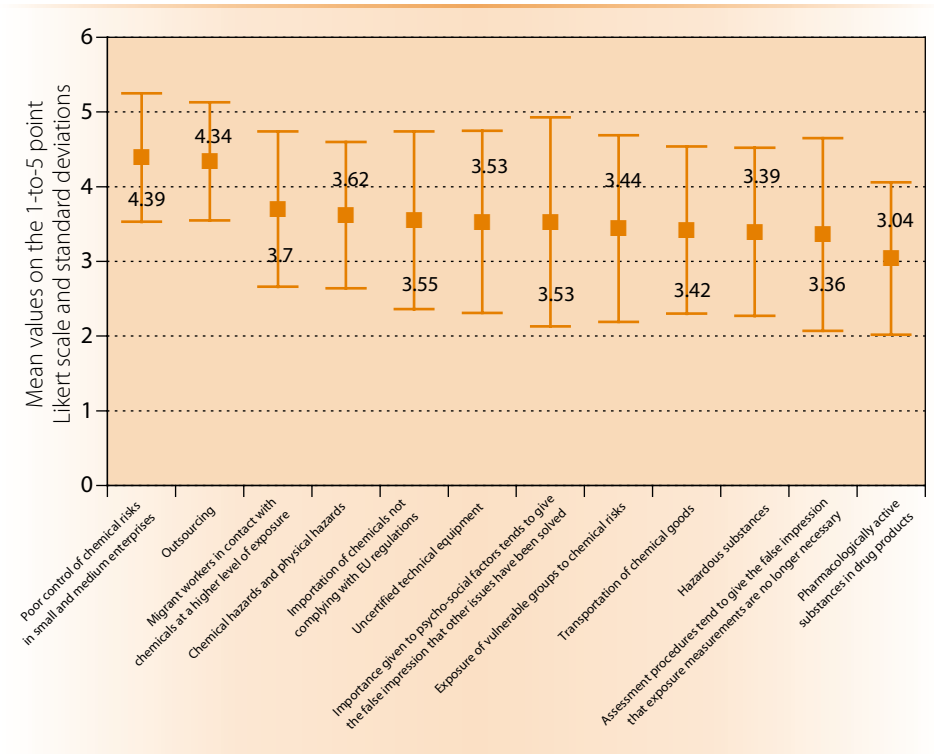
**Production of nitrogenous fertiliser, ammonia and nitric acid**

The health-damaging properties are well known and controlled.

# 5.7. MULTI-FACTORIAL RISKS RELATED TO DANGEROUS SUBSTANCES

Diagram 12 summarises the rating by the survey respondents for multi-factorial risks related to dangerous substances.

**Diagram 12: Multi-factorial risks related to dangerous substances identified in the survey**



Almost all of the items (11 of 12) related to multi-factorial chemical risks are agreed or even strongly agreed (two items) to be 'emerging risks' by the experts.

In particular, 'poor control of chemical risks in small and medium enterprises' (see Section 4.2.6.) and 'outsourced activities presenting chemical risks (e.g. in cleaning and maintenance activities) performed by subcontracted workers with poor knowledge of dangerous substances' are strongly seen as emerging and, especially for the latter item, the level of consensus among the respondents can be described as high.

Increasing mobility of workers is one of the growing demographic changes worldwide including in the EU. Migration is likely to increase in the next decade. The survey participants highlighted the higher exposure of migrant workers to dangerous substances as an emerging risk (MV=3.70). An Agency report <sup>(164)</sup> giving an overview of the most important occupational safety and health issues of migrant workers confirms that their working conditions are often more unfavourable than those of native workers.

The item 'combined effects of chemical hazards with physical hazards (e.g. ototoxic products and noise)' was rated as an emerging risk (MV=3.62) in this survey. This item was also rated as an emerging risk with a comparable mean value (MV=3.87) in a similar expert forecast on emerging physical risks <sup>(165)</sup>. The consistency in the respondents' evaluation in the two surveys may be considered to validate the forecast. Furthermore, a review carried out by the Agency <sup>(166)</sup> of various national, EU and international resources identifying future research needs in the field of occupational safety and health confirmed that 'many workers are exposed to a combination of low-dose substances that interact with other occupational risks such as noise, vibration, radiation and psychosocial factors'.

According to the Agency's ERO report, *Noise in figures* <sup>(167)</sup>, sectors with high exposures of workers to noise also have high exposures to dangerous substances (e.g. pesticides and solvents) and vibrations. Exposure to chemical solvents can affect hearing and such effects are probably underestimated. It is estimated that some 30 million people may work in environments where industrial chemicals may pose a serious hazard to hearing and balance <sup>(168)</sup>.

The effect of solvents on hearing has largely gone unnoticed as hearing impairment has been attributed to exposure to noise, which co-exists in industry and the possibility of potentiation by solvents remains unchecked. Known ototoxins include:

- solvents – carbon disulphide, *n*-hexane, styrene, toluene, trichloroethylene, xylene;

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*An Agency report giving an overview of the most important occupational safety and health issues of migrant workers confirms that their working conditions are often more unfavourable than those of native workers.*

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*Sectors with high exposures of workers to noise also have high exposures to dangerous substances (e.g. pesticides and solvents). Exposure to chemical solvents can affect hearing and such effects are probably underestimated.*

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<sup>(164)</sup> European Agency for Safety and Health at Work, *Literature study on migrant workers*, Office for Official Publications of the European Communities, Luxembourg, 2007. [http://osha.europa.eu/en/publications/literature\\_reviews/migrant\\_workers/view](http://osha.europa.eu/en/publications/literature_reviews/migrant_workers/view)

<sup>(165)</sup> European Agency for Safety and Health at Work, *Expert forecast on emerging physical risks related to occupational safety and health*, Office for Official Publications of the European Communities, Luxembourg, 2005. ISBN 92-9191-165-8. <http://osha.europa.eu/en/publications/reports/6805478/view>

<sup>(166)</sup> European Agency for Safety and Health at Work, *Priorities for occupational safety and health research in the EU-25*, Office for Official Publications of the European Communities, Luxembourg, 2005. <http://osha.europa.eu/en/publications/reports/6805648/view>

<sup>(167)</sup> European Agency for Safety and Health at Work, *Noise in figures*, Office for Official Publications of the European Communities, Luxembourg, 2006. <http://osha.europa.eu/en/publications/reports/6905723/view>

<sup>(168)</sup> *Noise and industrial chemicals: interaction effects on hearing and balance*. NoiseChem project description, RTD projects database, Cordis (Community Research and Development Information Service) website. [http://ica.cordis.lu/search/index.cfm?fuseaction=proj.simplifiedocument&PJ\\_RCIN=5267523&CFID=51899&CFTOKEN=27235854](http://ica.cordis.lu/search/index.cfm?fuseaction=proj.simplifiedocument&PJ_RCIN=5267523&CFID=51899&CFTOKEN=27235854)



- metals – arsenic, organotin, mercury and derivatives, manganese;
- drugs – some chemotherapy agents, antibiotics and aspirin and related medication;
- asphyxiates – carbon monoxide.

Industries with potential for hazardous combined exposure include printing, painting, boat building, construction, glue manufacturing, metal products, chemicals, petroleum, leather products and furniture making. This is also the case for agriculture and mining. This might enhance the effects of noise on hearing loss. Combined exposure to noise, vibration and heat can also occur in foundries. Many of these sectors are more predominant in the new Member States than they are in the EU-15 <sup>(169)</sup>. A further Agency’s ERO report dedicated to the combined exposure to ototoxic substances and noise will be published in 2009. The consistent results between the forecast and the review strengthen the importance of this issue.

In 2008, the Agency’s European Risk Observatory will start a more in-depth project aimed at providing a comprehensive picture of the risks associated with combined workplace exposure to noise and other substances that may affect the hearing ability of workers and of the ways in which they are being addressed across Europe.

The experts reached a low level of consensus for the following items:

- ‘importance given to psychosocial factors tends to give the false impression that issues related to dangerous substances have been solved’ (SD=1.403);
- ‘assessment procedures tend to give the false impression that exposure measurements are no longer necessary’ (SD=1.293);
- ‘exposure of vulnerable groups to chemical risks’ (SD=1.253);
- the use of ‘uncertified technical equipment’ (SD=1.217).

The prioritised list of multi-factorial risks related to dangerous substances identified in the survey is given in Table 13.

**Table 13: Prioritised list of multi-factorial risks related to dangerous substances**

	MV>4: risk strongly agreed as emerging		2.75≤MV≤3.25: status undecided
	3.25<MV≤4: risk agreed as emerging		2≤MV<2.75: risk agreed as non-emerging

NB: None of the risks was strongly agreed as non-emerging (MV<2).

Multi-factorial risks related to dangerous substances	N	Mean Value (MV)	Standard Deviation (SD)
Poor control of chemical risks in small and medium enterprises (SMEs).	46	4.39	0.856
Outsourced activities presenting chemical risks (e.g. in cleaning and maintenance activities) performed by subcontracted workers with poor knowledge of dangerous substances	47	4.34	0.788
Increasingly migrant workers (legal and illegal) are exposed to dangerous substances in their jobs at a level of concentration often higher than the Occupational Exposure Limit (OEL).	43	3.70	1.036

<sup>(169)</sup> European Survey of Working Conditions (ESWC)



Multi-factorial risks related to dangerous substances	N	Mean Value (MV)	Standard Deviation (SD)
Combined effects of chemical hazards with physical hazards (e.g. ototoxic products and noise).	45	3.62	0.984
Increasing importation of chemicals not complying with EU regulations (e.g. impure substances, wrong labelling of dangerous substances) making exposure control and risk assessment more difficult in workplaces.	44	3.55	1.190
Use of uncertified technical equipment and modification of it by non-certified staff – especially in SMEs – in order to cope with the market demand leading to the use of hazardous substances in poor safety conditions.	45	3.53	1.217
The importance given to psychosocial factors tends to give the false impression that chemical risks (and other OSH issues) have been solved.	43	3.53	1.403
Increased exposure of vulnerable groups to chemical risks (young workers, elderly workers, women, workers with chronic health problems) as a consequence of high unemployment rate.	45	3.44	1.253
Increasing transportation of chemical goods leading to more accidents involving dangerous substances.	45	3.42	1.118
Increase in the use of hazardous substances in the European Union leading to an increase in the number of diseases of systemic body functions (allergies, diseases of the neurological system, skin diseases, cancer and diseases of the endocrine system) as opposed to diseases caused by a single substance.	44	3.39	1.125
Assessment procedures based on models such as the COSHH (Control of Substances Hazardous to Health) Essentials tend to give the false impression that exposure measurements are no longer necessary.	47	3.36	1.293
Increasing exposure to pharmacologically active substances in drug products.	45	3.04	1.021

Note: N = number of experts answering the specific item.

### 5.7.1. Experts' comments

When available, the comments added by the respondents to the items are listed below to provide some context and support to the ratings.

#### *Risks agreed as strongly emerging (MV > 4)*

##### **Poor control of chemical risks in small and medium enterprises**

There is a general lack of information and awareness regarding occupational safety and health in SMEs, which together are also the biggest employer in Europe. These problems remain to be solved. More attention has to be paid to SMEs and, in particular, more resources for occupational safety and health should be made available to this group. This factor, together with the trend to outsource, results in dangerous procedures often being performed by workers with poor knowledge of dangerous substances. However, one respondent from Denmark commented that this is a well-known problem in Denmark and that this is not emerging.



### **Outsourced activities presenting chemical risks (e.g. in cleaning and maintenance activities) performed by subcontracted workers with poor knowledge of dangerous substances**

This type of outsourced activity is increasingly performed by workers from new EU Member States who are not able to communicate properly in the host country and have poor knowledge about dangerous substances.

#### *Risks agreed as emerging ( $3.25 < MV \leq 4$ )*

### **Increasingly migrant workers are exposed to dangerous substances in their jobs**

The number of migrant workers has increased considerably in recent years in some Member States such as Spain. Many of these workers are poorly skilled; some of them do not speak the national language of the host country, and most of them have a low or non-existent level of awareness of occupational safety and health risks. The sum of all these factors can be fatal in some situations.

Another issue which should be considered is the mobility of workers between Member States. This particular situation is linked to the danger of losing track of the history of exposure of the workers who can be exposed to different chemicals in each job they may have in the different countries where they work. Public institutions should therefore establish a mechanism of co-ordinating information on exposure for every worker. This information could be made available to the person or department in charge of health surveillance in every company. These historical records of exposure would allow every employer to provide proper health surveillance to all workers as well as safe workplaces.

### **Combined effects of chemical hazards with physical hazards (e.g. ototoxic products and noise)**

One respondent from Austria commented that Austrian experts believe the combined exposure to noise and ototoxic substances is an important problem and that the fact it has not been rated as an emerging risk with a high consensus may be linked to different national contexts and awareness from the respondents to the survey.

### **Import of chemicals not complying with EU regulations**

The increasing quantity of imported chemicals not complying with EU regulations (e.g. impure substances or wrong labelling of dangerous substances) makes exposure control and risk assessment at workplaces more difficult. However, one respondent hoped that REACH<sup>(170)</sup> will help to solve this problem.

### **The importance given to psychosocial factors tends to give the false impression that chemical risks (and other issues) have been solved**

The importance given to psychosocial factors means that other more 'classical' technical occupational safety and health risks such as chemical risks are less visible and, as a consequence, are being underestimated.

### **Use of uncertified technical equipment**

One respondent gave the example of cheap electronic tools used in the energy sector that produce more dust.

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<sup>(170)</sup> European regulatory framework for the Registration, Evaluation and Authorisation of Chemicals.



### **Exposure of vulnerable groups to chemical risks**

Worker groups more vulnerable to poor occupational safety and health conditions such as young workers, elderly workers, women, workers with chronic health problems are increasingly exposed to dangerous substances such as CMRs as the increasing unemployment rate pushes them to accept low quality jobs. Nevertheless, one respondent mentioned that awareness of this phenomenon is increasing and that some preventive measures have already been taken.

### **Assessment procedures based on models such as the COSHH Essentials (Control of Substances Hazardous to Health) tend to give the false impression that exposure measurements are no longer necessary**

Respondents deplored the fact that concentration measurements are performed in very few SMEs. One respondent thought that risk assessments completed with the help of computer-based tools by under-qualified people are often inadequate. Another mentioned that proper risk assessment can only be performed by competent experts and that models should be seen only as a complementary tool.

*Undecided (2.75 ≤ MV ≤ 3.25)*

### **Pharmacologically active substances in drug products**

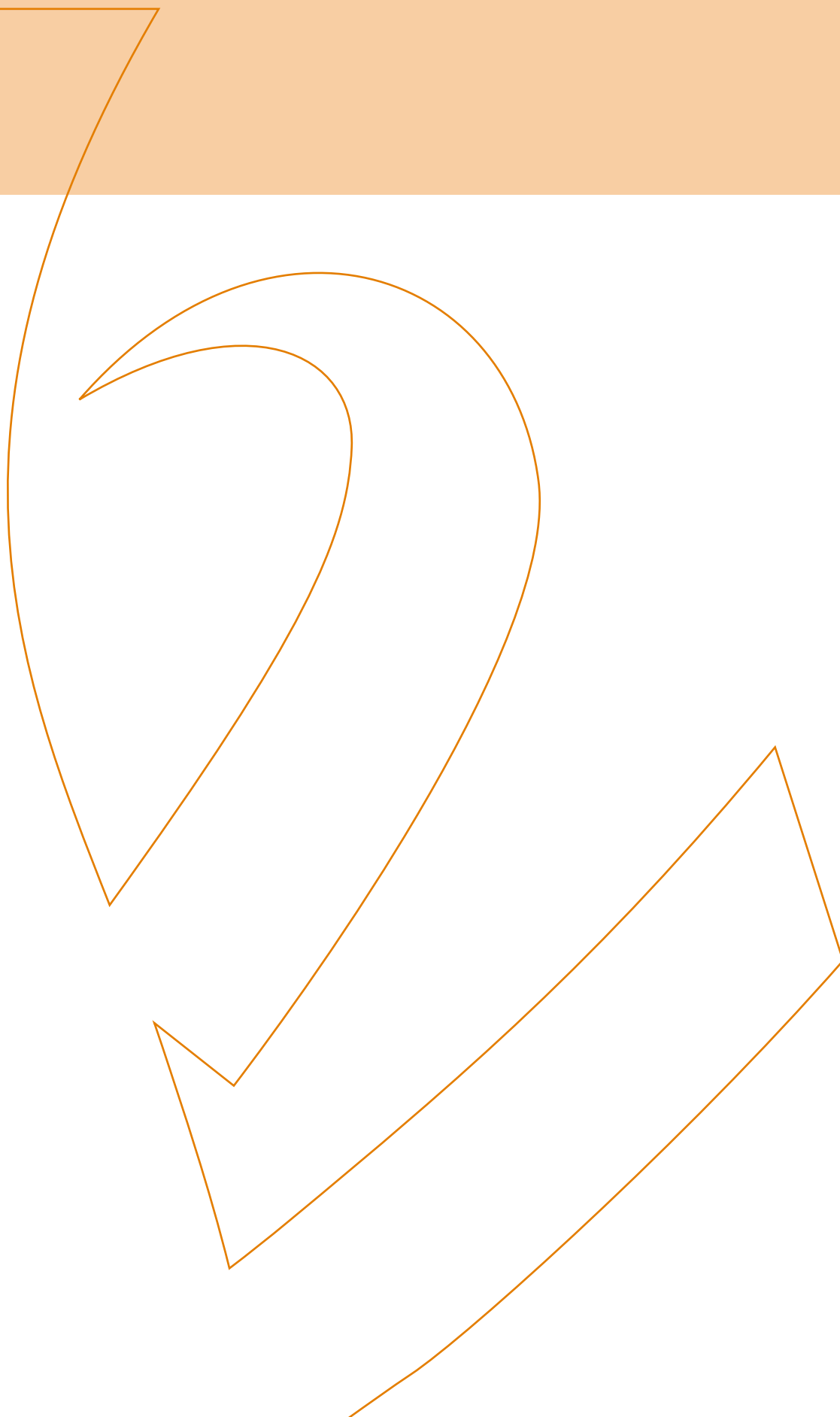
Workers' exposure to antibiotics is regarded as more problematic than cytostatics.





# 6.

## CONCLUSION



Occupational risks from chemicals are a very wide ranging and extremely challenging subject. The extent of the problem is primarily due to:

- the number of existing chemicals;
- the variety of their applications and types of workplaces where they are used;
- the multiplicity of their combinations found in most workplaces in addition to other types of exposures such as noise;
- the range of routes through which chemicals can enter the human body;
- the types of adverse health effects the chemicals may cause, which themselves vary greatly from one person to the other.

It is the wideness of these multiple exposures, multiple mechanisms and multiple outcomes – within the context of the permanently changing world of work – which makes the issue of dangerous substances complex and challenging when it comes to control. The large number of items mentioned and acknowledged as emerging risks in this forecast reflects this.

Given the complexity of the issue of chemical risks in the workplace and the very different national contexts throughout Europe, it is clear that such a survey could not be expected to obtain a consensual view of a situation true for all EU Member States. For some issues, there may well be no consensual European view but diverging views depending on the national context of the Member States. However, the survey was able to highlight a number of possible emerging problems, many of which were indeed common to most Member States. In addition, because the survey relied on the goodwill of the experts to complete the questionnaires, there was no way to avoid over- or under- representation by countries. Germany was actually over-represented with almost one third of the answers and this may have biased the results, especially because Germany is a leader in terms of the chemical industry.

The items identified are already existing, well-identified risks – perhaps with the exception of nanoparticles – rather than genuinely new risks. Although the term ‘emerging risk’ was defined in the questionnaire, respondents may have had different interpretations in mind when evaluating the items and hence rated them based on what they reckoned to be a ‘priority’ rather than an ‘emerging risk’. Surveys based solely on questionnaires may not be totally suitable for such a study as there is little room for quality control of the answers against the survey objectives. Starting the study with a workshop may have helped participants to focus on ‘emerging risks’ according to the definition, as a moderator could have intervened immediately to steer people towards the study’s aims and to clarify their doubts.

However, the key findings highlighted as ‘emerging risk’ in this survey have been agreed as such by 49 experts from 21 European countries after a validation process. Whether ‘priorities’ or genuine ‘emerging’ risks, they should not be overlooked but deserve closer scrutiny and attention. Furthermore, the very fact that longstanding issues have been reported as ‘emerging’ concerns emphasises the strong need to ensure that effective action is taken at the level of individual workplaces to control the risks presented by these substances.

**Particles, dust and aerosols were considered as a major concern, with nanoparticles the top emerging risk of this forecast.** The literature review on nanoparticles shows that, although already used in a range of applications, the degree of damage they may cause to human health is not yet established. A number of EU-funded projects have started which will hopefully bring light to these knowledge gaps and enable the development of competitive and safe nanotechnologies.

Other emerging risks identified under this category such as **diesel exhaust, crystalline silica, asbestos and wood dusts are among the main carcinogens** in Europe. For



continuously evolving materials such as **man-made mineral fibres, the development of new compositions may bring new health hazards and make the conduction of epidemiological studies difficult.**

**A second group of emerging risks was linked to the increasing use of allergenic and sensitising substances such as epoxy resins, isocyanates and detergents.**

The skin is the largest organ of the body exposed to chemical – as well as physical and biological - risk factors. However, there is still no validated scientific method to assess dermal exposure to dangerous substances. The thorough identification and control of risk factors of dermal exposure are therefore all the more important.

Although none of the items mentioned in the part of the survey dedicated to **carcinogenic, mutagenic and reprotoxic (CMR) substances** appeared among the main 10 emerging risks, nine items from this part of the survey were agreed as emerging risks – particularly **organic solvents, endocrine disruptors, persistent organic pollutants, aromatic amines, biocides, azo dyes and combined exposures to several carcinogens.** In addition, emerging risks from CMRs were mentioned throughout the survey – sometimes with regard to another of their characteristics (e.g. their physical state as particle, dust or aerosols such as diesel exhaust, asbestos, crystalline silica and wood dust).

**According to EU estimates, 32 million people are exposed to such carcinogens at levels which exceed what is considered as safe,** and between 35,000 and 45,000 cancer deaths per year are due to exposures occurring in the workplace <sup>(171)</sup>. **However, new studies <sup>(172)</sup> suggest that the magnitude of the work-related cancers is higher and that, in the EU-27, 95,581 deaths caused each year by cancer could be work-related.** The Committee on Employment and Social Affairs of the European Parliament <sup>(173)</sup> in autumn 2007 recommended that the carcinogen Directive 2004/37/EC should be amended:

‘to include mutagens and substances toxic for reproduction and to propose a revision of the binding occupational exposure limit values (BOELVs) for carcinogens listed in the directive and to establish new BOELVs for some carcinogens, mutagens and reprotoxins not yet included in the directive’.

The Agency’s European Risk Observatory chose carcinogens and occupational cancer as one of its priority topics for its activities in 2007 <sup>(174)</sup> and collected data across 25 Member States on carcinogens exposure and occupational cancer.

<sup>(171)</sup> Commission consults workers and employers on reducing exposure to substances that cause cancer and reduce fertility, Press release, Reference IP/04/391, Brussels, 26 March 2004. <http://europa.eu/rapid/pressReleasesAction.do?reference=IP/04/391&format=HTML&aged=0&language=EN&guiLanguage=en>

<sup>(172)</sup> A study by Hämäläinen P., Takala J. of Tampere University of Technology (Finland) for the International Labour Office available in: J. Takala, ILO, *Introductory Report – Decent work, Safe work*. XVIIth World Congress on Safety and Health at Work, Orlando, 18-22 Sep. 2005, <http://www.ilo.org/public/english/protection/safework/wdcongrs17/intrep.pdf>; European Agency for Safety and Health at Work, *Work-related cancers*, [http://osha.europa.eu/OSH\\_world\\_day/occupational\\_cancer](http://osha.europa.eu/OSH_world_day/occupational_cancer)

<sup>(173)</sup> European Parliament Committee on Employment and Social Affairs, *Draft report on the Community strategy 2007-2012 on health and safety at work*, Provisional 2007/2146(INI), 14 September 2007. [http://www.europarl.europa.eu/registre/commissions/empl/projet\\_rapport/2007/393990/EMPL\\_PR\(2007\)393990\\_EN.doc](http://www.europarl.europa.eu/registre/commissions/empl/projet_rapport/2007/393990/EMPL_PR(2007)393990_EN.doc)

<sup>(174)</sup> All the publications from the European Risk Observatory are available at <http://osha.europa.eu/en/riskobservatory/>



In addition, the Agency has been asked by the European Commission to bring together information on occupational exposure limits for carcinogens and mutagens in the workplace; 21 Member States have provided information about the limit values in place and about how they set these limit values at the national level. The Agency will publish its findings from these data collections in two reports in 2008-2009.

Of the emerging risks specific to certain occupations mentioned in the forecast, none of them are in the chemical industry or in industries where chemicals are used intentionally in the work process – except for cleaning and nursing activities where the chemicals used are needed for the proper performance of the work – but rather where dangerous substances are incidental products of the work. **Waste treatment was considered as one of the most hazardous occupations.** It was also one of the top emerging risks identified in the Agency's expert forecast on emerging biological risks with a view to workers' exposure to airborne micro-organisms. The consistency in the respondents' evaluation in the two surveys may be considered to validate the forecast.

Part of the survey was dedicated to **mixtures or combined exposures to dangerous substances, which are the reality of most workplaces.** Mixed exposures are also a priority of the US NORA programme. It is worth emphasising the fact that the survey respondents adopted a genuine holistic view of occupational safety and health, not only considering combined dangerous substances but also widening their reflections to risk factors of a physical nature (e.g. noise and ototoxic substances) and psychosocial nature such as the **poor control of chemical risks in SMEs** or the **increased vulnerability of certain groups of workers toward dangerous substances (e.g. subcontracted workers and migrant workers).**

Only a short time ago, the predominant approach tended to consider each risk factor independently; this is likely to lead to an underestimation of the real risks to workers. But **concern for multiple factors, multiple exposures and multiple outcomes is increasing as was also shown in the Agency's forecasts on emerging physical<sup>(175)</sup>, biological<sup>(176)</sup> and psychosocial<sup>(177)</sup> risks.** To respond to these concerns, the Agency initiated a series of projects in 2008 aimed at mapping out combined exposure situations and understanding how these exposures increase the effect of which health responses. These projects started with combined exposures to noise and ototoxic substances, and musculoskeletal disorders (MSD) and psychosocial risk factors.

Last, but not least, **the survey highlights trends related to the evolution of the labour market that largely contribute to the increase in concerns linked to exposure to dangerous substances such as the high number of SMEs, the increasing trend towards outsourcing and the increasing number of migrant workers, as these workers' groups are found to be less protected and at higher risk.** These issues need to be dealt with as a priority and deserve special support, for example in terms of provision of consultancy, tools, information and training from

<sup>(175)</sup> European Agency for Safety and Health at Work, *Expert forecast on emerging biological risks related to occupational safety and health*, Office for Official Publications of the European Communities, Luxembourg, 2007. [http://osha.europa.eu/en/riskobservatory/risks/forecasts/biological\\_risks/](http://osha.europa.eu/en/riskobservatory/risks/forecasts/biological_risks/)

<sup>(176)</sup> European Agency for Safety and Health at Work, *Expert forecast on emerging physical risks related to occupational safety and health*, Office for Official Publications of the European Communities, Luxembourg, 2005. <http://osha.europa.eu/en/publications/reports/6805478/view>

<sup>(177)</sup> European Agency for Safety and Health at Work, *Expert forecast on emerging psychosocial risks*, Office for Official Publications of the European Communities, Luxembourg, 2007. <http://osha.europa.eu/en/publications/reports/7807118/view>



public institutions as well as national and local administrations, insurance companies, public prevention services, etc.

The results of this forecast, together with the three complementary forecasts on physical risks, biological risks and psychosocial risks undertaken by the Agency, are only the first steps in a process of debate and consolidation that forms part of its work programme. In this context, these forecasts were discussed by representatives from major European occupational safety and health research institutes and from UNICE, ILO, DG Research and DG Employment at a seminar, 'Promoting occupational safety and health research in the EU', organised by the Agency in Bilbao on 1–2 December 2005.

During this seminar, several of the emerging risks identified in the forecasts were agreed for inclusion in a consensus list of top occupational safety and health research priorities. One aim of this list is to make these priorities more visible to policy-makers and to promote their inclusion into the 7th Research Framework Programme (FP7).

Additionally, in June 2007, a workshop dedicated to the issue of occupational risks arising from biological agents in the workplace brought together high-level representatives of the occupational safety and health community and from further disciplines concerned with the issue of biological risks – such as public health, animal health, food safety, environmental protection – as well as policy-makers and social partners in order to stimulate debate on the risks identified in this forecast and explore concrete ways to tackle them. A similar workshop took place on 8–9 April 2008 to debate the findings of the forecast on emerging psychosocial risks and another dedicated to the present publication will be organised 2–3 March 2009.

Because the world of work is constantly changing, a feasibility study for a future large-scale foresight study is currently being undertaken, building on the experience gained through these four Delphi surveys. The future study should enable the long-term follow-up of the constant technical and societal evolution, and provide a continuously up-to-date foresight on emerging occupational safety and health risks.

All the results from the work of the European Risk Observatory are available in a dedicated web feature <sup>(178)</sup>, also accessible from the Agency's portal <sup>(179)</sup>.

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<sup>(178)</sup> <http://riskobservatory.osha.europa.eu/>

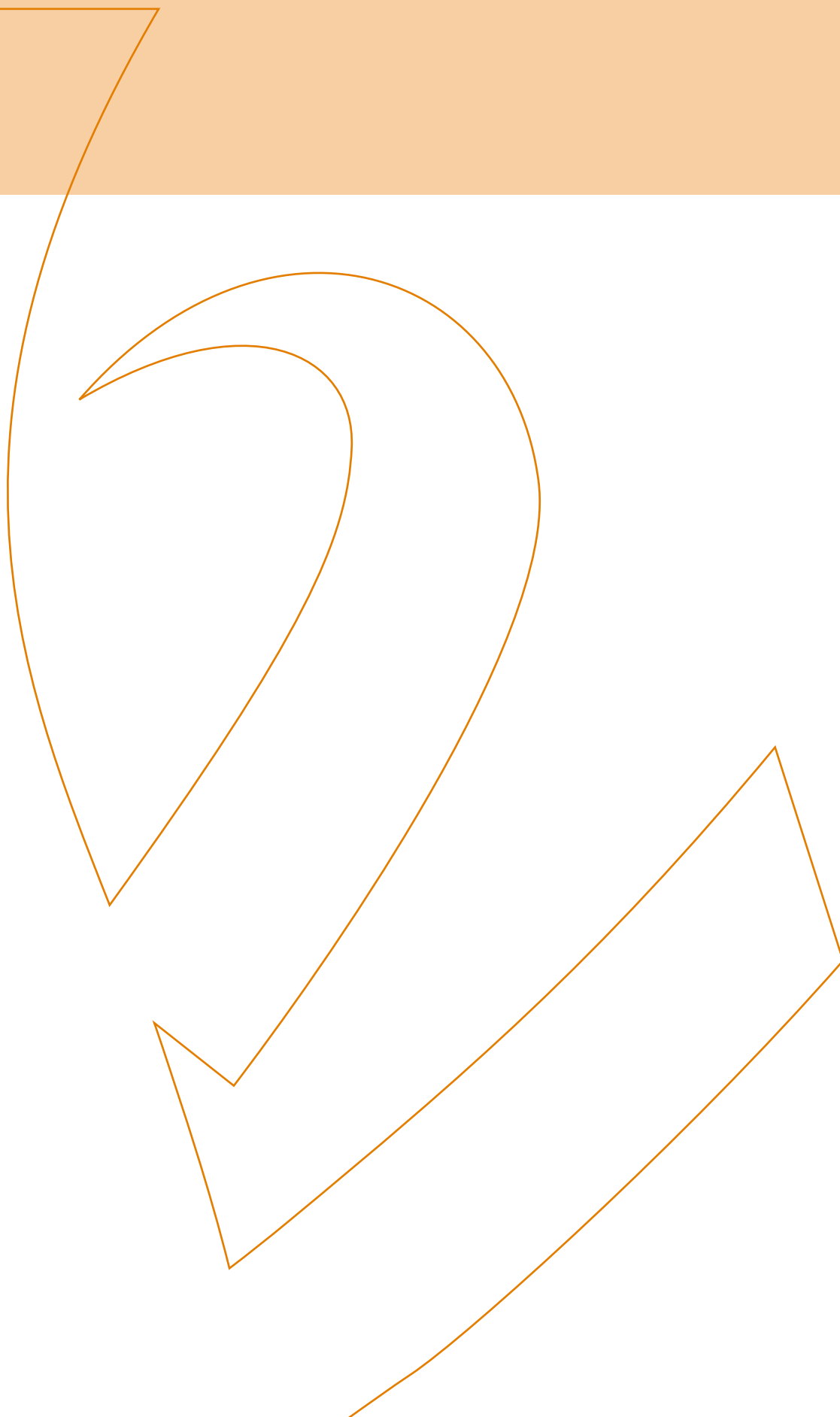
<sup>(179)</sup> <http://osha.europa.eu/>



European Agency for Safety and Health at Work

*EUROPEAN RISK OBSERVATORY REPORT*

**ANNEXES**



## ANNEX 1 — ORGANISATIONS CONTACTED FOR THE SURVEY ON EMERGING OSH CHEMICAL RISKS

Country	Organisations in which experts were invited to participate	Response to at least one round
Belgium	Aprim	No
Belgium	Arbeids-en verzekeringsgeneeskunde U.Z.	No
Belgium	Faculteit Geneeskunde, Katholieke Universiteit Leuven	Yes
Belgium	Federale Overheidsdienst Werkgelegenheid Arbeid en Sociaal Overleg	Yes
Belgium	Heymansinstituut voor farmacologie UGent	No
Belgium	Janssen Pharmaceuticalaan 3	No
Belgium	MIVEDI	No
Belgium	PREVENT	Yes
Belgium	SCK CEN	No
Belgium	Securex	No
Belgium	UCL Unité de Toxicologie Industrielle et Médecine du Travail	No
Belgium	UIA	No
Belgium	ULB	No
Belgium	ULB Hôpital Erasme	Yes
Belgium	ULB Institut de Pharmacie	Yes
Belgium	Ulg Lab d'oncologie, radiobiologie et mutagenèse expérimentale	No
Belgium	Ulg Pneumologie - allergologie, Physiologie du Travail	Yes
Belgium	Ulg Santé au travail et education pour la santé	Yes
Belgium	Ulg Toxicologie Industrielle et de l'Environnement	No
Belgium	VUB Lab voor cellulaire genetica	No
Bulgaria	National Centre of Hygiene, Medical Ecology, and Nutrition (NCHMEN)	Yes
Bulgaria	NCHMEN	Yes
Czech Republic	National Institute of Public Health	Yes
Denmark	Department of Environmental and Occupational Medicine, University of Aarhus	Yes
Denmark	National Institute of Occupational Health	Yes
Denmark	National Working Environment Authority	Yes
Germany	AAS Cottbus	No



Country	Organisations in which experts were invited to participate	Response to at least one round
Germany	Amt für Arbeitsschutz und Sicherheitstechnik	No
Germany	BASF Aktiengesellschaft	No
Germany	Bau-Berufsgenossenschaft Frankfurt	No
Germany	Berufsgenossenschaft der chemischen Industrie	Yes
Germany	Berufsgenossenschaft für Fahrzeughaltungen	No
Germany	Berufsgenossenschaft für Gesundheitsdienst und Wohlfahrtspflege (BGW)	Yes
Germany	Berufsgenossenschaften der Bauwirtschaft – GISBAU	No
Germany	Berufsgenossenschaft Druck und Papierverarbeitung	No
Germany	Berufsgenossenschaft der keramischen und Glas-Industrie	Yes
Germany	Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, BAuA	Yes
Germany	Bundesanstalt für Arbeitsschutz und Arbeitsmedizin	Yes
Germany	Degussa AG	No
Germany	Federal Ministry of Economics and Labour	No
Germany	Hauptverband der gewerblichen Berufsgenossenschaften	Yes
Germany	Kooperationsstelle Hamburg, KOOP	Yes
Germany	Landesanstalt für Arbeitsschutz, LfA	Yes
Germany	Landesinstitut für Arbeitsschutz und Arbeitsmedizin	Yes
Germany	Regierungspräsidium Kassel	Yes
Germany	Staatliches Amt für Arbeitsschutz Köln, Stafa Köln	Yes
Germany	Steinbruchs-Berufsgenossenschaft	Yes
Germany	Süddeutsche Metall Berufsgenossenschaft	Yes
Germany	University Heidelberg	No
Germany	Verband der Chemischen Industrie e. V.	Yes
Ireland	Health and Safety Authority	No
Spain	Dirección General de Trabajo. Consejería de Empleo y Desarrollo Tecnológico	Yes
Spain	INSHT- Centro Nacional de Condiciones de Trabajo	Yes
Spain	INSHT- Centro Nacional de Verificación de Maquinaria	Yes
Spain	Inspección de Trabajo y Seguridad Social	No
Spain	Instituto Aragonés de Seguridad y Salud Laboral	Yes
Spain	Instituto Nacional de Seguridad e Higiene en el Trabajo	Yes
France	INRS	Yes





## Expert forecast on emerging chemical risks related to occupational safety and health

Country	Organisations in which experts were invited to participate	Response to at least one round
Italy	"Santa Chiara" University Hospital in Pisa	Yes
Italy	Direzione Tecnico Scientifica , Federchimica	No
Italy	Istituto Superiore di Sanità	Yes
Italy	Polimeri Europa s.p.a.	No
Cyprus	Cyprus Petroleum Refinery	No
Cyprus	Department of Labour Inspection, Ministry of labour and Social Insurance	Yes
Latvia	Institute of Occupational and Environmental Health	Yes
Latvia	Ministry of Welfare	Yes
Lithuania	Occupational Medicine Centre	No
Lithuania	Training Center of Lithuanian Industrialists Confederation	Yes
Hungary	Fodor József National Center for Public Health	Yes
Hungary	National Institute of Occupational Health	Yes
Malta	Occupational Health And Safety Authority	No
Netherlands	Groningen University	Yes
Netherlands	Nederlands centrum voor Beroepsziekten	No
Netherlands	TNO Nutrition and Food Research	Yes
Netherlands	TNO Work and Employment	No
Netherlands	University Maastrich	Yes
Netherlands	University Medical Centre Nijmegen	No
Netherlands	VU University Medical Center Amsterdam	No
Austria	Arbeitskammer Oberösterreich	Yes
Austria	Arbeits- und Sozialmedizinisches Zentrum	Yes
Austria	ASC – Safety-Engineering	Yes
Austria	Austrian Accident Insurance Board	Yes
Austria	Lower Austrian Chamber of Workers	Yes
Austria	ppm - Research& Consulting	Yes
Austria	University Vienna	No
Poland	Central Institute for Labour Protection	Yes
Romania	Institute of Public Health Bucharest	Yes
Romania	Labour Inspection	Yes
Romania	National Research Institute for Labour Protection	Yes
Finland	Finnish Institute of Occupational Health	Yes
Finland	Kuopio Regional Institute of Occupational Health	No
Finland	Ministry of Social Affairs and Health	Yes



Country	Organisations in which experts were invited to participate	Response to at least one round
Finland	Tampere Regional Institute of Occupational Health	No
Sweden	Arbetslivsinstitutet	Yes
Sweden	Arbetsmiljöverket	Yes
Sweden	Institute of Environmental Medicine Karolinska Institutet	Yes
Sweden	Uppsala universitet, Institutionen för medicinska vetenskaper	No
United Kingdom	Amicus-MSF	No
United Kingdom	Cranfield Centre for EcoChemistry	No
United Kingdom	Dept of Pharmacy, Kings College London	No
United Kingdom	Health & Safety Laboratory	Yes
United Kingdom	Health and Safety Executive	Yes
United Kingdom	Imperial College London	No
United Kingdom	Medical Research Council - MRC Environmental Epidemiology Unit	Yes
United Kingdom	MRC Institute for Environment and Health	No
United Kingdom	School of Medicine, University of Leeds	No
United Kingdom	Unilever	No
United Kingdom	Union of Shop, Distributive and Allied Workers	No
United Kingdom	University of Stirling	No
United Kingdom	St. John's Institute of Dermatology	No
Iceland	Administration of Occupational Safety and Health	Yes
Switzerland	Institute for Health at Work (IST) in Lausanne	Yes
Switzerland	SUVA	No



## ANNEX 2 — QUESTIONNAIRE USED FOR THE FIRST SURVEY ROUND

### Expert forecast on emerging OSH\* chemical risks First survey: Identification of risks

\* OSH: Occupational Health and Safety

#### The survey

As part of an ongoing project on emerging health and safety at work risks, the European Agency's Topic Centre Research is formulating 'expert forecasts' in a number of areas.

This survey is the first step in the production of an expert forecast in the area of emerging OSH chemical risks. It aims to create a list of potential emerging OSH chemical risks and their context (cause, impact on workers' health, etc.). The results will be validated in a further survey round in order to establish a degree of consensus among the experts.

#### 'Emerging risks' – definition

For this project, an 'emerging OSH risk' is any occupational issue that is suspected to be a risk and that is both **'new'** and **'increasing'**.

By **'new'** we mean that:

- the issue is new and caused by new types of substances, new processes, new technologies, new types of workplaces, or social or organisational change; or
- a longstanding issue is newly considered as a risk due to a change in social or public perceptions (e.g. stress, bullying); or
- new scientific knowledge allows a longstanding issue to be identified as a risk (e.g. repetitive strain injury (RSI) where cases have existed for decades without being identified as RSI because of a lack of scientific evidence).

The risk is **'increasing'** if the:

- number of hazards leading to the risk is growing; or
- likelihood of exposure to the hazard leading to the risk is increasing, (exposure degree and/or the number of people exposed), or
- effect of the hazard on the workers' health is getting worse.

#### How to complete the questionnaire

**Please note that the aim of this questionnaire is not to produce a detailed list of all substances that are (potentially) dangerous.**

We ask you to identify up to five issues that in your opinion are emerging risks, according to the definition above, and to give some information about why you think this is the case. Consider not only new work situations, but also changing public perceptions and the development of knowledge about longstanding issues. Similarly, a risk is increasing not only when there is a higher likelihood of exposure, but also if there are new combined effects or if a different, more vulnerable, group is exposed.



Below are possible questions that you may ask yourself in order to identify OSH chemical risks. (The examples in parentheses aim only to illustrate the questions but are not necessary emerging risks).

Are there new groups or types of substances (e.g. mineral fibres replacing asbestos, waterborne systems replacing organic solvent based systems) likely to lead to (new) occupational diseases or work-related diseases?

Is there an increased use of types of substances likely to provoke more diseases (e.g. use of enzymes leading to an increase of respiratory allergies)?

Are there new forms of 'old' substances (e.g. nanoparticles) that may represent a health hazard although the substances themselves are harmless under their usual conditions of use (form and concentration)?

Are there new methods, new technologies, new working procedures or new types of workplaces that could lead to new problems (e.g. more nursing at home where the exposure to dangerous substances such as anti-neoplastic drugs is more difficult to control than in hospitals)?

Are there longstanding issues that are becoming more important in the public perception (e.g. ultrafine particles or endocrine disruptors) and suspected to be risks?

**Please note that you may include risks due to toxic properties as well as physical properties of chemicals (e.g. risks of fire, explosion, asphyxiation, etc.).**

Use as much space as necessary for your answers. There is space at the end of the questionnaire for comments.

**Please send your completed questionnaire in to [emmanuelle.brun@hvbg.de](mailto:emmanuelle.brun@hvbg.de) before 21 May**

**Thank you very much for taking part in this survey.**



### Part 1: General information:

Please fill in:

Date:			
Name:			
Country:			
Institution:			
Function:	<input type="checkbox"/> President/ Director <input type="checkbox"/> Researcher <input type="checkbox"/> OSH practitioner	<input type="checkbox"/> Head of department <input type="checkbox"/> Technician <input type="checkbox"/> Other:	<input type="checkbox"/> Professor/ Lecturer <input type="checkbox"/> Work inspector
Main activity:	<input type="checkbox"/> Research <input type="checkbox"/> Policy/ standards development <input type="checkbox"/> (Law) enforcement/ promotion <input type="checkbox"/> Work inspection <input type="checkbox"/> Consulting	<input type="checkbox"/> Development <input type="checkbox"/> Testing/ certification <input type="checkbox"/> Research planning/ management <input type="checkbox"/> Training/ teaching <input type="checkbox"/> Other:	
Do you have at least five years of experience in activities related to OSH chemical risks?			
<input type="checkbox"/> Yes		<input type="checkbox"/> No	



## Part 2: Emerging OSH chemical risks:

### In your opinion, what are the emerging OSH chemical risks of the next 10 years?

You may describe up to five OSH emerging chemical risks in the fields below. Please do not make a list of chemicals but focus on groups of substances, on types of work processes or technologies, and the groups of substances involved, etc. Please note that you may include risks due to physical as well as toxic properties of chemicals. (See 'How to complete the questionnaire' for more details). Use as much space as necessary for your answers.

Risk 1:
Risk 2:
Risk 3:
Risk 4:
Risk 5:

N.B. In the following questions, Risks 1 to 5 always refer to the corresponding risks you have identified in question 1.

### What are the cause(s) for the risk(s)?

Is it due for instance to a new type of substance, a new work process, a new type of workplace, a modification of the working environment, a lack of qualification, an unfavourable workplace design, etc.?

Please explain:

Risk 1:
Risk 2:
Risk 3:
Risk 4:
Risk 5:



**What are the health effects of the risk(s) (occupational diseases/ work related diseases/ sickness days)?**

Please describe:

Risk 1:
Risk 2:
Risk 3:
Risk 4:
Risk 5:

**Where is the risk to be found?**

Is it for instance branch specific? Or specific to a type of workplace? Or to a type of work process? Please specify if relevant:

Risk 1:
Risk 2:
Risk 3:
Risk 4:
Risk 5:

**Why do you think that the risk(s) is/are new?**

Is it for instance new because:

- The group of substances concerned is new? The work process or the technology involved is new? The conditions of use (form, concentration, etc.) are new?
- There is a new recognised occupational disease caused by this risk?
- The public concern/discussion about this issue is raising?
- There are more and more political debates about this issue?
- There is new scientific knowledge about it?
- There have been more requests for consultation activities from employers on this issue lately?
- New research programs on this topic have been created? Etc.



Please explain:

Risk 1:
Risk 2:
Risk 3:
Risk 4:
Risk 5:

**Why do you think that the risk(s) are increasing?**

Is it for instance because of an increase of:

- The number of hazards (e.g. increase in use of a group of substances)?
- The intensity of exposition to this hazard (e.g. increase of the concentration of a substance)?
- The number of people exposed? (If you are able to give an indication, please do so.)
- The number of occupational/ work related diseases or sick-leaves caused by this hazard? (If you are able to give an indication, please do so.)
- Or is the effect of this hazard on the workers' health getting worse? Etc.

Please explain:

Risk 1:
Risk 2:
Risk 3:
Risk 4:
Risk 5:





**Could you give us references of publications/studies dealing with these suspected emerging risks?**

Risk 1:
Risk 2:
Risk 3:
Risk 4:
Risk 5:

**Part 3: Further information**

- 1. Do you know about other studies/ publications dealing with emerging risks (not limited to chemical risks)? If yes, please give references:**
- 2. Can you recommend national or international experts whom we should invite to participate in this survey? Please give name, organisation, address, phone number, e-mail:**
- 3. Do you have any further complementary information or comments about our project in general? Any suggestions on how to improve our questionnaire?**

**Thank you very much for your time and co-operation.**

The results of this project will be available on the website (<http://osha.europa.eu/en>) of the European Agency for Safety and Health at Work from December 2004.



## ANNEX 3 — QUESTIONNAIRE USED FOR THE SECOND SURVEY ROUND

### Survey on emerging chemical risks related to occupational safety and health (OSH) 2nd round

#### About the survey

This survey represents the second step in the Agency's expert forecast on emerging chemical occupational safety and health risks. The questionnaire seeks your opinion on the issues identified by the experts in the previous round of the survey.

It is divided into seven parts, each one focusing on a particular topic in the field of chemical OSH.

**We would like to have your opinion:**

**How strongly do you agree that the following issues are emerging chemical OSH risks?**

#### Definition of 'emerging risk'

For this project, an 'emerging OSH risk' is any occupational risk that is both 'new' and 'increasing'.

By 'new' we mean that:

- the risk is new and caused by new processes, new technologies, new types of workplaces, or social or organisational change; or
- a longstanding issue is newly considered as a risk due to a change in social or public perceptions (e.g. stress, bullying); or
- new scientific knowledge allows a longstanding issue to be identified as a risk (e.g. repetitive strain injury (RSI), where cases have existed for decades without being identified as RSI because of a lack of scientific evidence).

The risk is 'increasing' if the:

- number of hazards leading to the risk is growing; or
- likelihood of exposure to the hazard leading to the risk is increasing, (exposure level and/ or the number of people exposed); or
- effect of the hazard on the workers' health is getting worse.

**Please send the questionnaire filled in to [eva.flaspoeler@hvbv.de](mailto:eva.flaspoeler@hvbv.de) by 7 February 2005.**

**Thank you very much for taking part in this survey.**

#### How to complete the questionnaire

The risks identified in the first step of the survey in 2004 are categorised and listed in tables. The first column in each of the tables gives feedback on the results of the survey's first round: It shows the number of experts who considered the risk to be emerging.



If you have at least **five years of experience in the area of chemical risks**, please rate each issue independently by ticking the corresponding box on a five-point scale ranging from 'Disagree' to 'Agree'.

- Tick the first box if you strongly disagree that the issue is an emerging risk.
- Tick the last box if you strongly agree that the issue is an emerging risk.
- Tick the middle box if you are undecided.

You may comment on your ratings in the column 'Comments' on the right of each issue. If you do so, please avoid unsubstantiated opinions and try to support your comments with objective arguments, e.g. research results, references to publications, statistics, etc. At the end of each part you may also add new additional possible emerging chemical risks, if in your opinion some relevant emerging chemical OSH risks are missing.

You will find some space for any additional comments on the survey in general at the end of the questionnaire.

### About you

All information is kept confidential within the project team and is only used for purposes of the Agency's expert forecast project.

Date:			
Name:			
Country:			
Institution:			
Function:	<input type="checkbox"/> President/ Director <input type="checkbox"/> Researcher <input type="checkbox"/> Other:	<input type="checkbox"/> Head of department <input type="checkbox"/> Engineer	<input type="checkbox"/> Professor/ Lecturer <input type="checkbox"/> Work inspector
Main activity:	<input type="checkbox"/> Research <input type="checkbox"/> Policy/ standards development <input type="checkbox"/> (Law) enforcement/ promotion <input type="checkbox"/> Work inspection <input type="checkbox"/> Consulting	<input type="checkbox"/> Development <input type="checkbox"/> Testing/ certification <input type="checkbox"/> Research planning/ management <input type="checkbox"/> Training/ teaching <input type="checkbox"/> Other:	



## Part 1: Risks due to particles, dusts and aerosols

Number of experts	Emerging risks due to particles, dusts and aerosols	Ratings		Comments
24	Nanoparticles and ultrafine particles: emerging risks due to increasing (new) industrial applications creating nanoparticles (e.g. laser treatment of material), lack of knowledge on toxicity of ultrafine particles leading to inappropriate or insufficient protective measures, to poor risk assessment and to unfavourable workplace design and environment. Health effects of ultrafine particles in general may have been underestimated so far. Potential health effects: inflammatory lung diseases, secondary effects on cardiovascular system (e.g. heart attack, stroke), tumours.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11	Man-made mineral fibres (e.g. refractory ceramic fibres, carbon/graphite fibres or composites): lack of knowledge on health effects of (new) fibre substitutes for asbestos, the use of which is increasing and for which exposure levels seem high enough for concern in certain areas. Potential health effects: respiratory diseases, cancer.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Asbestos (removing asbestos in facilities and buildings).	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Diesel exhaust.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Crystalline silica.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Passive smoking at the workplace.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Toners for printers/copiers.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Powder paints in painting/coating installations.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Welding aerosols at welding- and flame-cutting workplaces.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Other emerging risks due to particles, dusts and aerosols:</b>				



## Part 2: Risks due to carcinogenic, mutagenic and reprotoxic substances

Number of experts	Emerging risks due to carcinogenic, mutagenic and reprotoxic substances	Ratings		Comments		
11	Endocrine disruptors (PCBs, dioxins, styrene, pesticides, etc.).	Disagree	Agree			
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Persistent organic pollutants (POPs) (pesticides, polychlorinated biphenyls and terphenyls (PCBs, PCTs), dioxins, furans, etc.).	Disagree	Agree			
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Additives in foodstuffs and textiles (e.g. azo dyes).	Disagree	Agree			
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Formaldehyde: suspected carcinogenic effects (lung, nasopharyngeal and nasal squamous cell cancer); acute (short-term) and chronic (long-term) inhalation exposure to formaldehyde in humans can result in respiratory symptoms, and eye, nose and throat irritation.	Disagree	Agree			
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Dry-cleaning products (tetrachloroethylene).	Disagree	Agree			
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Nickel alloys: potential carcinogens.	Disagree	Agree			
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Beryllium – potential health effects: suspected human carcinogen; chronic beryllium disease (CBD) (an irreversible and sometimes fatal scarring of the lungs).	Disagree	Agree			
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Cadmium as a component of various alloys and compounds (e.g. nickel–cadmium batteries, cadmium pigment, zinc smelting, plastic stabiliser).	Disagree	Agree			
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Biocides (e.g. chlorothalonil, tributyltin compounds, acrolin): Exposure increases and the carcinogenicity is still uncertain.	Disagree	Agree			
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Reprotoxicants, to which women are increasingly exposed (because of the increasing female participation in the workforce) leading to an increasing number of reproductive health effects.	Disagree	Agree			
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Other emerging risks due to carcinogenic, mutagenic and reprotoxic substances:				



### Part 3: Risks due to allergens and sensitising substances

Number of experts	Emerging risks due to allergens and sensitising substances	Ratings		Comments
7	Dermal exposure leading to skin diseases.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	Cleaning and disinfection agents (e.g. where hydrocarbons have been replaced by glycols and esters, which are skin resorptive and have a 'carrier' function) leading to asthma, irritation of skin and mucous membranes, and sensitisation.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Isocyanates leading to allergic reactions: exposure occurs not only at the production stage but also during further processing (e.g. thermal or chemical degradation of polyurethane, grinding and welding of products containing polyurethane, for example, in car repair shops).	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Enzymes, leading to conjunctivitis, rhinitis, asthma and parenchymal disease.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Natural latex.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Cutting fluids and mineral oil mist resulting from cutting fluids in the metal processing branch, leading to cutaneous diseases.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Increasing industrial use of hydrocarbon mixtures leading to skin diseases.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Polymers which can reach the respiratory tract and lead to acute and chronic respiratory diseases.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Organic acid anhydrides (new application, e.g. in epoxy resins and paints) leading to skin and airways irritation and allergies.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Allergenic metals (ions of nickel, cobalt, chromium).	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Particles or irritant gases, leading to chronic obstructive pulmonary disease (COPD).	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Photo-allergic substances in the workplace, the health effects of which are increasing due to the thinning of the ozone layer.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Substances likely to increase the foetus' sensitivity to allergens, leading to an increase in allergies after birth (e.g. diesel exhausts).	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



Other emerging risks due to allergens and sensitising substances:



## Part 4: Risks due to flammable and explosive substances

Number of experts	Emerging risks due to flammable and explosive substances	Ratings		Comments
3	Oxygenates used as additives in petrol (e.g. methyl tertiary-butyl ether (MTBE), di-tert-butyl ether).	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Replacements for trichloroethylene in degreasing with flammable liquids.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Volatile organic compounds (VOCs): substitutes for polychlorinated biphenyls (PCBs) and terphenyls (PCTs) such as esters.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Liquefied petroleum gas (LPG) and hydrogen in the future (as substitutes for chlorofluorocarbons (CFCs), petrol, etc.).	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

### Other emerging risks due to flammable and explosive substances:






## Part 5: Risks due to substances and mixtures with newly recognised or unknown health effects

Number of experts	Emerging risks due to substances and mixtures with newly recognised or unknown health effects	Ratings		Comments
4	Complex mixtures: unknown or toxic effects of the mixture although each compound separately is not toxic.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Multiple chemical sensitivity syndrome (MCS): sensitisation to several substances characterised by a great variety of clinical symptoms (respiratory diseases, neurological diseases, musculoskeletal disorders, etc.).	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	New types of substances contained in hairstyling products (hair dyes, hair sprays, etc.) which could lead to new combined health effects.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Water-based paints and solvents including different cellosolves (glycol ethers and derivatives) containing preservative and antimicrobial agents. Potential health effects: skin allergies, nervous system damage, reproductive and mutagenic effect (cellosolves).	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Aromatic hydrocarbons (e.g. styrene) leading to damage to airways and the nervous system.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Increasing use of (new) organic solvents (e.g. glycol ether).	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Exposure to low concentrations of organic solvents, e.g. to low concentration of toluene or styrene suspected to lead to impairment of the visual function and to changes in neurobehavioral and neurochemical functions, which are potential precursors of more serious adverse effects.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Atomic oxygen and clathrates used in air purification systems.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	'Green products': substitution of substances damaging the environment by substances which protect the environment but endanger workers' health.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Exposure to nitric oxide (NO) (e.g. in processes involving diesel engines, warehouses, tunnel construction, etc.): the Scientific Committee for Occupational Exposure Limits (SCOEL) has reviewed the health effects of NO and recommends lowering the OEL for NO to 0.2 ppm.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



Other emerging risks due to substances and mixtures with newly recognised or unknown health effects:



## Part 6: Risks due to work processes and workplaces

Number of experts	Emerging risks due to work processes and workplaces	Ratings		Comments
4	Wood processing: exposure to hardwood dust, solvents and formaldehyde in glue and surface coatings leading to occupational cancers.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Semi-conductor industry: exposure to metal fumes and dust leading to skin sensitisation and respiratory diseases.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Extraction and refining of heavy metals.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Non-ferrous metallurgy (metallurgy of lead, copper, manganese).	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Production of nitrogenous fertiliser, of ammonia and of nitric acid.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Oil refining.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Construction sector (civil and industrial sector, including demolition, rebuilding and renovation activities): exposure to chemical agents (crystalline silica dust, asbestos, wood dust, diesel engine exhaust, welding fumes) leading to occupational cancers.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Nursing at home: exposure of (less trained) self-employed medical staff to chemical agents (e.g. cytostatic agents involved in cancer therapy) in a working environment where the safety conditions are less easy to control than in hospitals.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Sick Building Syndrome at indoor workplaces due to indoor emissions and/or poor heating ventilation and air conditioning (HVAC).	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Industrial, medical and domestic waste treatment: exposure to dust, microbes and endotoxins.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Handling and treatment of contaminated land (e.g. former wood impregnation sites, lead foundries, petrol stations): new exposure to old 'buried' chemicals with high toxic potential.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Uncontrolled/unmaintained waste deposits of dangerous substances where the risks are difficult to identify and to control.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Working on high-tech products with old fashioned tools (e.g. removing catalytic converters from cars, recycling computer equipment, dismantling of rare non-ferrous metals) leading to skin sensitisation and respiratory diseases.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



Number of experts	Emerging risks due to work processes and workplaces	Ratings		Comments
1	Recycling electronic scrap involving dangerous metals and chemicals: increasing activity due to the rising trend of manufacturing always newer technologies to replace older electronic devices.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Fine metal industry: wide use of specialised tools at poorly monitored workplaces (e.g. welding non-ferrous metals) leading to respiratory diseases.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Construction sector: exposure of poorly qualified workers to isocyanates.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Agriculture sector: exposure to farm dust, fungi and pesticides leading to allergies and poisoning.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Manufacturing of new medicines, which is a continuously renewing area.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Processing and use of new substances.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Production of electric and thermal energy, of gas and hot water: exposure to the chemical agents involved (e.g. fuel combustion exhausts) leading to occupational cancers.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Wet work (in hospitals, cleaning, catering, metal work, hairdressing) leading to skin diseases: increasing numbers of sensitised workers due to an increase in atopic dermatitis.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Indoor workplaces: degradation of polyvinylchloride (PVC) material of floors, due to moisture and ageing of the material, causing airways diseases (infections and asthma).	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Confined workplaces: lack of oxygen leading to death and invalidity.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Other emerging risks due to work processes and workplaces:</b>				



## Part 7: Multi-factorial risks related to chemical risks

Number of experts	Emerging multi-factorial risks related to chemical risks	Ratings		Comments
5	Poor control of chemical risks in small and medium enterprises (SMEs).	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Outsourcing (e.g. for cleaning and maintenance activities) performed by contracting companies with poor knowledge of chemical risks.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Increasing transportation of chemical goods leading to more accidents involving dangerous substances.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Increasing importation of chemicals not complying with EU regulations (e.g. impure substances, wrong labelling of dangerous substances) making the exposure control and risk assessment more difficult at workplaces.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Increased exposure of vulnerable groups to chemical risks (young workers, elderly workers, women, workers with chronic health problems) due to low income and high unemployment rate.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Importance given to psycho-social factors tends to give the false impression that issues related to hazardous substances (and other OSH issues) have been solved.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Increase in the use of hazardous substances in the European Union leading to an increase in the number of diseases of systemic body functions (allergies, diseases of the neurological system, skin diseases, cancer and diseases of the endocrine system) substituting diseases caused by a single substance.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Combined effects of chemical hazards with physical hazards (e.g. ototoxic products and noise).	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Use of uncertified technical equipment and modification of it by non-certified staff, especially in SMEs in order to cope with the market demand, leading to the use of hazardous substances in poor safety conditions.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	Assessment procedures based on models such as the COSHH (Control of Substances Hazardous to Health) Essentials tend to give the false illusion that exposure measurements are no longer necessary.	Disagree	Agree	
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



**Other emerging multi-factorial risks related to chemical risks:**


**Further Comments**

**Other emerging chemical risks not fitting any of the categories above:**


**Do you know about other studies/ publications dealing with emerging chemical OSH risks? If so, please give references:**




**Do you have any comments about this project or about this questionnaire? If so, please comment:**

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**Thank you very much for your time and co-operation.**



## ANNEX 4 — QUESTIONNAIRE USED FOR THE THIRD SURVEY ROUND

### Survey on emerging OSH chemical risks – 3rd round

#### About the survey

This survey represents the final step in the Agency's expert forecast on emerging chemical occupational safety and health risks. The questionnaire seeks your opinion on the issues identified by the experts in the previous two survey rounds and is divided into seven parts.

**We would like to have your opinion:**

**Which of these issues are really emerging chemical OSH risks?**

#### Definition of 'emerging risk'

For this project, an 'emerging OSH risk' is any occupational risk that is both 'new' and 'increasing'.

By 'new' we mean that:

- the risk is new and caused by new processes, new technologies, new types of workplaces, or social or organisational change; or
- a longstanding issue is newly considered as a risk due to a change in social or public perceptions (e.g. stress, bullying); or
- new scientific knowledge allows a longstanding issue to be identified as a risk (e.g. repetitive strain injury (RSI), where cases have existed for decades without being identified as RSI because of a lack of scientific evidence).

The risk is 'increasing' if the:

- number of hazards leading to the risk is growing; or
- likelihood of exposure to the hazard leading to the risk is increasing, (exposure level and/or the number of people exposed); or
- effect of the hazard on the workers' health is getting worse.

#### How to complete the questionnaire:

For each of the parts, please ONLY reply if you have at least five years of experience in the area concerned.

Please rate each issue independently by ticking the corresponding box on a five-point scale ranging from 'Disagree' to 'Agree'.

- Tick the first box if you strongly disagree that the issue is an emerging risk;
- Tick the last box if you strongly agree that the issue is an emerging risk;
- Tick the middle box if you are undecided.

**We have left a space at the end for your comments.**

**Please send the questionnaire to [eva.flaspoeler@hvbv.de](mailto:eva.flaspoeler@hvbv.de) by 27 September.**

**Thank you very much for taking part in this survey.**





## About you

(Information is kept confidential within the project team and is used only for the purposes of the Agency's expert forecast project).

Date:			
Name:			
Country:			
Institution:			
Function:	<input type="checkbox"/> President/ Director <input type="checkbox"/> Researcher <input type="checkbox"/> Other	<input type="checkbox"/> Head of department <input type="checkbox"/> Engineer:	<input type="checkbox"/> Professor/ Lecturer <input type="checkbox"/> Work inspector
Main activity:	<input type="checkbox"/> Research <input type="checkbox"/> Policy/ standards development <input type="checkbox"/> (Law) enforcement/ promotion <input type="checkbox"/> Work inspection <input type="checkbox"/> Consulting	<input type="checkbox"/> Development <input type="checkbox"/> Testing/ certification <input type="checkbox"/> Research planning/ management <input type="checkbox"/> Training/ teaching <input type="checkbox"/> Other:	
Do you have at least five years of experience in activities related to OSH chemical risks?			
<input type="checkbox"/> Yes		<input type="checkbox"/> No	



## Part 1: Chemical risks due to particles, dusts and aerosols

Nanoparticles and ultrafine particles: emerging risks due to increasing (new) industrial applications creating nanoparticles (e.g. laser treatment of material), lack of knowledge on toxicity of ultrafine particles leading to inappropriate or insufficient protective measures, to poor risk assessment and to unfavourable workplace design and environment. Health effects of ultrafine particles in general may have been underestimated so far. Potential health effects: inflammatory lung diseases, secondary effects on cardiovascular system (e.g. heart attack, stroke), tumours.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Man-made mineral fibres (e.g. refractory ceramic fibres, carbon/graphite fibres or composites): lack of knowledge on health effects of (new) fibre substitutes for asbestos, the use of which is increasing and for which exposure levels seem high enough for concern in certain areas. Potential health effects: respiratory diseases, cancer.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Diesel exhaust.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Asbestos (removing asbestos in facilities and buildings).	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Welding aerosols at welding- and flame-cutting workplaces.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Crystalline silica.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Powder paints in painting/coating installations.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Passive smoking at the workplace.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Toners for printers/copiers.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dust mixtures in the recycling sector.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Wood particles.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Flour dust.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increasing dust exposure leading to inflammatory diseases such as heart infarct or rheumatoid arthritis.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increased use of detergent sprays, room deodorants and cosmetics sprays leading to an increased indoor concentration of dangerous substances.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Combinations of different types of particles in dust or fume, especially in combination with gaseous substances are not known sufficiently (for instance in welding fumes).	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



## Part 2: Chemical risks due to carcinogenic, mutagenic and reprotoxic substances

Endocrine disruptors (PCBs, dioxins, styrene, pesticides, etc.).	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Persistent organic pollutants (POPs) (pesticides, polychlorinated biphenyls (PCBs) and terphenyls (PCTs), dioxins, furans, etc.).	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reprotoxicants, to which women are increasingly exposed (because of increasing female participation in the workforce) leading to an increasing number of reproductive health effects.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Biocides (e.g. chlorothalonil, tributyltin compounds, acrolin): Exposure increases and the carcinogenicity is still uncertain.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Additives in foodstuffs and textiles (e.g. azo dyes).	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Formaldehyde: suspected carcinogenic effects (lung, nasopharyngeal and nasal squamous cell cancer); acute (short-term) and chronic (long-term) inhalation exposure to formaldehyde in humans can result in respiratory symptoms, and eye, nose and throat irritation.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cadmium as a component of various alloys and compounds (e.g. nickel–cadmium batteries, cadmium pigment, zinc smelting, plastic stabiliser).	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Nickel alloys are (potential) carcinogens.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Beryllium. Potential health effects: suspected human carcinogen; chronic beryllium disease (CBD) (an irreversible and sometimes fatal scarring of the lungs).	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dry-cleaning products (tetrachloroethylene).	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Organic solvents with carcinogenic, mutagenic and reprotoxic effects.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Organic mercury compounds with carcinogenic, mutagenic and reprotoxic effects.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Combined exposure to more than one carcinogenic substance.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Strongly mutagenic ethidium bromide used in laboratories for separation of nucleic acids.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Aromatic amines in hair colorants leading to cancer and allergies.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Exposure to bitumen aerosols on e.g. construction sites.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



**Part 3: Chemical risks due to allergens and sensitising substances**

Isocyanates leading to allergic reactions: exposure occurs not only at the production stage but also during further processing (e.g. thermal or chemical degradation of polyurethane, grinding and welding of products containing polyurethane, for example, in car repair shops).	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dermal exposure leading to skin diseases.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cleaning and disinfection agents (e.g. where hydrocarbons have been replaced by glycols and esters, which are skin resorptive and have a 'carrier' function) leading to asthma, irritation of skin and mucous membranes, and sensitisation.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Enzymes leading to conjunctivitis, rhinitis, asthma and parenchymal disease.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Organic acid anhydrides (new applications, for example, in epoxy resins and paints) leading to skin and airways irritation and allergies.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Allergenic metals (ions of nickel, cobalt, chromium).	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Particles or irritant gases leading to chronic obstructive pulmonary disease (COPD).	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Substances likely to increase foetal sensitivity to allergens, leading to an increase in allergies after birth (e.g. diesel exhausts).	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cutting fluids and mineral oil mist resulting from cutting fluids in metal processing and other workplaces leading to cutaneous diseases.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Polymers which can reach the respiratory tract and lead to acute and chronic respiratory diseases.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increasing industrial use of hydrocarbon mixtures leading to skin diseases.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Photo-allergic substances in the workplace, the health effects of which are increasing due to the thinning of the ozone layer.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Natural latex.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hardeners such as acrylates and isocyanates used in polymer production.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increasing use of UV curable inks containing sensitising acrylate monomers in the printing industry.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increasing use of epoxy resins, on construction sites in general and, for example, in the construction of the wings of wind turbines used as power generators, or in the cabin of large aircraft.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The increasing number of allergens and sensitising substances contained in the growing number of chemicals produced and used results in new form of diseases.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



## Part 4: Chemical risks due to flammable and explosive substances

Replacements for trichloroethylene in degreasing with flammable liquids.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Oxygenates used as additives in petrol (e.g. methyl tertiary butyl ether (MTBE), di-tert-butyl ether).	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Liquefied petroleum gas (LPG) and hydrogen in the future (as substitutes for chlorofluorocarbons (CFCs), petrol, etc.).	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Volatile organic compounds (VOCs): substitutes for polychlorinated biphenyls (PCBs) and terphenyls (PCTs) such as esters.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increasing use of magnesium alloys in the construction of cars, railway coaches and other machineries, which makes them highly flammable and very difficult to extinguish, thus enhancing the risks not only for the fire brigades, but everybody involved.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



## Part 5: Chemical risks due to substances and mixtures with newly recognised or unknown health effects

Complex mixtures: unknown or toxic effects of the mixture although each compound separately is not toxic.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Water-based paints and solvents including different cellosolves (glycol ethers and derivatives) containing preservative and antimicrobial agents. Potential health effects: skin allergies, nervous system damage, reproductive and mutagenic effect (cellosolves).	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Multiple chemical sensitivity syndrome (MCS): sensitisation to several substances characterised by a great variety of clinical symptoms (respiratory diseases, neurological diseases, musculoskeletal disorders, etc.).	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Exposure to nitric oxide (NO) (e.g. in processes involving diesel engines, warehouses, tunnel construction, etc.): The Scientific Committee for Occupational Exposure Limits (SCOEL) has reviewed the health effects of NO and recommends lowering the OEL for NO to 0.2 ppm.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
New types of substances contained in hairstyling products (hair dyes, hair sprays, etc.) which could lead to new combined health effects.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Increasing use of (new) organic solvents (e.g. glycol ether).	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Atomic oxygen and clathrates used in air purification systems.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Exposure to low concentrations of organic solvents, e.g. to low concentration of toluene or styrene suspected to lead to impairment of visual function and to changes in neurobehavioral and neurochemical functions, which are potential precursors of more serious adverse effects.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
'Green products': substitution of substances damaging the environment by substances which protect the environment but endanger workers' health.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Aromatic hydrocarbons (e.g. styrene) leading to damage to airways and of the nervous system.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments



## Part 6: Chemical risks due to workprocesses and workplaces

Industrial, medical and domestic waste treatment: exposure to dust, microbes and endotoxins.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Construction sector (civil and industrial sector, including demolition, rebuilding and renovation activities): exposure to chemical agents (crystalline silica dust, asbestos, wood dust, diesel engine exhaust, welding fumes) leading to occupational cancers.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Wood processing: exposure to hardwood dust, solvents and formaldehyde in glue and surface coatings leading to occupational cancers.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Handling and treatment of contaminated land (e.g. former wood impregnation sites, lead foundries, petrol stations): new exposure to old 'buried' chemicals with high toxic potential.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Semi-conductor industry: exposure to metal fumes and dust leading to skin sensitisation and respiratory diseases.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Working on high-tech products with old fashioned tools (e.g. removing catalytic converters from cars, recycling computer equipment, dismantling of rare non-ferrous metals) leading to skin sensitisation and respiratory diseases.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Construction sector: exposure of poorly qualified workers to isocyanates.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Wet work (in hospitals, cleaning, catering, metal work, hairdressing) leading to skin diseases: increasing numbers of sensitised workers due to an increase in atopic dermatitis.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Recycling electronic scrap involving dangerous metals and chemicals: increasing activity due to the rising trend of manufacturing always newer technologies to replace older electronic devices.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Uncontrolled/unmaintained waste deposits of dangerous substances where the risks are difficult to identify and to control.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Agriculture sector: exposure to farm dust, fungi and pesticides leading to allergies and poisoning.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Nursing at home: exposure of (less trained) self-employed medical staff to chemical agents (e.g. cytostatic agents involved in cancer therapy) in a working environment where the safety conditions are less easy to control than in hospitals.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Processing and use of new substances.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Sick Building Syndrome at indoor workplaces due to indoor emissions and/or poor heating ventilation and air conditioning (HVAC).	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Fine metal industry: wide use of specialised tools at poorly monitored workplaces (e.g. welding non-ferrous metals) leading to respiratory diseases.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments
Extraction and refining of heavy metals.	Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	Comments



## Expert forecast on emerging chemical risks related to occupational safety and health

Non-ferrous metallurgy (metallurgy of lead, copper, manganese).	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Manufacturing of new medicines, which is a continuously renewing area.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Oil refining.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Indoor workplaces: degradation of polyvinylchloride (PVC) material of floors due to moisture and ageing of the material, causing airways diseases (infections and asthma).	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Production of electric and thermal energy, of gas and hot water: exposure to the chemical agents involved (e.g. fuel combustion exhausts) leading to occupational cancers.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Confined workplaces: lack of oxygen leading to death and invalidity.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Production of nitrogenous fertiliser, of ammonia and of nitric acid.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>





## Part 7: Multi-factorial risks related to chemical risks

Outsourcing (e.g. for cleaning and maintenance activities) performed by contracting companies with poor knowledge of chemical risks.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Poor control of chemical risks in small and medium enterprises (SMEs).	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increasing importation of chemicals not complying with EU regulations (e.g. impure substances, wrong labelling of dangerous substances) making the exposure control and risk assessment more difficult at workplaces.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use of uncertified technical equipment and modification of it by non-certified staff, especially in SMEs in order to cope with the market demand, leading to the use of hazardous substances in poor safety conditions.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Combined effects of chemical hazards with physical hazards (e.g. ototoxic products and noise).	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increasing transportation of chemical goods leading to more accidents involving dangerous substances.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increased exposure of vulnerable groups to chemical risks (young workers, elderly workers, women, workers with chronic health problems) due to low income and high unemployment rate.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increase in the use of hazardous substances in the European Union leading to an increase in the number of diseases of systemic body functions (allergies, diseases of the neurological system, skin diseases, cancer and diseases of the endocrine system) substituting diseases caused by a single substance.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Assessment procedures based on models such as the COSHH (Control of Substances Hazardous to Health) Essentials tend to give the false illusion that exposure measurements are no longer necessary.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Importance given to psycho-social factors tends to give the false impression that issues related to hazardous substances (and other OSH issues) have been solved.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increasing exposure to pharmacologically active substances in drug products.	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increasingly migrant workers (legal and illegal) are in contact with chemicals in their jobs at a level of exposure often higher than the Occupational Exposure Limit (OEL).	Disagree	Agree	Comments
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



**Further information:**

**Do you know about other studies/publications dealing with emerging OSH risks? If so, please give references:**

**Do you have any comments about this project or about this questionnaire?**

**Thank you very much for your time and co-operation.**



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