# MAINTENANCE AND HAZARDOUS SUBSTANCES – MAINTENANCE IN THE CHEMICAL INDUSTRY

## 1 Introduction

The European chemicals industry is one of the biggest industrial sectors and an important source of direct and indirect employment in many regions of the European Union, with a workforce of 1.2 million and sales of €537 billion (2007).

Small and medium-sized enterprises (SMEs) represent a significant share of the EU chemicals industry: 96% of all chemical companies have fewer than 250 employees and these are responsible for 28% of all sales and 35% of total employment. As producers of specialities, SMEs are often customers of the larger entities in the sector, rather than suppliers [1].

The chemicals industry produces a wide variety of substances and preparations which are essential for use in a very broad range of applications in virtually all sectors of the economy, including:

- base chemicals (petrochemicals and derivatives, basic inorganics and polymers) usually produced in large volumes;
- specialty chemicals (active ingredients and co-formulants for the pharmaceuticals industry and plant protection, auxiliaries for industrial processes, paints & inks, biocides, and dyes and pigments) usually produced in lower volumes; and
- consumer chemicals (soaps and detergents, perfumes and cosmetics). [1]

The chemical industry is one of the industries with the most stringent safety regulations. Regular revision, servicing and maintenance work is required due to the high stress placed on equipment by exposure to very aggressive substances, high temperatures and pressures. Depending on the size and type of plants and operations concerned, maintenance often involves complete shut-downs, however, specific production area maintenance and servicing operations are more common.

Whereas small-scale production like that of speciality chemicals is often run as a batch operation, large-scale production is mostly run as continuous operation. In both cases there may be various kinds of technical systems like chemical reactors (which often have to withstand high or low temperatures and pressures), separation devices (distillation, filtration, etc.), and fluid systems for liquids and gases (pumps, valves, tanks), etc.

The complex nature of chemical plants increases the risks for maintenance workers. In addition, they may come into close contact with a broad variety of often hazardous chemicals.

Some examples of accidents may be found in the EU-OSHA publication ‘Maintenance and occupational safety and health: a statistical picture’ [2]. This e-fact focuses on the specific risks related to various dangerous substances that maintenance workers in chemical plants are exposed to, and gives some basic recommendations on how these risks can be tackled, including some good practice examples. A complementary e-fact discusses maintenance and dangerous substances in general. https://osha.europa.eu/en/publications/e-facts/e-fact-66-maintenance-and-hazardous-substances/view

## 2 Exposure to substances during maintenance of chemical installations

Maintenance workers in (petro-) chemical plants may come into contact with a wide variety of substances. Generally, three major sources of exposure may be distinguished in chemical plant maintenance: the *use* of hazardous products or substances; substances that are *emitted* as a result of certain activities; and – most commonly – substances that may be *present* in production facilities that are maintained.

*Substances or products used in maintenance*

In most cases, maintenance of chemical plants does not involve a high use of products or substances. In cleaning operations in particular, water is in fact the most frequently used agent, although detergents may be added. In more specific though rare cases, volatile organic substances are used for cleaning metal parts or surfaces. In such cases, it is not uncommon for 'cheap' products such as gas oil to be used. More long-term periodic maintenance may involve painting activities. However, these are not very specific to maintenance of chemical plants, and they are dealt with in the general e-fact 'Maintenance and hazardous substances': https://osha.europa.eu/en/publications/e-facts/e-fact-66-maintenance-and-hazardous-substances/view

*Substances emitted as a result of maintenance activities*

Substances emitted may include those that are generated as a result of maintenance activities and the equipment used. Welding of steel structures generates welding fumes, which 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 any residues of substances such as greases, degreasing agents or paints that are present on the object.

The use of power generators, pumps, forklift trucks or vacuum cleaning trucks may bring about exposure to diesel engine exhaust. Diesel exhaust contains a complex mixture of gases and particles (soot) – the latter with polycyclic aromatic hydrocarbons adsorbed to them.

Sanding or blasting operations may generate various types of dust, such as paint or metal dusts.

Finally, toxic gases, vapour or fumes may be generated by certain maintenance or repair activities. A well-known example is the formation of toxic phosgene as a result of welding activities, when residues of chlorinated solvents are present, e.g. as a result of cleaning and degreasing. Unwanted chemical reactions can also occur.

*Substances present in facilities to be maintained*

In the maintenance of (petro-) chemical installations, substances present in non-core production installations such as storage facilities, refrigerating systems and waste treatment, as well as in the production installations to be cleaned or maintained may constitute a risk During shutdowns, regularly used tanks and warehouses that have to be maintained will still contain feedstock, intermediates or final products. However, temporary storage facilities may be used as well during shutdowns. It has been observed that in those cases accidents may arise from the fact that incompatible chemicals are stored close to each other, in particular when maintenance work is subcontracted [3].

Substances present in production installations may be residues of final products or intermediates, or catalysts and contaminants that are produced in the course of the production processes. A large variety of substances may be encountered depending on:

- The sector of industry (e.g. oil refineries, or the production of polymers, paints, chlorine, etc.)
- The actual production process (batch or continuous process, the use of catalysts)
- The final products, intermediates and contaminants that are produced.

**Figure 1: Complicated systems, such as this one at BASF, can increase the risks posed by maintenance operations**

Thus, the actual type and constitution of the residues present in production vessels, pipelines, etc., may be very variable indeed. Generally, it is not possible to link a specific type of production facility to a 'standard' mixture of substances present. However, some major groups of substances that are frequently encountered are described below.

- In *petrochemical* installations, residues of crude mineral oil may be present, which may contain carcinogenic polycyclic aromatic hydrocarbons (PAH). Other common carcinogens in refineries include 1,3-butadiene and benzene. Additionally, various fractions of distillation products may be encountered in production vessels and pipelines, such as hydrocarbons of different volatility. In 'BTX' plants (benzene-toluene-xylene), apart from benzene, residues of toluene and xylenes are to be expected.
- A well-known problem in oil refineries is the potential emission of the toxic gas hydrogen sulphide ($H_2S$). Mineral oil contains sulphides, and $H_2S$ may build up to lethal concentrations in confined spaces, such as production vessels, storage tanks or waste product tanks. $H_2S$ may also be emitted from wastewater treatment plants within the refinery.
- *Heavy metals* such as mercury may be present as well. Confined space atmospheres with elemental mercury deposits can result in high mercury vapour concentrations. The most common locations for mercury accumulation are separators and heat exchangers. Short-duration exposure may occur when, for example, a welder repairs or cuts a pipe that has mercury adsorbed on the interior pipe wall corrosion products [4].
- Mercury may also be a problem in *chlorine production* plants that use the mercury process. Continuous monitoring of mercury (and chlorine gas) is needed in those plants.
- The production of *plastics and resins*, in the manufacture of paints and adhesives, for example, may involve the presence of residues of highly toxic intermediate products, such as mono-isocyanates (polyurethanes), vinyl chloride (PVC), epichlorohydrin (epoxy resins), ethylene oxide (PET), benzene (e.g. polystyrene) etc. [5].
- Cleaning of production vessels for a great variety of chemical products may pose a risk of exposure to hazardous *catalysts* as well [6]. These catalysts may, for example, be (heavy) metals such as nickel or cobalt, or inorganic acids. The metal catalyst may be present in the form of powders, and exposure to the metal dust may be an actual risk in maintenance work.

- In production equipment for *inorganic chemicals* such as strong acids or lyes, residues of these products themselves may constitute the risk, which may for example be present when pipes or valves have to be opened.

Generally, during maintenance operations, for example during *plant shutdowns*, workers come into much closer contact with production equipment and hazardous (residues of) substances than during normal operations. Enhanced contact with substances may be due to opened machinery, pipes, fittings and valves (sometimes working overhead), and entering confined spaces such as storage tanks, process vessels and silos.

Certain activities related to maintenance, the *preparation of shutdowns*, and the subsequent *start-up phase*, such as emptying vessels, cleaning them, hot work (e.g. welding), assembly and disassembly, and working at defective mountings, are associated with increased health and safety risks, [3, 7]. Hazardous gases and fumes may be generated while washing process equipment, and gases may contaminate the working environment at a certain distance as well [3]. Research on incidents that have occurred during maintenance activities has shown that 'unknown chemical reactions' may occur, and that both the chemical company itself and the contractors are not always aware of the contents of production facilities and of possible reactions [8].

**Figure 2: Maintenance work at a chemical plant, BASF**

When urgent repairs are needed (in other words when the maintenance work is not pre-planned), the work may have to be carried out *while production continues*. This may increase the chances of workers coming into direct contact with process chemicals, e.g. through leaks, overfilling, opening of safety valves, and the fact that safety systems may not be fully operational [7].

Manual sweeping, manual brushing in order to remove rust or other solid residues, or sanding or blasting may generate high concentrations of (hazardous) dusts. The manual use of high-pressure water cleaning may result in exposure to contaminated aerosols. Manual solvent degreasing may result in high exposures to solvent vapours.

*Confined spaces* are commonplace in chemical plants and occasionally need to be accessed for maintenance. A confined space can be defined as any poorly ventilated enclosed area. They include storage tanks / vessels, silos, chemical reactors and piping / ductwork, but also trenches, sewers, basements and even rooms with inadequate ventilation.

Working in confined spaces can be extremely dangerous, as they have the potential for containing atmospheres which are hazardous to health.

In particular:

- *Absence of oxygen*
  This could be caused by the presence of an asphyxiating gas (such as nitrogen or carbon dioxide), or the oxygen could have been consumed in a chemical reaction (e.g. formation of rust consuming oxygen).
- *The presence of toxic gases*
  The atmosphere in confined spaces can become polluted with toxic gases given off by residue solids or liquids.

In addition, confined spaces can be susceptible to other hazards. These include fires and explosions (if flammable gases are allowed to build up), risk of drowning and exposure to hot conditions.

# 3 Health risks and outcomes

Exposure to hazardous chemicals can have many different health effects including:

- Acute effects, such as poisoning, suffocation
- Long-term effects, for example respiratory diseases, occupational cancers
- Health effects that can be both acute and long-term, such as skin diseases, allergies, reproductive problems and birth defects,

During maintenance operations, *skin injuries* may occur from e.g. splashes of cleaning solvents used, deposition of sprayed aerosols or dusts, or direct contact with contaminated surfaces. When strong acids or lyes are involved, chemical burns to the skin may result. 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, epoxy resins, isocyanates, oils and greases. When sensitising (allergenic) substances are involved, such as epoxy resins, allergic contact dermatitis may develop. Moreover, dermal exposure to e.g. crude mineral oil, PAHs or certain heavy metals (chromium) may lead to skin cancer.

*Inhalation* of irritant substances may result in acute irritation of the *airways*, e.g. through inhalation of welding fumes. Irritants may also exacerbate existing airway complaints (e.g. asthma, chronic obstructive pulmonary disease (COPD)). In severe cases of high exposure an acute form of asthma may even develop (RADS – reactive airways dysfunction syndrome). One may expect such effects for example after exposure to chlorine or ammonia in case of accidents in production plants. Chronic effects to the airways, including COPD (chronic bronchitis, emphysema) may result from exposure to irritants such as welding fumes. Exposure to inhalatory allergens, such as isocyanates, may result in allergic rhinitis or asthma. Exposure to diesel motor exhaust may contribute to the development of lung cancer [9]. Acute poisoning or suffocation can occur if working in confined spaces is not managed safely.

Inhalation of hazardous substances or residues used in maintenance activities might lead to a range of additional health effects. High exposure to solvents, for example in degreasing activities, may lead to neurologic disease such as chronic toxic encephalopathy [10, 11]. Certain substances that may be present in (petro-) chemical facilities, such as toluene and xylene, have reproductive health effects. Carcinogens that may be present include benzene, 1,3-butadiene, ethylene oxide and epichlorohydrin.

# 4 European legislation

European occupational safety and health directives transposed into the national legislation of the Member States set minimum standards of protection for workers. **The Framework Directive (89/391/EEC)** lays down the obligation of the employers to evaluate the risks to the safety and health of workers, among others those arising from the chemical substances or preparations used. It contains the general principles of prevention, the elimination of risks and accident factors, the informing, consultation and balanced participation and training of workers and their representatives.

European legislation related to chemical agents and chemical safety relevant for maintenance involving dangerous substances 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 OSH directives, e.g. concerning, work on board fishing vessels, mineral-extracting industries, and temporary or mobile construction sites
- Other OSH-related directives on health, environmental protection and the substitution of dangerous products, such as the directives on the limitation of emissions of volatile organic compounds, on persistent organic pollutants, and others.
- Directive 96/82/EC, on the control of major-accident hazards involving dangerous substances, is aimed at the prevention of major accidents which involve dangerous substances
- For more information see the European Agency for Safety and Health at Work (EU-OSHA) website:
  http://osha.europa.eu/en/legislation/directives/exposure-to-chemical-agents-and-chemical-safety/
  http://osha.europa.eu/en/legislation

# 5 OSH management, basic principles and rules for safe maintenance

A significant proportion of the serious and fatal accidents in the chemical process industry are connected with maintenance activities or are a result of faulty maintenance. Most of these accidents are caused by the release of dangerous materials during maintenance; for example, accidents involving pipework failure in chemical plants [12].

Regular servicing and maintenance work is required due to the high stress placed on equipment in this industry by exposure to very aggressive substances. Three kinds of maintenance work may be identified in the chemical industry: ongoing or daily maintenance work (executed without shutdown of the installation but where the equipment may be isolated), maintenance with a shutdown of the installation, and modification or construction of new units. Subcontractors may be involved in all three kinds of maintenance work. Outsourcing maintenance work is becoming the norm in the chemical industry.

Good OSH management practices are at the heart of reliable and safe maintenance. OSH management should be integrated in the general maintenance management. Key elements of OSH management include planning, an adequate risk assessment, safe systems of work, health and safety training, and an effective communication structure. Management commitment, and a good health and safety culture in the organisation, and involvement and participation of the workers in the health and safety management are important factors contributing to good health and safety outcomes.

## 5.1 Planning

Health and safety aspects have to be integrated in the planning process of the maintenance operations. Issues to consider include potential hazards and risks, health and safety communication, competence and health and safety training, and the impact of maintenance in terms of health and safety on others in the workplace. Emergency procedures, safe access and egress also need to be planned. An initial risk assessment can be completed and control measures and site rules can also be defined at this stage. Consideration should be given to the need for permits to work and similar procedures.

When outsourcing maintenance, companies need to consider the health and safety implications of the job they want to be done and select a contractor who can demonstrate the necessary competencies for the work and who is also operating in accordance with appropriate health and safety systems. This

requires integrating health and safety aspects into the procurement procedure and giving significant weighting to health and safety considerations in the selection and award criteria for the contract.

## 5.2 Risk assessment

Maintenance is a non-routine operation and maintenance workers might be at increased risk of exposure to dangerous substances, 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 situations that can occur during the maintenance processes. In chemical plants, in the risk assessment procedure special attention needs to be paid to hazards from dangerous chemicals during maintenance operations as large quantities of hazardous substances including flammable and toxic materials are stored and processed, and these substances or their residues might be still present in the plant during maintenance.

Risk assessment for dangerous substances follows the same basic principles as for other occupational risks. It involves making an inventory of the substances present in the plant and considering their hazardous properties, evaluating the risk of exposure and identifying those at risk and developing measures to eliminate or reduce the risks,

In the risk assessment particular attention should be paid to groups of workers who may be at increased risk e.g.:

- Young workers, older workers
- Pregnant women and nursing mothers
- Migrant workers
- Untrained or inexperienced staff
- Cleaners, contractors and members of the public.

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

- **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:

Dangerous Substances and Risk Assessment at:
http://osha.europa.eu/en/topics/ds/materials/en_ds.ppt

Factsheet 34 - Elimination and substitution of dangerous substances at
http://osha.europa.eu/en/publications/factsheets/34

## 5.3 Control measures

If a substance or process cannot be eliminated or substituted exposure have to be prevented or reduced through engineering or organisational measures and safe systems of works,

*Permit-to-work system:*

The permit-to-work system is an essential element of a safe system of work. The petroleum, chemical and allied industries store and process large quantities of hazardous substances including flammable and toxic materials, so the potential for serious incidents is clear and permit-to-work systems are a vital part of effective management of the hazards. A permit-to-work system is a formal recorded process used to control work which is identified as potentially hazardous. Permits to work should be used for high-risk tasks. The permit to work is a documented procedure that authorises certain workers to carry out specific work within a specified time frame. It is a way to control hazardous

activities. It describes what work will be done and how, setting out the precautions required to complete the work safely, based on a risk assessment. A permit-to-work is a formal check to ensure that all the elements of a safe system of work are in place before starting the work [13]. Examples of work permits in the chemical industry:

- Hot work permit (for an operation that could include the application of heat or ignition sources to tanks, vessels or pipelines, e.g. welding);
- Cold work permit;
- Electrical work permit;
- Equipment disjointing permit (used for any operation that involves disconnecting equipment or pipework that contains (or has contained) any hazardous or high-pressure fluids or other substances);
- Confined spaces entry permit (used to specify the precautions to be taken to eliminate exposure to dangerous fumes or to an oxygen-depleted atmosphere before a person is permitted to enter a confined space);
- Machinery permit (used for work on large, complex items of machinery to ensure correct isolation before the work is carried out);
- Isolation permit (used as a means of ensuring that the particular equipment is mechanically and electrically isolated before it is worked on);
- Radiation permit.

**Figure 3: Last-minute check: permit hand-over in the field e.g. for line breaking activities, BASF**

*Lock-out procedures*:

Lock-out procedures are implemented to ensure that all energy sources to the relevant equipment are isolated, disconnected or discharged, in order to prevent an inadvertent activation or energisation. Lock-out procedures must be established and implemented for the inspection, cleaning, repair or maintenance of any equipment that may cause injury to any person, if started inadvertently.

*OSH certification systems for contractors*:

OSH certification (or health, safety and environmental (HSE) certification is a system to verify that companies implement a health and safety management system and fulfil the requirements of health and safety (and environmental) protection (e.g. safety card in Finland, VCA Certificate in the Netherlands, MASE in France, etc.). OSH certification systems are a growing trend in chemical industry.

*Competence and training*:

Appropriate training, instruction and supervision have to be provided to ensure that safe work procedures are followed. This includes induction training for contractors, training for own staff, and training and instruction for those issuing, using, monitoring and auditing the permits for work.

*Emergency response programme associated with maintenance activities*:

An emergency during maintenance activities is an unexpected condition, state or situation (e.g. fire, explosion, leak of products or gas, loss of containment or threat) with resulting damage risks to health, life and livelihoods. Emergencies require specific emergency response programmes, consisting of an emergency response plan describing the procedures to be followed, and the resources required to execute the plans, employee training, and procedures to ensure the program is up-to-date. In the particular case of plant shutdowns, the local fire brigade and the police should be informed about the shutdown and the risks in connection with it.

## 5.4 Plant shutdowns procedures

Safety management procedures should also cover the shutdown periods. Chemical hazards need to be addressed during shutdowns because hazardous process chemicals are still present at the installation in storage tanks, warehouses, silos and pipelines even when the production process is not running. The consequences of a chemical accident during a shutdown may be severe as the number of persons working at the plant is typically quite high due to the presence of external maintenance workers [14].

The optimal time between two shut-downs is steadily increasing. Nowadays plants might run for 18 months or more without being shut down which means the personnel have fewer opportunities to become experts in planning and executing shut-downs. Unique hazards occur during shutdowns that sometimes are not well understood by plant personnel. Therefore, a communication plan should be put into place during shutdowns,

Examples of chemical accidents that might happen during shut-downs are [14]:

- exposure to chemicals during the preparation phase when vessels are emptied and equipment is cleaned;
- accidents due to inadequate isolation of the object worked on during the shut-down;
- accidents caused by the maintenance work itself (loss of containment, fire and explosions due to hot work);
- accidents happening at plant sections that are in operation during the shut-down (for example overfilling, leaks and opening of safety valves);
- accidents during start-up of a part of the facility.

Examples of tasks that must be carried out when preparing a process plant for a shut-down [14]:.

- Drawing up a plan for dealing with the process chemicals that will remain at the plant during the shut-down.
- making sure a sufficient amount of portable gas meters are available, checked, and calibrated.
- Informing providers of gases, other chemicals and utilities about the shut-down in order to avoid unnecessary deliveries during the shut-down
- Making sure that the persons in charge of preparing the plant for the shut-down have the necessary skills to carry out their tasks.
- Emptying and cleaning process equipment, pipes, valves, pumps, and other machinery in a safe and reliable way.
- Depressurising and flushing pipelines containing compressed air, inert gases, water or steam if not used during the shut-down.
- Equipment and plants to be maintained must be reliably isolated from those containing chemicals or still working during the shut-down and the effectiveness of the isolation must be verified
- Putting in place a procedure to assess when a piece of equipment is cold enough, clean enough and ventilated enough to be worked on by the maintenance personnel.
- Putting in place an emergency response programme

# 6 Good practice examples

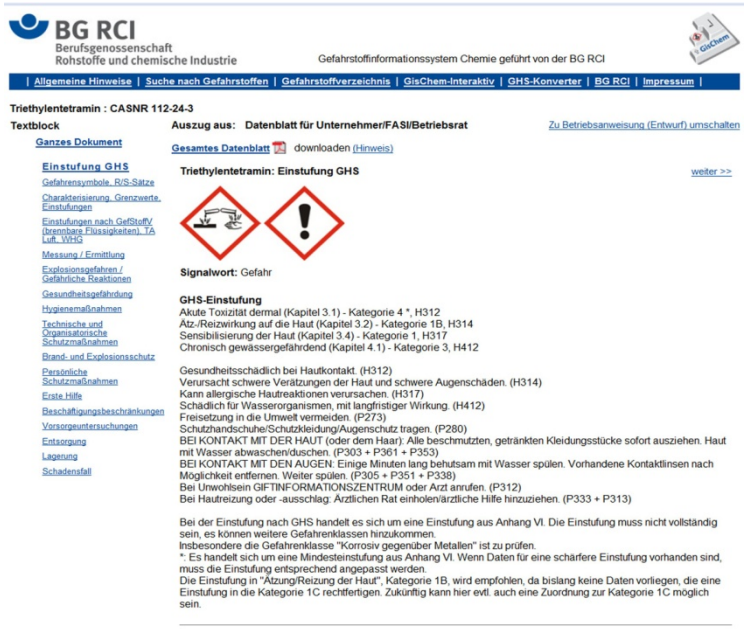
- **GisChem**

The German organisation BG RCI (Berufsgenossenschaft Rohstoffe und chemische Industrie; accident insurance association for raw materials and chemical industries) has developed a hazardous substances information system called GisChem. This internet-based tool, so far only available in German, provides overviews of the specific hazards and states the related preventive measures for the following processes:

- Polyurethane foam production (fittings and block foams)
- Manufacture of mechanical rubber goods
- Epoxy resin production
- Polyester resin processing
- Workshops / solvents and workshops / sprays and aerosols
- Recycling facilities for animal by-products and biogas plants
- Handling of ionizing radiation
- Hazardous substances in biotechnology laboratories.

According to the developers, the database has to be understood as an introduction to the hazardous substance issue for the chemical industry and related sectors and can be seen as an aid in carrying out the relevant risk assessments. The GisChem website also offers instruction sheets for workers; however, these need to be further adapted to the specific needs of the specific company.

**Figure 4: GisChem screenshot, KOOP**




An evaluation of this system, looking into how it influences actual work-related health problems in companies, is not yet available. However, GisChem is well known and used among OSH professionals in the German chemical industry [15].

- **Safety passport scheme**

Texaco's United Kingdom Pembroke refinery was one of the founding members of a national training programme for client contractors. The aim of the safety and health awareness training course is to ensure that any contractor working for a participating client has a basic knowledge of safety and health. They should therefore, after appropriate site induction, work on-site more safely and with lower risk to themselves and others. For this Client/Contractor National Safety Group (CCNSG) passport

training scheme a steering group was formed in order to review and develop the course contents and set standards and maintain quality control over training providers.

The courses have been adopted nationwide. Among other topics, the syllabus covers:

- Safe working practices
- Safe access and egress
- Fire precautions and procedures
- COSHH and personal protective equipment (PPE)
- Manual handling.

The United Kingdom's Health and Safety Executive (HSE) evaluated the scheme in 1998/1999, finding that the passport scheme has fulfilled the original intentions of its sponsors. The HSE report also emphasised that courses appear to sensitise workers to safety and health matters in a way they can relate to, so producing a long-term effect [16]

### SCC (VCA) checklist

The Dutch VCA system (Veiligsheids Checklijst Aannemers) or in English the SCC scheme ('Safety, health and environment (SHE) Checklist Contractors') was developed in 1994 to objectively evaluate and certify the SHE management systems of contractor companies that provide services to the petrochemical and chemical industry. The SCC scheme is owned and managed by a body made up of representatives of associations of both client and contractor companies.

Contracting parties can insist that their suppliers use the SCC scheme. The aim of the scheme is to achieve greater uniformity in SHE management systems and more continuous improvement of SHE performance within contractors' enterprises. An important element of the scheme is the requirement for SCC-certified enterprises to demonstrate clearly that their staff have received the obligatory SHE training. For this purpose a uniform national safety passport has been introduced in which all accepted and necessary safety training can be written down. More than 200,000 copies of this passport have been issued to workers in SCC-certified companies.

The SCC scheme consists of a list of questions that must be answered. Every question is explained and motivated in the SHE checklist contractors and some concrete verification points are mentioned that can demonstrate to the certification agencies whether the criteria mentioned in a question can be met. Certification agencies that have an accreditation for SCC certification will audit the company.

An evaluation by TNO in 1998 showed that SCC-certified companies experienced a notable drop in accident rates [16].

### BASF

BASF has developed three key elements of its health and safety management system to minimise risks for maintenance workers.

The permit-to-work system includes an assessment of all specific hazards involved in the tasks. All necessary measures to reduce the risks to a minimum have to be documented: those which have to be implemented before the maintenance work can start, and those to be observed during the job. Each maintenance job needs written permission and it is always the production department that has to give permission to start a job. There are different permits for different types of jobs, such as line breaking, hot work, work in confined spaces, excavation work. The person actually issuing the document has to be an experienced, trained worker (generally a shift supervisor). The permit receiver (contractor) must have been trained on how to use BASF permits (e-learning with test). All workers are informed by their supervisor about the required measures. Still there are special precautions: the four-eyes principle, meaning that the hazard assessment and the safety measures (for example covering work in confined spaces and hot work), must be checked by two people (shift supervisor and plant manager). In addition, there is a last-minute check during the permit hand-over in the field, e.g. for all line breaking activities.

In order to ensure that only highly qualified workers are allowed to do the maintenance tasks, BASF selects only contractor companies with a good safety performance and implemented safety

management systems such as SCC (see above). This means that contractor employees have to undergo safety training consisting of basic safety training, certified training on critical tasks (e.g. explosion/oxygen measurements, use of respiratory equipment, etc.) and site-specific training before they can access the site. For shutdown projects there is an obligatory kick-off safety meeting with written information/training on specific project-related hazards and measures. On-site there are BASF Mentors appointed who 'translate' relevant site rules and carry out regular checks on safety performance. Additional training is foreseen, for example the permit-to-work system (only trained supervisors are allowed to sign for receipt of permits) and for the use of specific PPE. To learn from experience, regular safety evaluations are conducted. These are held periodically for on-site contractors and also after completion for project contractors. For easy exchange a contractor safety experience exchange platform is available including a quarterly meeting between BASF and contractor representatives to discuss general points of improvement, new safety initiatives, etc.

**Figure 5: Safety training at BASF, BASF**

The third pillar of the BASF safety system is thorough work preparation. A maintenance job is broken down into different steps to create a detailed work plan. This plan includes all necessary safety aids for each step (e.g. scaffolds, special PPE, etc.) and a permit request is necessary for each step. Careful scheduling helps avoid interaction hazards between different jobs. The availability of workers and materials has to be checked. Of overall importance is careful plant preparation. All necessary permits and measures have to be established. A great deal of experience is needed to evaluate additional hazards that may arise due to urgent, unplanned work. Then, finally, if all measures have been taken the permits will be issued and the work can begin. The workers have to confirm that they have been informed of the measures to be taken and that BASF will conduct safety observations [18].

# 7 References

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