MAINTENANCE AND HAZARDOUS SUBSTANCES

1 Introduction

The European standard – EN 13306:2010 – defines maintenance as a 'combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function'.

Because maintenance is carried out in all sectors and workplaces and involves a wide range of tasks, it is associated with many different hazards and risks, including chemical hazards. Maintenance workers come into close contact with a broad variety of often hazardous chemicals. Depending on the specific type, these chemicals may not only cause diseases like skin sores or cancer, but many of them are highly flammable and explosive. This e-fact focuses on the specific risks related to various dangerous substances that maintenance workers in general are exposed to, and gives some basic recommendations on how these risks can be tackled, including some best practice examples. A complementary e-fact: https://osha.europa.eu/en/publications/e-facts/e-fact-67-maintenance-chemical-industry/view, deals with maintenance and dangerous substances in the chemical industry.

2 Sources of exposure to hazardous substances during maintenance operations

Due to the wide variety of maintenance operations that take place in very different sectors, maintenance workers may come into contact with a huge variety of dangerous substances. Generally, three major sources of exposure may be distinguished in maintenance:

- a heavy **use** of products and substances in certain operations, such as cleaning and degreasing (e.g. detergents, solvents, acids, lyes), painting operations (paint removers, solvents, paints), and concrete or wood repair (epoxy resins);
- contact with substances that are **generated as by-products** during maintenance activities and by the equipment used, such as welding fumes, diesel exhaust (e.g. from generators), and sanding dust;
- dangerous substances that may be **encountered** in the maintenance workshop or the plant to be maintained, such as lubricants and hydraulic fluids, flour or animal feed dusts, ammonia in cooling systems, or process chemicals that might be present in pipelines or storage tanks, poisonous gas, fume or vapour when working in confined spaces such as tanks, process vessels, enclosed shipboard spaces and silos.

Maintenance workers may be exposed to practically all substances that have been identified as 'emerging chemical risks' by EU-OSHA [1]: ultrafine particles (welding), diesel exhaust, nanoparticles (e.g. in coatings), man-made mineral fibres (e.g. in insulation), isocyanates (e.g. in vehicle refinish coatings), epoxy resins (e.g. in adhesives, concrete and wood repair products), and silica (e.g. while drilling in concrete) and wood dust in the construction industry.

3 Maintenance activities involving exposure to hazardous substances

- *General cleaning activities,* in offices or schools for example, involve the manual use of water-based cleaning agents which contain detergents as their main constituents, and in specific cases (sanitary cleaning) weak acids. Cleaning agents may also contain fragrances, some of which may be sensitising.
- *Cleaning in the food industry* (e.g. abattoirs, dairy factories) often involves the use of stronger acids (e.g. phosphoric acid) and strong lyes (e.g. sodium hydroxide) which are generally sprayed onto surfaces and equipment in the form of foam. Disinfectants such as sodium hypochlorite, sodium isocyanurate and quaternary ammonium salts may also be used in the same manner.
- *Metal degreasing* in car repair, maintenance of small metal parts, and maintenance of machinery, such as printing machines or mixing vessels in the paint or adhesives industry. In the latter case,

degreasing may partly be carried out in confined spaces. A variety of products may be used, including water-based degreasing agents (containing detergents and in some cases lyes), fatty acid esters or emulsions thereof, high boiling solvents or low boiling solvents. A number of different techniques may be employed, including closed equipment for small metal parts. However, manual cleaning with volatile solvents is still common in certain activities, such as car and truck maintenance.

- *Painting* activities take place in many branches, e.g. in the maintenance of steel structures (bridges, etc.), and all kinds of buildings. The painting process includes a range of activities with potential exposure to hazardous substances. Generally, surface preparation is carried out first, which may include paint removal (for which dichloromethane-free solvents are now obligatory in non-industrial applications), sanding or blasting (generating paint, wood and silica dust), and degreasing (with solvents, ammonia, or water-based detergents). The actual painting process may involve either spray painting or brushing and rolling. The type of paint used depends very much on the actual sector [2]. Water-based high solids or full-solid (solvent-free) coatings are common in some applications (e.g. interior building maintenance, basecoats in car refinishing, steel structures), but solvent-based paints are still common in other cases (exterior maintenance of buildings, ship, yacht and aeroplane coating, car refinishing). In demanding applications, two-component coatings that contain isocyanates (car refinishing, yacht and aeroplane coating) or epoxides (exterior steel structures) are commonly used.

Figure 1: Repair lamination of wind generator wings, KOOP

- *Welding* is often carried out during the maintenance of cars, ships, railways and steel structures such as bridges. Welding fumes contain various irritating gases and vapours as well as (ultra-) fine particles, including metal oxides. The exact composition of the complex mixture depends on the particular welding process (welded material, temperature, flux and protective gases), and on any residues of substances such as greases, degreasing agents or paints that are present on the object.
- Many maintenance activities involve the use of *lubricating* products. Examples are motor oils in cars, hydraulic fluids, brake fluids and lubricating oils and greases in practically all machinery and equipment that has moving metal parts. The appearance of the products may range from greases of high viscosity, to oily liquids, to sprays in aerosol cans. Chemically, the main components in the products may vary from refined mineral oils to synthetic oils from either mineral (e.g. polyglycolether) or renewable (fatty acid esters) origin, and Teflon or silicone oils – the latter generally supplied in aerosol cans. Lubricating products may contain considerable varieties of additives, such as corrosion inhibitors, thickeners and anti-foam additives [3]. Moreover, used oils may contain various contaminants, originating from thermal decomposition or from the equipment (e.g. metals from engines). Old hydraulic systems might in some cases still contain toxic PCBs. In most cases, inhalatory exposure to lubricating agents – including the additives – is limited, as most of them are not volatile. Skin contamination may, however, occur due to splashes, spills or handling contaminated equipment.
- *Car maintenance* involves a wide range of activities and potential exposures in addition to those mentioned above, such as dermal and inhalatory exposure to cooling fluids (alcohols, glycols), strong acids in batteries (sulphuric acid), asbestos in (old) brake linings or motor packings, and (diesel) motor emissions.

Figure 2: Welding fumes contain irritating gases and vapours as well as ultrafine particles, HVBG/Senn

- Specific to the *vehicle repair* branch are coating activities, generally referred to as 'vehicle refinishing'. This is a specialised, procedure, which involves several steps: cleaning and degreasing, sanding, and the application of fillers (polyester, styrene-emitting), primer-surface coatings (solvent-based), base colour coatings (mainly water-based) and top coatings (solvent-based). All coating layers are applied by spray painting, in state-of-the-art cases in spray booths with downdraft ventilation. Modern basecoats and topcoats generally are two-component products for which isocyanate hardeners are used. In addition, vehicle repair may involve welding and the use of adhesives and sealants (e.g. isocyanate-based products). Thus, major exposures include solvents (styrene and many others), isocyanates, and polyester resin.
- The repair or maintenance of *concrete structures* such as bridges, cellars, dams, flat galleries and so on may be carried out with cement-based products or products that are mixtures of cement and resins – mostly epoxy resins. Both cement and epoxy resins are irritant substances. Epoxy resins and their hardeners are strong sensitisers as well, and cement usually contains small amounts of sensitising chromium. Exposure to cement dust during mixing with water or to vapours from epoxy resin hardeners (amines) may easily occur as well. Additionally, exposure to crystalline silica may occur when drilling in concrete. Finally, recent developments point at the use of nanoparticles in concrete repair products, e.g. silica fume [4,5].
- Repair of *wood rot* in wooden window frames and other wooden structures often involves the use of epoxy resins. In addition, exposure to wood dust may occur during sanding.
- Maintenance activities may also bring about the need to remove, renew or install *thermal insulation*, either in buildings or in production units. Various insulation materials exist, including various types of man-made mineral fibres (MMMF), such as glass wool or rock wool, and polyurethane foam (isocyanates). In some cases, asbestos may still be encountered (see e-facts on Asbestos in building maintenance at http://osha.europa.eu/en/publications/e-facts/efact48/view.
- Maintenance of *façades* of buildings may involve graffiti removal, removing cement veils or soot, and waterproofing impregnation. Products used may be solvent-based cleaning agents, strong acids and lyes, and silicone-based impregnation products, which may be either solvent-based or water-based emulsions [2]. In many cases these products are sprayed onto the façade, giving rise to both dermal and inhalatory exposure.
- Maintenance of refrigeration and *cooling systems* in the food industry or ice-skating facilities, for example, may pose the risk of contact with ammonia (toxic, corrosive), propane/butane or HCFCs (acute narcotic solvent effects).
- In maintenance of *swimming pools* there may be a risk of the release of toxic chlorine gas.
- In *road maintenance* a variety of exposures are possible, for example to road marking paints (solvent- or water-based), two-pack or thermoplastic road marking resins, asphalt fumes, and traffic exhaust. In the maintenance of *waste treatment* plants exposure to organic dust and endotoxins may take place, while in *hospitals* specific risks may include the use of disinfectants and exposure to (carcinogenic) actinoplastic drugs.
- Finally, in many operations, exposure to *diesel motor exhaust* may occur, e.g. as a result of using power generators. Diesel exhaust contains a complex mixture of gases and particles (soot) – the latter with polycyclic aromatic hydrocarbons adsorbed to them.

Health risks due to specific chemical exposures during maintenance operations

Skin contact with products used or contaminants in equipment may lead to acute irritation, or even burns when strong lyes or acids are used, e.g. in cleaning the outsides of buildings or food production facilities, or corrosive amine hardeners for epoxy resins. Chronic or repeated exposure of the skin to weaker irritants – including water – may result in irritant contact dermatitis (eczema). A wide variety of irritating substances may be responsible, including solvents, detergents in cleaning agents, MMMF, epoxy resins, isocyanates, cement, oils and greases. Maintenance workers with a known high prevalence of irritant contact dermatitis include mechanics and painters [6]. Also susceptible are concrete repair workers (cement, epoxies) and insulation workers (MMMF). When sensitising (allergenic) substances are involved, allergic contact dermatitis may develop. For instance, up to one in five workers who handle epoxy resins – e.g. in concrete repair or wood repair, or painting – may develop an epoxy allergy once in their working life [7].

Inhalation of irritant substances may result in acute irritation of the *airways*, e.g. inhalation of MMMF or welding fumes. Irritants may also exacerbate existing airway complaints (e.g. asthma, COPD). In severe cases of high exposure an acute form of asthma may even develop (RADS – reactive airways dysfunction syndrome). Such effects may be expected after exposure to chlorine or ammonia in the case of accidents in swimming pools, or in the maintenance of cooling systems. Chronic effects to the airways, including COPD (chronic bronchitis, emphysema) may result from exposure to irritants such as wood dust (painters) or welding fume. Wood dust causes airway and eye irritation, and may lead to airway disease such as bronchitis. Many types of wood dust are either proven or suspected carcinogens, and high exposures potentially lead to nasal cancer. Depending on the specific type, MMMF may pose the risk of skin, airway and eye irritation, or more severe effects in the lungs [1].

Figure 3: Highly risky cleaning in a garage, KOOP

Exposure to inhalatory allergens, such as isocyanates (e.g. in car refinishing), may result in allergic rhinitis or asthma, which has been demonstrated in spray painters [8]. Besides, exposure to silica, for example during repairs to concrete structures, and to diesel motor exhaust, may contribute to the development of lung cancer [9,10]. Diesel exhaust has been classified as ‘probably carcinogenic to humans’ (IARC cat. 2A). Additional health effects of diesel motor exhaust are cardiovascular effects and the exacerbation of asthma complaints.

With respect to the potential inhalation of nanoparticles present in coatings or concrete materials, many of the risks are still not known. However, if these particles are inhaled in relevant quantities, similar effects as those described for diesel motor emissions might be expected [11].

The inhalation of hazardous substances in maintenance activities might lead to a range of additional health effects. High exposure to solvents – e.g. in spray painting and degreasing activities – may lead to neurological diseases such as chronic toxic encephalopathy [12,13,14,15]. Certain toxic substances that are still used in coatings for the maintenance of steel structures – such as toluene, xylene, and in some cases lead chromate pigments – have reproduction effects. Others are suspected carcinogens, such as dichloromethane that is used in paint strippers.

Finally, products used or activities carried out in maintenance may also bring about *fire and explosion* risks. These include, for instance, welding, or the use of flammable solvents. A dramatic case occurred in the Netherlands when two painters used a flammable thinner to remove a wax layer from a historic wooden floor in one of the government buildings (the ‘Catshuis’). The little flame of a gas

heater ignited the solvent vapours; the resulting explosion killed one painter and seriously injured the other.

4 European legislation

Health and safety requirements for maintenance operations involving hazardous substances are laid down in the European and international legislation and are enforced at national level. European legislation includes the OSH Framework Directive (Directive 89/391), which lays down the basic obligations for employers and workers, namely to evaluate all the risks to the safety and health of workers, particularly arising from the chemical substances or preparations used during work.

European legislation related to chemical agents and chemical safety include

- OSH directives concerning exposure to asbestos, carcinogens and mutagens at work, indicative occupational exposure limit values and risks related to chemical agents at work;
- OSH related directives concerning the transport of dangerous goods, Regulation (EC) No 1272/2008on the classification, labelling and packaging of substances and mixtures (CLP), Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), directives on the control of major-accident hazards and plant protection products.
- Other relevant OSH directives concerning risks from explosive atmospheres, safety and/or health signs, use of work equipment and personal protective equipment and workplace requirements).Sector-specific and worker-related provisions of OSH directives concerning prevention from sharps injuries in the hospital and healthcare sector, work on board fishing vessels, mineral-extracting industries, including drilling and temporary or mobile construction sites
- Other OSH-related directives on health, environmental protection and the substitution of dangerous products include those: such as the directives on the limitation of emissions of volatile organic, on persistent organic pollutants, and others.
- For more information see the European Agency for Safety and Health at Work (EU-OSHA) website, available at: http://osha.europa.eu/en/legislation/directives/exposure-to-chemical-agents-and-chemical-safety/ and http://osha.europa.eu/en/legislation

5 OSH management

The specific details of maintenance vary between industry sectors and depend on specific tasks. One of the best ways to prevent and control occupational risks related to maintenance is to address them early in the design process of buildings and structures, work environments, materials and plant (prevention through design – eliminating hazards at the design stage) [16].

The analysis of the results and success factors of several examples presented in the report ‘Safe maintenance in practice’ [16] demonstrates clearly that good occupational safety and health (OSH) management practices are at the heart of reliable and safe maintenance. A well-conducted risk assessment (before starting any maintenance work) involving the workers right from the start of the assessment is integral part of OSH management and it is a legal obligation.

5.1 Risk assessment for maintenance operations involving hazardous substances

Maintenance is a non-routine operation and maintenance workers might be at increased risk, therefore a separate risk assessment has to be conducted for maintenance activities. Risk assessment for maintenance operations is an especially difficult task because of the various uncertainties and unexpected situation during the maintenance processes. See also Dangerous Substances and Risk Assessment. Available at: http://osha.europa.eu/en/topics/ds/materials/en_ds.ppt

A number of different risk assessment tools have been developed that may be applied to maintenance operations involving hazardous substances. Some tools are particularly oriented to occupational exposure estimation (for example, Stoffenmanager 4.0, Riskofderm, EMKG-EXPO-TOOL, The ECETOC TRA and COSHH Essentials).

ECETOC’s targeted risk assessment (TRA) [17]

One of the key challenges of the European Community Regulation on chemicals and their safe use (REACH) is that it envisages the registration and evaluation of different chemicals by producers and importers. Many of these chemicals will require Chemical Safety Assessments to support their registration. To achieve these aims, ECETOC has developed a tiered (step-by-step) approach for calculating the exposure to and risks from chemicals that might reasonably be expected in defined circumstances of use. The approach addresses exposure to consumers, workers and the environment. ECETOC's targeted risk assessment (TRA) tool, known as the ECETOC TRA Worker tool, allows the user to calculate predictions for inhalatory and dermal exposure (Tier 1 level) for the benefit of performing Chemical Safety Assessments.

HWI Risk assessment checklists [18]

The risk assessment tool is designed to help users to go through all the steps of a risk assessment procedure. The tool defines five fundamental steps of a risk assessment procedure – collecting information, identifying hazards, assessing risk arising from hazards, planning actions to eliminate or reduce risk, reviewing assessment and documenting risk assessment. Different checklists are available to identify hazards. Checklist No. 07 (hazard: chemical substances) is particularly oriented to the identification of hazards related to chemical substances in the workplace. Examples of preventive measures which can be used to reduce the risks are also presented in the checklist.

COSHH Essentials [19]

COSHH Essentials was developed to help firms comply with the Control of Substances Hazardous to Health Regulations (COSHH) in the United Kingdom. It provides advice on controlling the use of chemicals for a range of common tasks, e.g. mixing and drying. For most tasks the tool takes the user through a number of steps and asks for specific information about processes and tasks, the chemicals in use, how harmful they are, hazard groups, what quantities of the chemicals are used and how often. In the end, the tool gives advice on how to protect the worker and the others. The guidance sheets advise on areas such as design of equipment, maintenance, examination and testing, cleaning and housekeeping, personal protective equipment, training and supervision.

Stoffenmanager 4.0 [20]

The Stoffenmanager was developed as a tool helping SMEs to prioritise their health risks on account of dangerous substances and to determine effective control measures. The tool combines hazard information on a substance or product with an inhalation and/or dermal worker exposure assessment to calculate a risk score. When risks are presumed, the effects of control measures can be examined. An action plan shows an overview of the risk assessments with control measures. The Stoffenmanager contains a quantified and validated exposure model for estimating inhalation exposure to both inhalable dust and vapour. This means the Stoffenmanager may be used to estimate inhalation exposure concentrations relating to tasks in specified units.

Riskofderm [21]

Skin irritation and dermatitis are major causes of sick leave, as well as diseases that impair optimal functioning of the skin, caused by contact with surfaces contaminated by chemicals. The software is an essential tool for the management of dermal exposure and prevention of ill health: a validated predictive model for estimating dermal exposure for use in risk assessment of single chemicals and a practical dermal exposure risk management tool for use by SMEs and others, for workplaces.

EMKG-EXPO-TOOL [22]

The EMKG-EXPO-TOOL is part of the 'Easy-to-use workplace control scheme for hazardous substances' (EMKG 'Einfaches Maßnahmenkonzept für Gefahrstoffe') of the German Federal Institute for Occupational Safety and Health (BAuA). Within the context of REACH the tool can be used for a first exposure estimate at the workplace.

5.2 Control measures for maintenance operations involving hazardous substances

Based on the result of risk assessment, preventive measures have to be developed and implemented follow the hierarchy of measures to prevent or reduce the exposure of workers to DS:

- **Elimination**
  Elimination is the best way to reduce the risks associated with dangerous substances. It consists in removing the need to use the dangerous substance by changing the process or product in which the substance is used.
- **Substitution**
  If elimination is not possible, the dangerous substance should be substituted or replaced with non-hazardous or less hazardous alternatives
  See also Factsheet 34 Elimination and substitution of dangerous substances at http://osha.europa.eu/en/publications/factsheets/34
- **Control**
  If a substance or process cannot be eliminated or substituted exposure have to be prevented or reduced through *engineering or organisational measures*, such as enclosure of the process that results in dangerous substance being emitted, control of the emission at the source, reducing the number of workers exposed to the dangerous substance, and the duration and intensity of exposure .Where exposure cannot be prevented by other means, ensure that individuals have suitable *personal protective equipment* and are trained in its use.

In Germany, the Hazardous Substances Ordinance defines four sets of protective measures called protection levels, based on the labelling of the hazardous substance: [23]

- Protection level 1: Applies to irritant (Xi), noxious (Xn), and caustic (C) hazardous substances at low exposure; includes activities involving negligible risk, with the use of only small amounts of hazardous substances, with cumulative duration and amount of exposure to hazardous substances being relatively low. The measures of protection level 1 represent the minimum measures applicable to all activities involving hazardous substances (see Table 1).
- Protection level 2: Applies additionally to the same hazardous substances as above in case of higher exposure if the results of a risk assessment show that protection level 1 does not suffice any more (see Table 2).
- Protection level 3: Applies additionally in case of handling toxic (T) and very toxic (T+) hazardous substances; extremely hazardous activities (see Table 3).
- Protection level 4: Applies additionally if carcinogenic, mutagenic, or fertility-damaging hazardous substances are used (see Table 5).

Table 1: Example of the hierarchy of control measures applied to Protection Level 1

Control measure	Example of minimum safety measures during activities involving hazardous substances – Protection Level 1
Engineering	Hazardous substances must be stored and warehoused in such a way as to avoid any deleterious effect on the environment or human health.
Administrative	Limit the number of workers that are or could potentially be exposed to hazardous substances; Limit exposure duration and intensity; Realise appropriate hygiene measures and, above all, cleaning the workplace at regular intervals; Limit the quantity of hazardous substances at the workplace to the quantity that is required for the activity of interest; Ensure that hazardous substance are handled, stored and transported safely at the workplace;

Control measure	Example of minimum safety measures during activities involving hazardous substances – Protection Level 1
	Audit the functionality and efficacy of technical safety measures at regular intervals and document the results of such audits; Ensure that all substances and preparations used for work activities are readily identifiable; If particularly sensitive persons complain of irritation, the advice of health experts should be sought.

Source: based on BAuA, Hazardous Substances Ordinance (Gefahrstoffverordnung – GefStoffV), 2011

Table 2: Example of the hierarchy of control measures applied to Protection Level 2

Control measure	Example of basic measures for activities involving hazardous substances – Protection Level 2
Substitution	Use of a substitute substance or preparation if possible; Replace hazardous substances with substances, preparations, products or processes that are not deleterious, or less deleterious, to worker health and safety.
Engineering	Elaboration of suitable processes and technical control systems; Collective protection measures at the risk source such as the installation of exhaust and ventilation equipment and organisational measures; Restrict the emission of hazardous substances at their point of origin.
Administrative	Personal protective equipment must be stored properly, tested and inspected prior to use, and cleaned following its use. Any personal protective equipment that is found to be damaged or defective must be repaired or replaced prior to re-use; Separate storage facilities for work/protective clothing and street clothing (the contamination of work clothing resulting from work activities could endanger workers' health and safety); Determine, by means of workplace measurements or comparable evaluative tools, whether the facility complies with occupational exposure limit values; Workers shall refrain from consuming foodstuffs of any kind in work areas in which there is a risk of contamination from hazardous substances.
PPE	If occupational exposure limit values are non-compliant despite the implementation of technical and organisational safeguards, or if a health risk could arise from skin contact with any hazardous substance that (a) is absorbed through the skin (b) provokes cutaneous hypersensitivity (c) is irritating, corrosive, or cutaneously sensitising or (d) could induce irreversible injury or disease, supplementary safeguards must be implemented, and in particular personal protective equipment must be provided to the workers affected.

Source: based on BAuA, Hazardous Substances Ordinance (Gefahrstoffverordnung – GefStoffV), 2011

Figure 4: Cleaning metal with a vegetable oil-based ester, KOOP

Table 3: Example of the hierarchy of control measures applied to Protection Level 3

Control measure	Examples of additional measures for highly hazardous activities – Protection Level 3
Isolation	If, for technical reasons, a hazardous substance is not amenable to replacement by a substance whose use or application is not hazardous or is a lesser hazard for worker health and safety, such substance must be kept in a closed system.
Engineering / Administrative	Airtight containers must be used, so as to ensure that hazardous substances are stored, handled and transported safely; Substances bearing the label T+ or T must be stored in a locked facility or in such a way that only persons with expertise in the use of such substances can have access to them.
Administrative	Measures must be taken in order to ensure that the workplace complies with the relevant limit values and the necessary measurements must be conducted in order to verify such compliance; The results of such measurements must be documented, archived and made available upon request to all workers and their agents and representatives; Measures must be implemented to ensure that workers have access only to those work areas to which they require access in order to carry out their work or perform specific work duties.

Source: based on BAuA, Hazardous Substances Ordinance (Gefahrstoffverordnung – GefStoffV), 2011

Table 4: Example of the hierarchy of control measures applied to Protection Level 4

Control measure	Supplementary safeguards for activities involving the use of substances that are carcinogenic, mutagenic or toxic to reproduction – Protection Level 4
Engineering	No exhaust air from any area in which activities involving the use of these substances shall be recirculated back into such area; Any hazardous area must be clearly delimited and identified. Safety and warning signage, including signs displaying 'No smoking', shall be installed in any area in which workers are or could be exposed to category 1 or 2 substances.
Administrative	In the case of any activity that could greatly increase workers' exposure to the substances and for which all possible technical safeguards for limiting such exposure have been realised, the employer shall implement measures that limit the duration of worker exposure to such substances insofar as possible.

Control measure	Supplementary safeguards for activities involving the use of substances that are carcinogenic, mutagenic or toxic to reproduction – Protection Level 4
PPE	The employer shall provide exposed workers with protective clothing and breathing apparatus which such workers shall be required to wear during the entire period of heightened exposure. Such period shall be of limited duration and shall be minimised for each worker.

Source: based on BAuA, Hazardous Substances Ordinance (Gefahrstoffverordnung – GefStoffV), 2011

6 Good practice examples

6.1 The CatSub substitution database

The CatSub database (www.catsub.eu) provides a publicly accessible catalogue of more than 300 examples of substitution of hazardous chemicals – case studies describing successful substitutions with less hazardous chemicals or hazard-free products.

The examples primarily come from companies, occupational health services and the Danish Working Environment Authority. Many of the examples deal with substances commonly used in maintenance and repair work in a variety of industries. Four examples from the database are discussed here:

Figure 5: CatSub database screen shot, KOOP

1. Cleaning of plastic injection moulding machines at LEGO: Before changing the raw material required for the injection moulding of plastics, it is sometimes necessary to clean the cylinders and worms of the injector. Methyl methacrylate was commonly used for this task but its fumes are hazardous. The company wanted to avoid exposure to organic solvent vapours and tried using 'Suprapur' instead. This product is a very fine powder and caused dust problems, thus also creating hazardous fumes during the cleaning process. In 2003 the use of a plastic granulate was developed. A mixture of SAN (styrene acrylonitrile) and PEHD (polyethylene high density) proved to be very effective. It is pressed through the injector without having to disassemble the machine. The cleaning is done at ambient temperature and as a result no vapours develop. This turned out to be the optimum solution. The company still uses this

process, which has the advantages of both eliminating health risks and saving time, since the machinery does not have to be taken apart.

2. Brake cleaning: Aerosol cans containing highly volatile organic solvents are normally used for brake cleaning in garages. They pose a high risk of fire and explosion as well as potentially lead to inhalation of the solvents by the workers. In this company hot water washers are used instead. These machines are recommended by the German accident insurance for this sector. Lorry and van drum brakes are washed clean of mud, dust and sand for repair and maintenance purposes. The hot water washer is a kind of wash stand fitted with a flow heater and a spray gun. The tap water is heated to 95°C and sprayed on the brakes, thereby removing the dirt and also heating the brakes so they dry rapidly after cleaning, having a similar effect to the fast-evaporating hydrocarbons that are normally used. The jet does not cause scalding of the skin, because it is a very finely sprayed mist.
3. Removal of acrylate residue when coating optical fibres at OFS Fitel Denmark: Connecting fibre optic cables requires the application of a long-lasting coating. This, in turn, requires the thorough cleaning of the fibres beforehand. Often dichloromethane is used to remove acrylate residue. OFS wanted to substitute this highly dangerous solvent and first replaced it with cyclohexanone. This did not prove satisfactory, so the company tested NMP (N-methylpyrrolidone). However, they discovered that NMP has a strong irritating effect on skin and eyes and there is limited evidence that it may cause fertility disorders at a medium level of exposure. According to the Danish Working Environment Authority (WEA), NMP can also cause nerve damage at the level of SRI 2, but there is no risk at normal working levels of exposure. Finally, in 2003, the company adopted the use of DBE (dibasic esters). Unhardened UV-coating material and UV-colour is cleaned from metal nozzles using DBE in an ultrasound bath. Afterwards the work pieces are rinsed manually in ethanol. The company is satisfied with the performance of these less toxic chemicals and is still using them.

In July 2010 the internet portal SUBSPORT (SUBStitution Support PORTal – Moving Towards Safer Alternatives http://www.subsport.eu/) went online. The portal combines substitution information from several countries (e.g. Denmark, Sweden, Spain, Germany and the USA) and offers comprehensive information, tools and case studies in the area of substituting of hazardous chemicals in products and processes with safer ones. The portal is available in English, German, French and Spanish.

6.2 The GISBAU hazardous substances information system

GISBAU is an information system for hazardous substances in the German construction sector.
GISBAU provides information on:

- products and mixtures in the construction industry;
- less hazardous products as substitutes;
- user instructions related to specific products and activities;
- concrete specifications in particular with regard to technical and personal preventive measures.

GISBAU also includes information and guidance on:

- working in contaminated areas
- renovation of buildings and concrete constructions
- roofers
- coating removal (stripping) and alternatives to chemical stripping agents
- tile laying
- floor covering work
- cleaning buildings
- insulation – handling mineral wool insulation materials
- painting work
- laying parquet floors (primers and adhesives) and sanding work
- acid-proof construction
- wood preservatives
- wood glues

- the builders yard.

The information for workers is presented in the form of user instructions, which only need to be complemented by the company with data specific to the workplace and the particular operation. Some guidance is available in languages other than German.

6.3 Further information

EU-OSHA (2012) E-fact 67 – Maintenance in the chemical process industry. https://osha.europa.eu/en/publications/e-facts/e-fact-67-maintenance-chemical-industry/view

EU-OSHA (2003), Factsheet 34 – Elimination and substitution of dangerous substances. http://osha.europa.eu//en/publications/factsheets/34

EU-OSHA (2010), E-fact 48 – Safe maintenance – Asbestos in building maintenance.

http://osha.europa.eu/en/publications/e-facts/efact48

BAuA – The Federal Institute for Occupational Safety and Health. Easy-to-use workplace control scheme for hazardous substances. http://www.baua.de/en/Topics-from-A-to-Z/Hazardous-Substances/workplace-control-scheme.pdf?__blob=publicationFile&v=2

HSE – Health and Safety Executive. INDG136: Working with substances hazardous to health – What you need to know about COSHH. http://www.hse.gov.uk/pubns/indg136.pdf

ECHA – European Chemicals Agency. Guidance on Information Requirements and Chemical Safety Assessment. http://guidance.echa.europa.eu/docs/guidance_document/information_requirements_en.htm?time=1255444731

7 References

[1] EU-OSHA (2009), Expert forecast on new and emerging chemical risks. Available at: https://osha.europa.eu/en/publications/reports/TE3008390ENC_chemical_risks

[2] Tebert, C. et al. (2009), Implementation and review of directive 2004/42/EC, Hamburg, Oekopol GmbH. Available online from: http://ec.europa.eu/environment/air/pollutants/pdf/eu_decopaint.pdf

[3] Krop, H.B. (2002), Health and environmental hazards of commonly used additives in lubricants, IVAM Chimiewinkel, Amsterdam.

[4] Van Broekhuizen, F. et al. (2009), Nanoparticles in the European construction industry, IVAM, Amsterdam/ EFBWW, Brussels.

[5] Cornelissen, R. et al. (2010), Nanomaterials in the Dutch Construction industry (in Dutch), IVAM/ Arbouw.

[6] Diepgen, T.L. (2003), 'Occupational skin disease data in Europe', Int. Arch. Occup. Environ. Health, Vol. 76, pp. 331–338.

[7] Spee, T. et al. (2006), 'Epoxy resins in the construction industry', Annals of the NY Academy of Science, Vol. 1076, pp. 429–438.

[8] Pronk, A. (2007), 'Isocyanate exposure and respiratory health effects in the spray painting industry', Thesis Utrecht University, Netherlands.

[9] Tjoe Nij, E. (2003), 'Radiographic abnormalities among construction workers exposed to quartz containing dust', Occup. Environ. Med., Vol. 60, pp. 410–417.

[10] Steenland, K. et al. (1998), 'Diesel exhaust and lung cancer in the trucking industry: exposure-response analysis and risk assessment', Am. J. Ind. Med., Vol. 34, pp. 220–228.

[11] Maynard, A.D. et al. (2011), 'The new toxicology of sophisticated materials: nanotechnology and beyond', Tox Sci Advance Access, Vol. 120, suppl. 1.

[12] Dick, F.D. (2006), 'Solvent neurotoxicity', Occup. Environ. Med., Vol. 63, p. 221–226.

[13] Meyer-Baron, M. (2008), 'The impact of solvent mixtures on neurobehavioural performance – Conclusions from epidemiological data', NeuroToxicology, Vol. 29, pp. 349–360.

[14] Seeber, A. et al. (1996), 'In search of dose-response relationships of solvent mixtures to neurobehavioural effects in paint manufacturing and painters', Food and Chemical Toxicology, Vol. 34, pp. 1113–1120.

[15] Triebig, G. and Hallermann, J. (2001), 'Survey of solvent related chronic encephalopathy as an occupational disease in European countries', Occup. Environ. Med., Vol. 58, pp. 575–581.

[16] EU-OSHA (2010), Safe Maintenance in Practice. Available online at: http://osha.europa.eu/en/publications/reports/safe-maintenance-TEWE10003ENC/view

[17] ECETOC (European Centre for Ecotoxicology and Toxicology of Chemicals) Targeted Risk Assessment (TRA) Tool. Available online from: http://www.ecetoc.org/tra

[18] EU-OSHA (2007), HWI Risk assessment checklists. Available online from: https://osha.europa.eu/en/campaigns/hwi/about/material/rat2007

[20] HSE (Health and Safety Executive) (2009), Working with substances hazardous to health: What you need to know about COSHH. Available online from: http://www.coshh-essentials.org.uk/assets/live/indg136.pdf

[21] Aarbo portaal. Stoffenmanager 4.5. Retrieved 4 April 2011 from: http://www.stoffenmanager.nl/Public/Explanation.aspx

[22] Eurofins. RISKOFDERM – Risk assessment for occupational dermal exposure to chemicals. Available online from: http://www.eurofins.com/product-testing-services/services/research-development/projects-on-skin-exposure-and-protection/riskofderm-skin-exposure-and-risk-assessment.aspx

[23] BAuA (German Federal Institute for Occupational Safety and Health) German REACH-CLP Helpdesk of the Federal Authorities, Exposure estimate at the workplace. Available online from: http://www.reach-clp-helpdesk.de/reach/en/Exposure/Exposure.html

[24] BAuA (German Federal Institute for Occupational Safety and Health) Hazardous Substances Ordinance (Gefahrstoffverordnung – GefStoffV) (2011), available online from: http://www.baua.de/en/Topics-from-A-to-Z/Hazardous-Substances/TRGS/pdf/Hazardous-Substances-Ordinance.pdf?__blob=publicationFile&v=2

[25] EU-OSHA (2011), Healthy Workplaces. A European Campaign on Safe Maintenance – European Good Practice Awards, 2011. Available online at: https://osha.europa.eu/en/publications/reports/good_practice_awards_maintenance-TEAL11001ENC