



Safe maintenance in practice



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FOREWORD

Maintenance is to keep and preserve equipment and facility in a functional state. Maintenance is not only necessary to ensure reliability of technical structures or productivity of the company, but regular maintenance has an important role in providing safer and healthier working conditions. Lack of maintenance or inadequate maintenance can cause serious and deadly accidents or health problems.

Maintenance itself is a high-risk activity. It is estimated that around 10-15% of all fatal accidents and 15-20% of all accidents are related to maintenance operations. Scientific studies indicate that occupational diseases and work-related health problems (such as asbestosis, cancer, hearing problems, and musculoskeletal disorders) are also more prevalent among workers involved in maintenance activities.

The European Agency for Safety and Health at Work (EU-OSHA) focuses its Healthy Workplaces Campaign 2010-2011 on Safe Maintenance. During the two years of the campaign, the European Agency for Safety and Health at Work will be supporting a wide range of activities at the national and European level, to promote safe maintenance. With the campaign, we want to raise awareness of the importance of maintenance for workers' safety and health and of the risks associated with maintenance. In the same time, we encourage employers to consider health and safety aspects in maintenance. The Campaign promotes an integrated approach to OSH management in maintenance, based on an adequate risk assessment.

This report supports the campaign by providing information on successful initiatives in the workplace illustrating how safety and health risks associated with maintenance can be managed.

Many companies, insurers and authorities have successfully developed solutions to improve safety and health during maintenance. The new approaches presented in this report demonstrate clearly that good occupational safety and health (OSH) management practices are at the heart of reliable and safe maintenance.

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 (machinery and equipment). The report contains several examples of considering maintenance during the design phase. Examples also show that the combined efforts of all parties concerned can lead to the best solutions to ensure the reliability and safety of maintenance operations.

The report is primarily aimed at maintenance managers and engineers, production managers who procure external maintenance services, managers of maintenance companies that carry out contract maintenance, and safety and health representatives.

I would like to take this opportunity to thank all our European partners as well as Agency and Topic Centre Working Environment staff who have contributed to the compilation of the report.

Jukka Takala, Director (EU-OSHA)



1.

INTRODUCTION



According to the European Standard EN 13306, maintenance can be defined as “(the) 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” on page 3. These items can be workplaces, work equipment, or means of transport like cars, ships, trains and aeroplanes.

Maintenance is critical to ensure productivity, to produce products of high quality and to maintain a company’s competitiveness. But it also has an impact on occupational safety and health. Regular maintenance has an important role in eliminating workplace hazards and providing safer and healthier working conditions. Lack of maintenance or inadequate maintenance can cause serious and deadly accidents or health problems affecting not only workers but also the general public. But maintenance itself is a high-risk activity and it has to be performed in a safe way, with appropriate protection of maintenance workers and other people present in the workplace.

The cases presented in this report focus on the safety and health and protection of the maintenance workers themselves

Maintenance is a generic term for variety of tasks in all sectors and all kinds of working environments. The wide range of maintenance activities include inspection, testing, measurement, adjustment, repair, upkeep, fault detection, replacement of parts, servicing, lubrication, and cleaning.

As a result, the performance of maintenance tasks is not confined to one occupation – for example mechanics, electricians, car mechanics, electronics engineers, building caretakers and office workers may all perform some maintenance tasks. The type of maintenance may be different depending on the sector in which the maintenance task is conducted. As a result, the hazards to which maintenance workers are exposed can also be very different depending on the task and the sector being worked in. They include physical, chemical, biological, and psychosocial hazards. Chronic exposure to certain hazards may cause health problems such as asbestosis, cancers, hearing problems, skin diseases, respiratory diseases, musculoskeletal disorders with, as a consequence, a higher-than-usual sickness absence rate.

Physical hazards

- Maintenance workers are frequently exposed to excessive noise during work. This is particularly the case for those involved in the maintenance of roads, tunnels, bridges and rail tracks, plane and car mechanics, metal workers, etc. Noise can be caused by machinery, equipment or by vehicles. Repeated exposure to high sound levels may have several undesirable effects on the health of operators, causing hearing impairment, hearing loss or tinnitus, and non-auditory complaints difficulties in concentrating, sleeping disorders, gastric ulcers, and increased blood pressure.¹
- Workers performing maintenance tasks might also be exposed to vibrations. Exposure to hand-arm vibration occurs when hand-held power tools, such as grinding, polishing

¹ Mateo Floria, P., *Gestión de la higiene industrial en la empresa*, Madrid: Fundación Confemetal, 2000
Vardhan, H., Karmakar, N. C. & Rao, Y. V., “Experimental study of sources of noise from heavy earth-moving machinery”, *Noise Control Engineering Journal*, No. 53(2), 2005, pp. 37-42

Blute, N. A. et al., “Exposure characterization for highway construction. Part I: cut and cover and tunnel finish stages”, *Applied Occupational & Environmental Hygiene*, No. 14(9), 1999, pp. 632-641

Klerlein, M. et al., “Nouvelle norme de dosimétrie de bruit: impact sur les niveaux sonores relevés en maintenance aéronautique”, *Archives de Maladies Professionnelles et de l’Environnement*, No. 67(6), pp. 843- 848

Kjellberg, A. et al.: “Fatigue effects of noise on aeroplane mechanics”, *Work & Stress*, No. 10(1), 1996, pp. 62-71



or riveting tools, percussion hammers, vibrating compactors, mowers or chain saws are used. These tools can transmit vibrations to the worker's hand causing vascular, neurological and musculoskeletal disorders such as white finger syndrome, a decrease in the sense of touch, and elbow arthritis.² Exposure to whole-body vibration occurs when a large part of the body rests on a vibrating surface. This is the case for drivers of commercial vehicles, such as tractors, fork-lift trucks, lorries or buses. Vibrations can be transmitted through seats or through the feet while workers are standing.³

- Maintenance workers in some industries are exposed to uncomfortable or extreme environmental conditions. They can be exposed to high or low temperatures, to excessive humidity, to poor ventilation or to UV radiation or radiant heat sources⁴ (Arc welders, for example, are exposed to ultraviolet and visible light from the electric arc, in addition to metal fumes). Working in cold environments may exacerbate effects of some of physical workload hazards. (see below)⁵

Ergonomic hazards⁶

- Maintenance work sometimes requires lifting heavy loads such as parts of machines, tools and equipment. The conditions for this type of work are not always ideal. Parts may not be within easy reach, access may be poor or there may not be sufficient space to move. Floors may be slippery or cables might be in the way, and some work may have to be performed at low level – under knee height or above shoulder height without lifting devices.
- Workers performing maintenance tasks can be exposed to repetitive movements, such as turning many screws by hand when no appropriate power tools are available, or the tools that are to hand are poorly designed.
- Sometimes workers have to hold tools or parts of the installation they are working on in place for some time and this can lead to significant static muscular workload and local muscle fatigue.
- Additionally, operators are often confronted with situations where force is needed to manipulate or lift parts of machines, installations and equipment.

Chemical hazards

- In certain industries, such as the chemical industry, construction, and agriculture, and in certain tasks, maintenance workers can be exposed to chemical hazards. During maintenance work on buildings, roads, machinery and other infrastructures, chemical substances can be released into the working environment by the task being carried out and the worker may come in contact with them. Workers might be exposed to chemical hazards for example, during electric arc welding, while working in car repair shops or waste treatment plants, while performing maintenance of swimming pools or industrial installations where hazardous chemicals are present.

² Falagán Rojo, M. J., Higiene industrial: manual práctico. Tomo I: contaminantes químicos y biológicos. Tomo II: agentes físicos y actividades especiales, Oviedo: Fundación Luis Fernández Velasco, 2008

³ Falagán Rojo, M. J., Higiene industrial: manual práctico. Tomo I: contaminantes químicos y biológicos. Tomo II: agentes físicos y actividades especiales, Oviedo: Fundación Luis Fernández Velasco, 2008

⁴ Falagán Rojo, M. J., Higiene Industrial Aplicada, Oviedo, Fundación Luis Fernández Velasco, 2001

⁵ Tenkate, T. D., Collins, M. J., "Angles of entry of ultraviolet radiation into welding helmets", American Industrial Hygiene Association Journal, No. 58(1), 1997, pp.33-38

Cole, H. et al., "Particulate and gaseous emissions when welding aluminium alloys", Journal of Occupational and Environmental Hygiene, No. 4(9), 2007, pp. 678-687

⁶ Prevent, Belgian Institute for Prevention and Well-being at work, www.prevent.be



- Specific maintenance operations may involve risks associated with asbestos fibres. Operations during which workers might be exposed to asbestos include the demolition of buildings, removal of asbestos in buildings, the scrapping of ships, and the maintenance of industrial installations and buildings where asbestos is present in the structure.

Exposure to chemical hazards leads to diverse and sometimes severe health problems. Asbestosis, skin diseases, and respiratory diseases are just a few examples.

Biological hazards

- Sectors in which maintenance workers may be exposed to biological hazards include food production, agriculture, health care, veterinary practice, waste water and solid waste treatment plants. Biological hazards are micro organisms capable of causing infections, allergies or poisoning.⁷ They include viruses such as those that cause hepatitis, bacteria such as Legionella, and fungi and the exotoxins produced by them.

Psychosocial hazards⁸

Maintenance workers may experience stress caused by the very nature of the maintenance work. Stress might be caused by any or the combination of the following factors:

- Time pressure – during maintenance work, the productivity of an organisation is frequently hindered and maintenance workers have to cope not only with the demands of the task in hand, but also with a sense of responsibility for the swift resumption of production and for workers waiting to resume their tasks. This problem is compounded when staff cut-backs have led to a decrease in number of maintenance workers available to deal with emergencies.
- Complex technology combined with non-routine situations.
 - Communication problems – for example, working with contractors, or several contractors at the same site
 - Working alone and in isolation.
 - Irregular working hours such as shifts, weekend work, night work, or being on call
 - Insufficient knowledge – as, for instance, when workers are not familiar with the building lay-out or the machines they have to use or to maintain.)
 - Insufficient training – when workers may not know how to perform certain maintenance tasks.)

Accidents

Maintenance is also associated with a high risk of all kinds of accidents.

Occupational accidents during maintenance work are numerous. Based on the data from several European countries, it is estimated that 10-15% of fatal accidents at work, and 15-20% of all accidents, are connected with maintenance.⁹ In Germany, where

⁷ Falagán Rojo, M. J., Higiene Industrial Aplicada, Oviedo, Fundación Luis Fernández Velasco, 2001

⁸ Prevent, Onderhoud: definities en belang, PreventFocus, 2007/02 <http://nl.prevent.be/net/net01.nsf/p/B7229AED9D7F1ED4C1257284003DB8E3>
Prevent, Belgian Institute for Prevention and Well-being at work, www.prevent.be

⁹ EU-OSHA – European Agency for Safety and Health at Work, Maintenance and occupational safety and health: a statistical picture, 2010. Available at: http://osha.europa.eu/en/publications/literature_reviews/maintenance_OSH_statistics



more than 15% of the workforce is employed in maintenance, about 20% of all fatalities occurred during maintenance work in 2001. According to "Berufsgenossenschaftliche Information" BGI No. 577 (accident insurance organisations' guidance) approximately 50% more accidents happen during maintenance work than during normal production. These accidents often result in severe injuries and prolonged time off work.

Maintenance workers are not only at risk of being involved in a work-related accident, but also of developing occupational diseases.

Maintenance-specific hazards and risks

In addition to the risks associated with any working environment, maintenance operations involve some specific risks.

These include working alongside a running process and in close contact with machinery. During normal operation, automation typically diminishes the likelihood of human error that can lead to accidents. In maintenance activities, contrary to normal operation, direct contact between the worker and machine cannot be reduced substantially – maintenance is an activity where workers need to be in close contact with processes.

Maintenance often involves unusual work, non-routine tasks and it is often performed in exceptional conditions, such as working in confined spaces.

Maintenance operations typically include both disassembly and reassembly, often involving complicated machinery. This can be associated with a greater risk of human error, increasing the accident risk.

Maintenance involves changing tasks and working environment. This is especially true in case of contract workers. Subcontracting is an aggravating factor in terms of safety and health – numerous accidents and incidents relate to subcontracting maintenance.

Working under time-pressure is also typical for maintenance operations, especially when shutdowns or high-priority repairs are involved.

It seems obvious that attention to the management of risks associated with maintenance work is very important in order to prevent harm.

Many companies, insurers and authorities have successfully developed solutions to improve the safety and health of maintenance workers. A selection of good practice case studies are presented in this report. The interventions are based on the requirements of the European Framework Directive 89/391/EEC "on the introduction of measures to encourage improvements in the safety and health of workers"¹⁰ and its daughter-directives. These Directives oblige employers to conduct and document risk assessment and to take the necessary measures to ensure the safety and health of workers in every aspect of their work. The provisions of the directives are enacted through national law in each Member State.

¹⁰ Available at: <http://europe.osha.eu.int/data/legislation/1>



The Framework Directive requires all businesses to conduct risk assessments, meaning identification and a careful examination of factors that could cause harm to workers – so that it can be decided whether sufficient precautions have already been taken or whether more should be done to prevent harm. Any risk assessment process should:

- identify the hazards (whether arising from work activities or from other factors, such as the layout of the premises)
- establish who might be harmed and how, and identify groups of workers who might be at greater risk
- evaluate the risks involved – the number of persons exposed, the frequency and duration of exposure, possible outcomes
- decide whether existing precautions are adequate or whether more control and preventive measures should be introduced
- involve employees and workers' representatives in the risk assessment process, including providing information on risk assessment results and consulting them about the preventive measures needed
- take into account the individual worker's capabilities in general and specific risk assessments
- take action – decide on measures needed, plan how they will be implemented decide who does what and when
- monitor and review the process
- record the findings.

Workers or their representatives should be involved in the process.

The new approaches presented in this report demonstrate clearly that good occupational safety and health (OSH) management practices are at the heart of reliable and safe maintenance. The link between good OSH management, particularly when it is applied to maintenance work, and the quality assurance procedures is clearly demonstrated.

Risk assessment for maintenance operations is an especially difficult task because of the various uncertainties typical for these work processes. A number of companies have developed special tools to deal with these challenges.

Furthermore, some best practice examples demonstrate how to deal with various risks and hazards affecting maintenance jobs, such as working at height, working with various kinds of technical equipment, whether machines or structures, working with hazardous substances such as solvents and asbestos, and dealing with stress.

Examples also show that the combined efforts of all parties concerned can lead to the best solutions to ensure the reliability and safety of maintenance operations.

The table below presents an overview of the cases in this report with a short description of the initiatives, the results and the success factors for each of the cases.



Nr	Subject	Keywords	Title	Organisation	Country	Initiatives	Result	Success factors
1	Safety and health management	Chemical hazards, organisational measures, contractors	Good maintenance at BASF: chemical industry	BASF SE	DE	<ul style="list-style-type: none"> Guidelines for safety, health and environment Work permit Safety rules for skilled labour Consignment notes Safety, health and environment (SHE) quality standards in its contracts Advice, audits and training of contractors Information and training of workers 	<ul style="list-style-type: none"> No notifiable accidents due to exposure to dangerous substances in maintenance works since 2003. General accident numbers remain far below the chemical industry's average. 	<ul style="list-style-type: none"> Maintenance work flow and responsibilities clearly defined Guidelines for safety, health and environment, and training Communication between all stakeholders on procedures related to maintenance, on the results of risk assessment Lively safety culture. Procedures for working with contractors
2	Prevention by design	Unexpected start-up of machinery, safety function	Improving maintenance work safety by altering the design of a reeling machine	Central Institute for Labour Protection – National Research Institute	PL	<ul style="list-style-type: none"> Prevention of unexpected start-up of machinery during maintenance work by the inclusion of a safety shut-down function in the machinery control system. Risk assessment to specify safety requirements for safety function 	<ul style="list-style-type: none"> The manufacturer has met safety requirements included in the 98/37/EC directive Safe for the employees to perform maintenance work on the machine 	<ul style="list-style-type: none"> Risk identification in the design stage of the machine Implementing preventive measures in the machine's design stage



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Nr	Subject	Keywords	Title	Organisation	Country	Initiatives	Result	Success factors
3	Safety and health management	Behavioural safety initiatives, safety procedures, risk assessment	Health and safety management system at Romec	Romec	UK	<ul style="list-style-type: none"> Implementation of safety procedures, safety systems, risk assessments. Back-up of the system by behavioural safety initiatives: training and communication. Many elements relate directly or indirectly to maintenance work. 	<ul style="list-style-type: none"> The comprehensive health and safety management system has been registered by the British Standards Institute (BSI) to the OHSAS18001 management system standard. RoSPA Gold Award 2007. 	<ul style="list-style-type: none"> OSH management system approach Support by behavioural safety initiatives
4	Remote controlled maintenance management system	Forecasting of malfunctioning, remote controlled system for maintenance operations: design and development of a prototype	"Smart" remote controlled geographical system for maintenance operations: design and development of a prototype	University of Rome, CNIM & ISPESL	IT	<ul style="list-style-type: none"> Development of a remote-controlled maintenance management system which Allows remote diagnosis of problems and detection of malfunctions and lowering of safety standards 	<ul style="list-style-type: none"> High level of management efficiency Avoiding emergency interventions has a positive impact on the safety levels for maintenance and operating personnel 	<ul style="list-style-type: none"> Better follow-up of necessary maintenance tasks and fewer emergency maintenance interventions
5	Risk assessment	Multidisciplinary steering group	Renault; analysis of risk situations	GRAM Normandy	FR	<ul style="list-style-type: none"> Applying SPO (Suppress or limit – Protect – Organise) accident prevention method, based on a comprehensive approach to risk management Conducting interviews and analysing the results to identify risks 	<ul style="list-style-type: none"> Creating a safer working environment Through the implementation of preventive measures Improved ergonomics, comfort, reduced stress Significant improvements in terms of productivity and reduced machine downtime 	<ul style="list-style-type: none"> Management commitment and support. Multidisciplinary steering group Active involvement of workers. Integrated approach towards safety

Nr	Subject	Keywords	Title	Organisation	Country	Initiatives	Result	Success factors
6	Safety and health management	Major overhaul, communication, contractors	Major overhaul of a conventional thermal power station	Electrabel	BE	<ul style="list-style-type: none"> Developing preventive measures based on risk assessment Efficient planning of a major overhaul including the preparation execution phase, evaluation phase. Development of a work permit system Repeated risk assessments "built-in" to this process method further minimise the risk of dangerous situations arising during overhaul. 	<ul style="list-style-type: none"> Better communication between maintenance and production personnel. Good communication between stakeholders Better productivity Lower risk of accidents Effective communication structure Continuous evaluation and development Involvement of both employees and contractors' workers throughout the whole process 	
7	Safety and health management	Awareness raising, proactive maintenance	Maintenance practice in the printing industry	HSL	UK	<ul style="list-style-type: none"> Research study on the occurrence and effects of proactive maintenance in printing industry. Promotion of good maintenance practice. 	<ul style="list-style-type: none"> Identification of positive effects of effective and proactive maintenance. Involvement of employees and management Integration of maintenance as a key productivity element in a manufacturing strategy 	
8	Code of good practice	Risk assessment, "safe system of work" plan	Efforts to reduce accidents related to repair and maintenance of farming equipment in Ireland	HAS, Irish Health and Safety Authority	IE	<ul style="list-style-type: none"> A code of practice for safe maintenance in agriculture, including a risk assessment document and a "safe system of work" plan has been developed. 	<ul style="list-style-type: none"> Over 11,000 farmers are receiving training each year. Fewer fatalities over the last five to six years. Partnership between the HAS and the statutory advisory committee on safety and health in agriculture (Farm Safety Partnership). 	





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Nr	Subject	Keywords	Title	Organisation	Country	Initiatives	Result	Success factors
9	Working at height	Innovative climbing system	Safe access system used for the maintenance of a power supply line network	Nordostschweizerische Kraftwerke AG (power supply North East Switzerland)	Switzerland	<ul style="list-style-type: none"> ■ Introduction of the HighStep-system, allowing safe and ergonomic access to the pylons and masts, using portable climbing equipment. ■ NOK expects to eliminate accidents related to climbing masts and pylons. ■ Movements during climbing are ergonomically improved. ■ The system saves money because faster, safer access to structures means less time is needed for maintenance work 	<ul style="list-style-type: none"> ■ Support of the Minister of State at the Department of Enterprise, Trade and Employment ■ Participation of interested farmers ■ Management commitment to adapt a tool to reduce risk ■ Thorough testing and adapting of the system to the specific conditions 	
10	Training and information	Awareness raising	Safe maintenance concept for the Oresund fixed link	Öresundsbro Consortium	SE, DK	<ul style="list-style-type: none"> ■ Compulsory safety courses ■ Detailed planning before performing maintenance work ■ Safety procedures available via Internet and safety booklets 	<ul style="list-style-type: none"> ■ The number of accidents is kept low 	<ul style="list-style-type: none"> ■ Management commitment ■ Cooperation between health and safety coordinator, employees and contractors ■ Frequent audits and checks on the spot to verify compliance with the rules

Nr	Subject	Keywords	Title	Organisation	Country	Initiatives	Result	Success factors
11	Prevention by design	3D computer simulation	A virtual tool to plan in advance for real-world defects	Air France KLM	FR	<ul style="list-style-type: none"> Simulation of a new workplace using a 3D simulation software tool. 	<ul style="list-style-type: none"> The simulation enabled workers to visualize themselves in their future working environment. Problems related to the ergonomics and safety of the premises were anticipated at the design stage Early acceptance of new working conditions by the employees was ensured 	<ul style="list-style-type: none"> Management commitment to create safe work conditions for maintenance workers Involvement of workers in the design of workplace Addressing safety, ergonomic and production issues at the design stage.
12	Training and information	Hydraulic systems, interactive training	Safe maintenance of hydraulic systems	Accident prevention and insurance association for the metal working industry	DE	<ul style="list-style-type: none"> Publication of BGI 5100 – information on the specific risks related to the repair and maintenance of hydraulic systems. Implementation of a course based on this publication, to raise awareness of the risks and promote safe work practices. 	<ul style="list-style-type: none"> Provision of information used in daily routines. More attention to preventive maintenance of hydraulics. Safety instructions and qualification schemes adapted in accordance with BGI 5100. Awareness regarding safety and health risks has increased. 	<ul style="list-style-type: none"> Workers' involvement Provision of theoretical information combined with practical training Interactive training





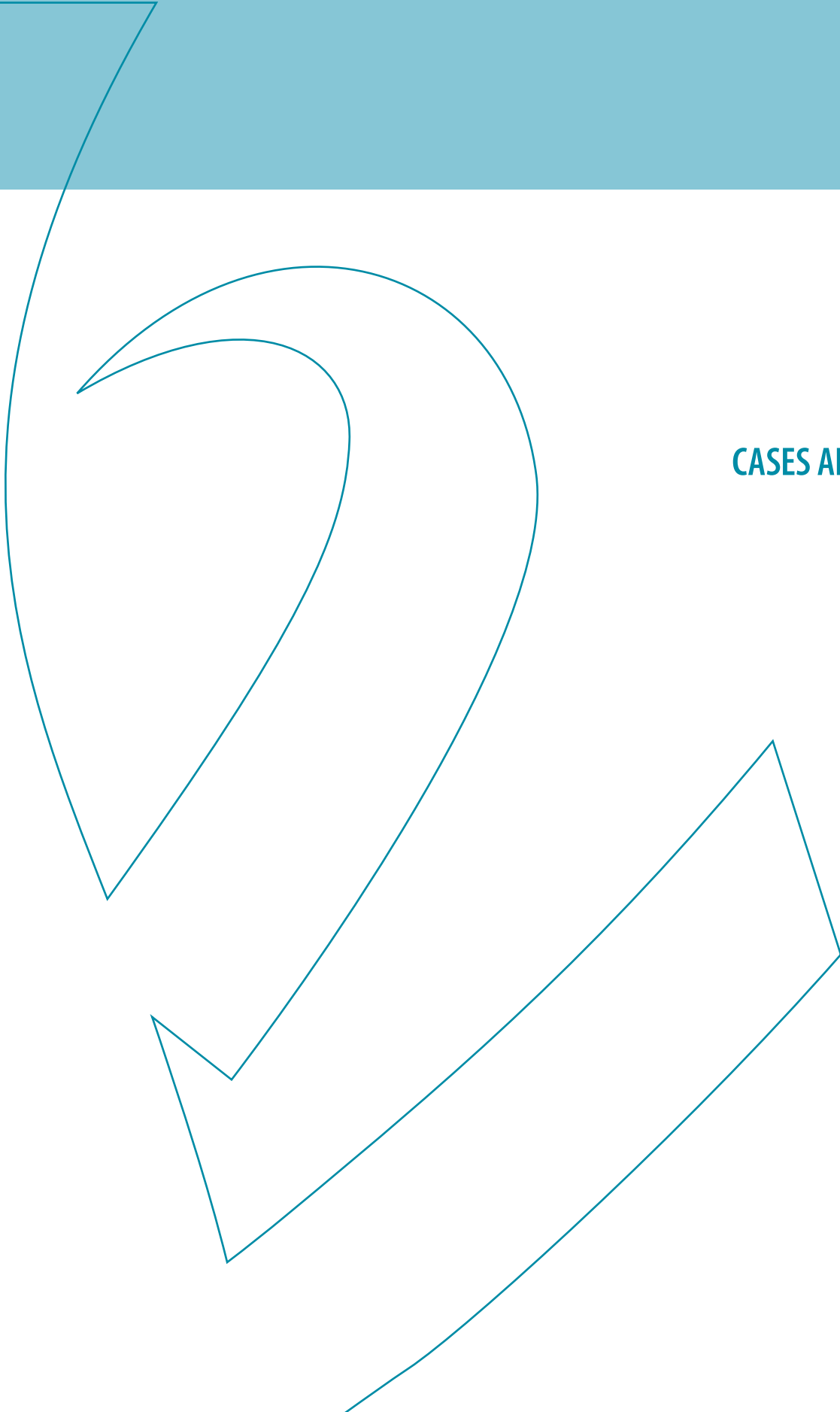
Nr	Subject	Keywords	Title	Organisation	Country	Initiatives	Result	Success factors
13	Chemical hazards	Substitution	Substitution of hazardous chemicals in repair and maintenance work	CatSub	DK	<ul style="list-style-type: none"> Development of CatSub, a publicly accessible database of more than 300 examples of substitution of hazardous chemicals by less hazardous or hazard-free products. 	<ul style="list-style-type: none"> Information on substitution of dangerous substances is freely available to companies and many companies use the CatSub database. 	<ul style="list-style-type: none"> Free information
14	Asbestos	Training and information, good practices	How to protect workers from asbestos risks	NuovaQuasco	IT	<ul style="list-style-type: none"> Creation of a training package for technicians and employers consisting of a manual and a CD-ROM to help construction workers understand current regulations about the handling of asbestos and to improve compliance with these regulations. 	<ul style="list-style-type: none"> Facilitating workers' understanding of current regulations concerning asbestos, improving compliance and implementing safe working practices 	<ul style="list-style-type: none"> Presentation of complex issues through simple, clear messages such as "remember that" and "what you must not do"
15	Asbestos	Chemical hazards, Compliance with HSE guidance	Taking risks with asbestos: What influences the behaviour of maintenance workers?	HSE	UK	<ul style="list-style-type: none"> Research was done to find out why maintenance workers do not always follow HSE guidance, and to identify ways of encouraging workers to follow the guidance in the future. 	<ul style="list-style-type: none"> Identification of factors influencing individual behaviours towards asbestos. 	<ul style="list-style-type: none"> Involvement of workers through interviews.

Nr	Subject	Keywords	Title	Organisation	Country	Initiatives	Result	Success factors
16	Stress	Training and information, risk identification	Solutions to reduce occupational stress in maintenance	Accident prevention and insurance association for the metal working industry	DE	<ul style="list-style-type: none"> ■ A risk-reduction workshop was run with the participation of maintenance workers and managers ■ Establishment of a mitigation plan. 	<ul style="list-style-type: none"> ■ Identification of risks to which workers doing maintenance tasks are exposed. ■ Increase of awareness among maintenance workers and managers of risks factors that might cause stress. ■ Development of approaches that can prevent or reduce work-related stress. 	<ul style="list-style-type: none"> ■ Participation of managers ■ Participation of employees in the identification of risks and the development of preventive measures. ■ Open discussion between managers and workers.
17	Training and information	Awareness-raising	Training based on comprehensive guidelines to improve health and safety in waterways maintenance work	NuovaQuasco	IT	<ul style="list-style-type: none"> ■ Producing guidelines for the application of health and safety regulations, detailed descriptions of work processes and related preventive measures ■ Training technicians 	<ul style="list-style-type: none"> ■ A database with examples of preventive measures to be taken on site. ■ Guidelines for completing a safety plan 	<ul style="list-style-type: none"> ■ Involvement of maintenance technicians ■ Health and safety advice integrated into technical drawings
18	Prevention by design	Maintenance of trains, design of the workplace	A source-oriented strategy to reduce workplace risks during the maintenance of trains.	NedTrain	NL	<ul style="list-style-type: none"> ■ Design of a new workshop for maintenance of trains entailing number of innovations in the workshop design to boost employees' safety 	<ul style="list-style-type: none"> ■ A safer work environment for maintenance workers ■ A flexible workplace adjustable to future technical evolution 	<ul style="list-style-type: none"> ■ Including health and safety aspects in the design phase of the new workshop. ■ Involvement of various parties such as management and employees in the brainstorming sessions.



2.

CASES AND SNAPSHOTS



2.1.

CASE 1: GOOD MAINTENANCE AT BASF; CHEMICAL INDUSTRY

GERMANY

Organisation: BASF SE

Key points

- Organisational measures
- Prevention of chemical risks
- Hazardous chemicals and dead spaces
- Opening and working on enclosed installations
- Unexpected occurrences in opened systems

Introduction / Background

At the BASF site in Ludwigshafen there are more than 32,000 workers and about 6,000 contract workers. Maintenance is dealt with by approximately 7,000 skilled workers, made up of 4,000 employees and 3,000 contractors. The workers are well qualified in their professions, e.g. mechanics, electricians or welding operators.

The site's 225 production units are supplied with liquid and gaseous chemicals by more than 2,000 km of pipes. Safe maintenance of the piping system and machinery requires continuous attention and improvement.

Among the risks to which maintenance workers are exposed is the possibility of coming into contact with hazardous liquid substances while pipes or valves are being dismantled.

Aims and objectives

The continuous development of good practice in maintenance works is part of the BASF safety philosophy. Some of the improvements presented in this case study have been introduced as a consequence of an accident in 2003 when a maintenance worker was burned by acrylic acid while opening a ball cock valve. ("Kugelhahn").

The aim of the company's current safety policy is to prevent such accidents by making maintenance work-flow more transparent and clearly organised, ensuring that all steps, from the dismantling to the re-mounting of all components, are included in the work plan.

Scope of the project

Guidelines for Safety, Health and Environment ("Richtlinie SGU")

The Guideline for Safety, Health and Environment is the basis for all maintenance works. It specifies that before starting any maintenance work a risk assessment has to be carried out. The guideline also gives advice on how to carry out a risk assessment and contains full examples of the correct documents to be used.

This documentation is made available to all the craftsmen doing the maintenance works, whether employees or contract workers. A special set of guidelines entitled



“Safety Rules for skilled labour” (“Sicherheitsregeln für handwerkliche Arbeiten”) describes the specific safety measures set out following the risk assessment. These guidelines help the workers to take appropriate precautions. (See below for more information on the guidelines “Safety Rules for skilled labour”).

Working permit (“Arbeitserlaubnisschein”)

Working permits define which works can be carried out by the maintenance workers. Manual and online tutorials help the responsible person to fill in data correctly and precisely. The permit identifies the person or people responsible for co-ordinating the work and instructing maintenance workers. Crucially, the working permit is always checked by a second person who proofreads it, confirming that the safety measures outlined in the permit are appropriate, and countersigns it – this is known as the “four eyes principle”.

- All preparatory safety measures are based on the findings of the risk assessment. These safety preparations have to be carried out by BASF workers.¹¹ Maintenance work cannot start until the preparations are finished and the safety representative has countersigned the documents confirming their completion.
- Work practices are based on the risk assessment which takes into account hazards such as dangerous substances, machinery or installations.
- An extra fire permit is needed for certain works, such as welding, which may be particularly dangerous if pipes contain chemical residues.
- The working permit also sets out what personal protective equipment is needed for the job.
- Additional safety measures may be necessary after the maintenance work is completed, such as pressure tests. These measures are also set out in the working permit and the maintenance worker must sign the permit to confirm that all final safety measures have been carried out.

Before the maintenance work itself starts, workers are informed by BASF’s responsible supervisors about the results of the risk assessment, the working permit system and all personal protective equipment needed. Work does not begin until BASF’s responsible supervisor declares that the preparatory safety measures are complete and countersigns the working permit.

During maintenance, work will immediately stop if something unexpected happens. For example;

- When the leakage of a hazardous substance is much greater than the residual volume estimated in the original risk assessment
- When an installation is damaged

At this point a new risk assessment is carried out and new safety measures are drawn up.

Safety Rules for skilled labour (“Sicherheitsregeln für handwerkliche Arbeiten”)

These additional guidelines give examples of how to use work permits. They define responsibilities and set out rules and advice for maintenance works. The guidelines are explicitly aimed at maintenance workers and help them to identify safety measures required by their specific trade. They contain a catalogue of potential risks and how they can be prevented. All the information in the guidelines is based on the requirements set up by the statutory accident insurances, but the guidelines also cover emergency and exit plans and offer examples of good practice. The most

¹¹ If this can not be done, an own working permit has to be filled in for maintenance workers.



hazardous maintenance tasks involve dismantling of pipes containing dangerous substances, pipes under pressure, working in height, etc.

Thus the good practice examples describe how to open valves and pipes, how to lock connections, how to set blind discs and how to work safely overhead. When removing a tube from its mountings, for example, safety measures should include:

- Checking that it is the correct tube as specified in the job order.
- Preparing the work area.
- Following the safety measures outlined in the work permit.
- Not touching hot or smeared tubes with unprotected hands.
- Loosening the screws of the flanges from the side furthest from the body, before loosening remaining screws carefully, always ensuring that a screw can be tightened again quickly if necessary.
- Standing to the side of flange couplings rather than underneath them.
- Wherever possible, working below eye level rather than above it

Figure 1: How to open a flange overhead



© By courtesy of BASF Ludwigshafen

- Push apart the flange coupling so that the pressure can be released. Liquids which may run out should always be treated as if they are hazardous.
- Screws must not be loosened before the pressure is released.
- Screws must not be fully loosened and removed until any leakage of liquid has stopped.
- If the pipe is still under pressure, it must be braced – for example, with bolts and holding devices.
- Do not lean ladders against a pipe which is being worked on.
- Heavy tubes and equipment must be supported to prevent oscillation or collapse.
- Curved tubes may bounce dangerously if allowed to fall to the ground.
- Distancing devices should be used to hold couplings and joints apart to protect fingers while work is carried out.

Figure 2: How to attach tubes to the ceiling in order to prevent them from falling down



© By courtesy of BASF Ludwigshafen

Such work practices are essential to avoid the harm that can be caused by dangerous substances which may remain in pipes being worked on. The guidelines show which tools should be used for which tasks and under which circumstances: e.g. tools for safe maintenance works on glass pipes which contain hazardous substances, or tools needed for additional tasks, such as leakage or pressure tests once the work is completed.

The information in the guidelines also forms part of workers' training, stating that maintenance workers or contractors will be given advice by safety supervisors on working techniques, tools and personal protective equipment. In individual cases, special protective equipment and special tools can also be provided by BASF.



Consignment notes ("Begleitscheine")

After an accident in 2003 in which a worker was burned by acrylic acid when opening a ball-cock valve in the workshop, BASF decided to introduce "consignment notes" for maintenance works. Although the pipes and other equipment are flushed to clear hazardous substances, residues may remain. The consignment note gives an overview of the results of the risk assessment for a particular job and summarises the special risks that might be involved. It specifically states which dangerous substance – and how much of it – might be in the installation, and how it should be dealt with if any residues remain.

The consignment note has to accompany components and pipes at all times, from the moment they are taken from their mountings to be taken to the workshop until they are re-mounted.

This means that staff in the workshop can take appropriate cautionary measures before opening the parts. This prevents accidental exposure and accidents resulting from contamination or from adverse chemical reactions. Standard practice within the company is now that maintenance work will not start without a consignment note. If there is no note, the part will stay be stored until the situation can be clarified by the BASF employee responsible for the job.

Correct use of consignment notes is part of the training of all maintenance workers and every step of the process is monitored.

Advice, audits and the training of contractors

Contractors are told by responsible safety experts or BASF supervisors of the results of risk assessments, the use of working permits and the personal protective equipment required before maintenance work begins. Work does not begin until BASF's responsible supervisor is satisfied that all necessary safety measures have been completed and countersigns the working permit.

To ensure that contracting companies have all relevant information about internal safety culture and standards, BASF sets out safety, health and environment (SHE) quality standards in its contracts. All contracting companies have to be SHE-certified. BASF also offers audits of management systems to the contracting companies to ensure their reliability and the compatibility of their work and occupational safety and health standards with BASF's.

The BASF safety management team is also interested in learning from its partners, sharing knowledge of internal safety culture and good work practices in seminars.

Informing and training workers; adaptability of standards

The guidelines and standards of BASF can be adapted quickly to new developments. New practices are constantly being developed through co-operation between safety experts and engineers. Managers, shift supervisors and foremen are informed monthly about new developments through newsletters.

Various newsletters and information brochures are used to communicate new safety and health standards and practices:

- The "Blue Arrow" ("Blaue Pfeile") contains updates, amendments, new checklists, good practice and information about new legal requirements. A team of safety experts and engineers can react to new developments quickly and release a new issue in 2 or 3 days.



- The “Red Arrow” edition (“Rote Pfeile”) summarises accidents and incidents. The aim of this publication is to raise awareness, to keep alertness high and to show how accidents can be prevented. News of the introduction of the consignment note was issued first in the “Red Arrow”
- The Newsletter (“Aktuelles”) reports incidents which could happen again and suggests possible preventive measures.

Once a year workers attend safety trainings. All training materials and texts are prepared by safety experts and re-checked by engineers to be sure that they are applicable in the workplace.

Since 2003, when the consignment note (“Begleitschein”) system was introduced, notifiable accidents during maintenance works caused by dangerous substances have been avoided.

Problems faced

Communicating the BASF safety culture to contractors is a continuing difficulty. Not all contractors are willing to accept BASF’s standard safety practices and feel patronised by the bigger partner. The average number of accidents involving workers from contractors remains higher than those involving BASF employees.

Success factors

However, the fact that the numbers of workplace accidents remain significantly below the average for the chemical industry in recent years can be seen as a success for the company’s safety policies. Maintenance work flow is well organised and responsibilities are clearly defined and the various parts of the process, beginning with risk assessment and ending with safety tests, mesh like gear wheels and ensure a high standard of safety.

A lively safety culture is now part of the BASF philosophy. The guidelines, organisation and training offered by the company’s health and safety department are enhanced by the co-operation, motivation and good practice of colleagues. The careful management of all levels of workers, whether employed or on contracts, is addressed by the BASF safety philosophy.

The focus remains on the further development of a thriving safety culture. Improving safety culture means promoting team-building measures to create an atmosphere of trust at work, improving processes and process planning. Furthermore, encouraging everyone involved to accept that safety is more important than economic considerations is an important aim of these activities.

Results and evaluation of the project

General statistics demonstrate the effectiveness of BASF’s safety and health management. In 2006 1.52 notifiable accidents per million working hours were registered, compared to 9.05 for the whole chemical sector in Germany.

Transferability of the project

Some of the literature used by BASF, such as *Safety Rules for skilled labour*, is available to all safety experts and management teams through bookshops. Publications of this kind are updated and re-edited by BASF’s experts every seven or eight years.

Seminars are also held with contractors at which BASF’s safety team share expertise, safety culture and good working practices. BASF also offers audits for contracting



companies to help them assess and improve their own health and safety management processes.

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Web information

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CASE 2: IMPROVING MAINTENANCE WORK SAFETY BY INHERENTLY SAFE DESIGN OF A REELING MACHINE

2.2.

POLAND

Key points

- manufacture of machinery and equipment n.e.c.,
- safety of machinery,
- safety function,
- functional safety,
- safe maintenance

Organisation: Central Institute for Labour Protection – National Research Institute

Introduction

A re-winder of the rubber strip used to make conveyor belts (Figure 3) was designed and built for an individual customer.



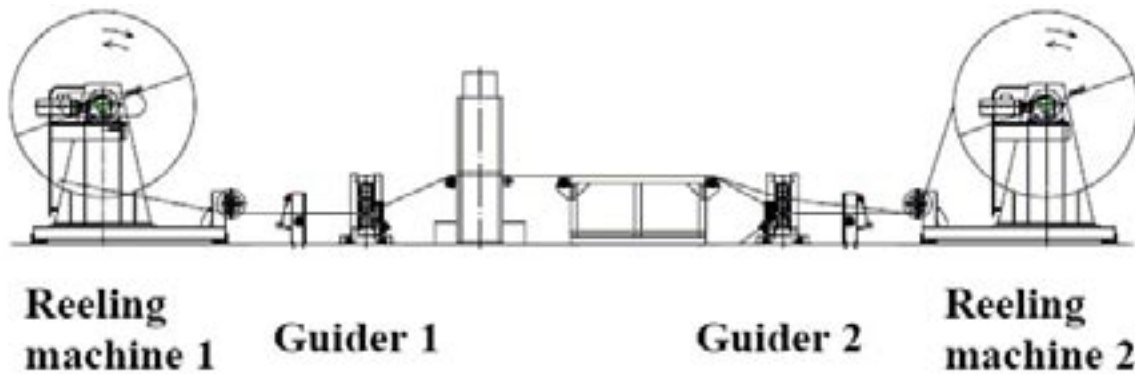
Figure 3: Rewinder of the rubber strip



MAWOS Sp. z o.o.

The machine is composed of two reeling machines (Figure 4), two pushing devices, a maintenance table and two series-connected guiders to guide the strip onto the reels.

Figure 4: Two reeling machines



SEMPERTRANS BECHATW Sp. z o.o 97-427 ROGOWIEC Ul. Transportowa 5 POLAND

The machine is used to check and repair rubber conveyor belt strips. It can work in the following configurations:

- Rewinding of the strip from reeling machine 1 to reeling machine 2
- Rewinding of the strip from reeling machine 2 to reeling machine 1
- Independent control of each of the reeling machines

The machine can operate in three modes:

- Mode 0, system shut off – in this mode no device can be set in motion apart from the driving of the holders of the reels;
- Preparation mode – used when preparing the machine to work in the checking mode. Preparation involves putting on a new strip, changing a reel, manual correction of potential irregularities, and a number of other procedures;
- Checking mode – used when checking the strip and repairing it, when both reeling machines are working in a coordinated manner. One reel works as a winding machine the other as an unwinding machine.



Strip guiders are controlled manually and independently of the selected mode. The machine can be used for making repairs and for carrying out maintenance work on strips of various widths, so the spacing of the holders of the reels is adjustable.

In order to adjust them, it is necessary to:

- Stop the line using the “STOP” button
- Set the mode switch to “0” position
- Unscrew the holder mounting screws of the reels
- Switch on the “move the holder/guide” switch
- Move the holder by turning and holding the ‘move the holder/guide’ switch
- Re-tighten the holder mounting screws
- Switch off the “move the holder/guide” switch.

Aims and objectives

The risk assessment carried out by the designer showed that during the process of adjusting the spacing of the holders of the reels, the unpredictable start-up of the reeling machine can cause its instability and, as a consequence, seriously injure the operator.

Design solutions were needed to prevent such incidents.

Scope of the project

In order to prevent unexpected start-up of the reeling machine when performing adjustment of the guides, safety functions using fail-safe device were applied. The risk assessment showed that when mounting screws were unscrewed during adjustment the main hazard consisted in the loss of holder stability. Therefore, the safety function had to control the position of the mounting screws to ensure general supervision over the screwing attachment of the holder using fail-safe device.

If one of the mounting screws is left undone or not tightened up sufficiently, the fail-safe device makes it impossible for the reeling machines to be set in motion. If the safety system detects a missing mounting screw, it triggers an emergency stop of the entire machine.

The safety function monitoring holders mounting screws position is implemented by means of limit switches linked to a control system of the machine.

Because unintended easing of the mounting screws during the standard operation of the machines can also put operators at risk, two safety measures were designed.

1. An emergency stop is automatically turned on if the screw mounting the holders is loosened. The mounting screws are monitored by means of limit switches. This function is active in the “checking” mode, during normal operation of the machine, and shuts off the whole machine.
2. An automatic emergency stop of the main drives of the reeling machines when a loose or missing screw in the strip guides is detected. This function is active in all three modes while the machine is stopped.

The first of these fail-safe functions overrides the second.

A risk assessment was carried out to identify the fail-safe functions needed to improve the safety of the machines. Given that the machines had a programmable electronic control system, this assessment was carried out in accordance with the EN 62061:2005



standard, "Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems".

The risk assessment process analysed information acquired from users of similar machines as well as data on the incidents and accidents which had occurred at particular workplace. The crucial role in the design stage, however, was given to the machine operators. Their feedback and informed opinion based on first-hand experience with similar machines enhanced the quality of the risk assessment.

The following values of risk parameters were set:

- **Severity of the harm** – possibility of fatality or serious injury, $Se = 4$.
- **Exposure frequency** – adjustments made on average once a week, $Fr = 4$.
- **Probability of occurrence of hazardous event** – accidental start-up of the machine happens rarely, $Pr = 2$.
- **Probability to avoid the harm** – if the hazardous event does take place, avoiding harm is highly unlikely – $Av = 5$.
- Class of probability of the harm – $Cl = 11$

Required Safety Integrity Level according to the Table A6 in EN 62061:2005 – SIL 3

Table 1: SIL assignment matrix IEC 62061:2005

Severity (Se)	Class (Cl)				
	3-4	5-7	8-10	11-13	14-15
4	SIL 2	SIL 2	SIL 2	SIL 3	SIL 3
3		(OM)	SIL 1	SIL 2	SIL 3
2			(OM)	SIL 1	SIL 2
1				(OM)	SIL 1

The table indicates the SIL assigned as the target for the safety function. The lighter shaded areas should be taken as recommendation that other measures (OM) be used.

This required Safety Integrity Level was fulfilled by use of the certified elements and subassemblies of the control system (safety limit switches, programmable electronic control system certified according SIL 3 requirements).

Results and evaluation of the project

Machine operating accidents occur mostly when performing repairs, maintenance work or adjustment of the machine, rather than when it is being operated. It is for this reason that in the risk assessment phase a machine designer should also consider these aspects of a machine’s use. The reeling machine case demonstrates how accidents can be effectively prevented by the design of fail-safe devices and systems that protect workers when the machine is being adjusted – the manufacturer of the reeling machine has met the safety requirements included in the 98/37/EC directive which states that machinery must be designed and constructed so that it can be operated, adjusted and maintained without putting persons at risk.

Furthermore, the use of fail-safe devices that detect potential risks during the adjustment and maintenance of the machine ensures the safety of the operators in compliance with the 89/655/EEC directive and framework directive.

Success factors

The described case demonstrates clearly that good design, taking into account all potential risks, helps to ensure safety during repair and maintenance work. It also



shows how effective cooperation between a machine designer and its users can be achieved. The end users of the machine were actively involved throughout the whole risk assessment process and played a crucial role in ensuring that the new machine was safe to operate.

Transferability of the project

The described methodology, which reduces risk by applying appropriate machine design solutions, can be used in the design of the majority of machines. Almost every machine requires maintenance and adjustment, and this is often when accidents are most likely. This should be considered at the design stage so that appropriate fail-safe measures can be included from the start.

Appropriate risk assessment proves to be fairly problematic in the case of machines where a product standard is lacking and, as a result, there are no guidelines to help the designer include all the safety devices and precautions a particular machine may need.

The practical example presented here shows how the need to regularly adjust a machine can be taken into account during the design stage.

When designing safety into a machine, the designer needs good information about where the dangers lie and exactly what devices are needed to make it safe to operate.

The case described here demonstrates how, in a simple way, hazards can be identified and effective risk assessments can be carried out.

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SNAPSHOT 1: HEALTH AND SAFETY MANAGEMENT SYSTEM AT ROMEC

2.3.

UNITED KINGDOM

Organisation: Romec Ltd.

The issue under discussion

Romec employs approximately 5,000 workers across the UK, many of whom are involved in building maintenance, looking after services such as power supply, lighting, heating, air-conditioning, ventilation and water supply and drainage. Many employees may encounter materials or situations that pose a risk to their health and safety (e.g. asbestos, use of step-ladders, etc.). Romec has therefore implemented a health and safety management system that can continually be updated and revised in light of new risks or practices.



The action taken

Robust safety procedures, safe systems of work and risk assessments have been implemented throughout the business. These procedures have been backed up by behavioural safety initiatives designed to create a working environment where safety is easy to understand and becomes second nature. Emphasis has been placed on providing training and maintaining communication with all employees, and on ensuring that subcontractors work to the same standards.

Romec has a diverse, widespread workforce and its health and safety management system contains many elements that relate directly or indirectly to maintenance work. For example, there are approximately 400 generic risk assessments covering all products used within the business and the routine tasks that workers carry out. These are linked directly to more than 600 Safe Systems of Work descriptions that are available to all employees in both electronic and paper formats.

All Health and Safety policies are reviewed at least once a year in the Management System Review Process. Internal and external audits show how effective current policies are and these findings shape proposals for further development of the policies. Those proposals are put to the Executive and are adopted through objectives, targets or actions.

The results achieved

The comprehensive health and safety management system has been registered by the British Standards Institute (BSI) to the OHSAS18001 management system standard. The system undergoes continual development, alteration and evaluation.

No data is available to assess objectively the impact of the health and safety management system on employee health and safety.

However, Romec won the UK's Royal Society for the Prevention of Accidents (RoSPA) Gold Award in 2007 for their health and safety management system.

2.4. CASE 3: "SMART" REMOTE-CONTROLLED GEOGRAPHICAL SYSTEM FOR MAINTENANCE OPERATIONS: DESIGN AND DEVELOPMENT OF A PROTOTYPE

ITALY

Key points

- Maintenance
- Technical plants result management
- Tele-maintenance



Organisation: University of Rome “Sapienza”, CNIM – National Italian Committee for Maintenance, ISPESL – National Italian Institute for Occupational Health and Prevention – Department of Safety Technologies

Introduction

Maintenance systems designed specifically for each individual workplace are easier to set up thanks to the wider availability of new and cost-effective technologies.

Intelligent tele-maintenance systems can now effectively monitor the technical and administrative management of plants across a wide geographical area, even though each plant may have very different technical features.

Such systems provide both management and maintenance service contractors with the possibility of “total availability” of information about the machinery in a wide variety of factories, and of “zero failures” thanks to monitoring and control from a remote center. These systems (Figure 5) have two main elements:

- a Plant Result Management Model, and
- a Tele-maintenance Intelligent System to forecast the reliability and safety level of each plant, and to plan and schedule maintenance operations.

Figure 5: General diagram of the system

These two complementary elements, used in an integrated manner, have led to the development of a management tool capable of guaranteeing “Total Availability” of the plants.

Aims and objectives

The system had to allow for the checking and monitoring of machinery from a geographically distant control centre so that an effective maintenance strategy could be followed and emergency interventions could be avoided.

Better follow-up of necessary maintenance tasks and fewer emergency maintenance interventions would have a positive impact on the safety of maintenance workers.

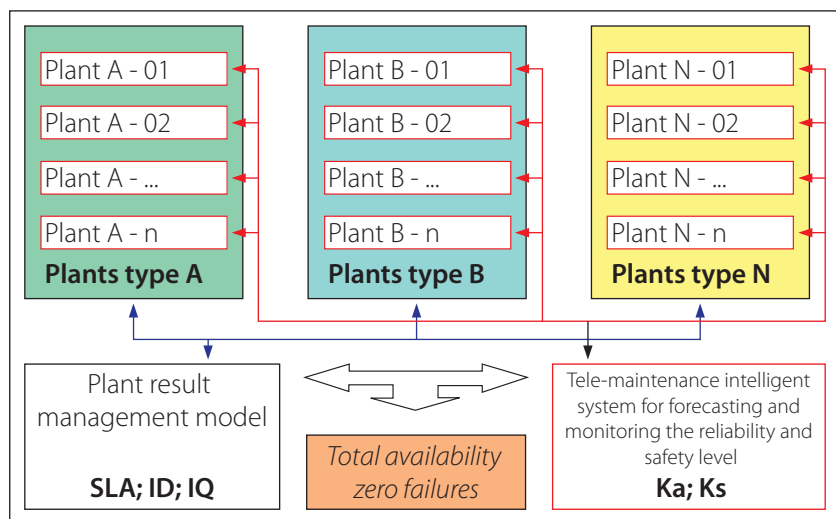
Scope of the project – What was done and how?

Plant result management model

After the analysis of a specific plant by using the “Plant Result Management Model”, it is possible to arrive at a global quality index value (IQ).

The series of phases that lead to the IQ value are described in detail and are shown below in a block diagram.

The IQ can only be calculated if certain indices are available. These indices have to be calculated by using information from the Service Level Agreement (SLA) and the



By courtesy of Prof. Lorenzo Fedele



indicators – the explanation below shows what these two aspects of the analysis involve and how they are carried out

After the classification of the different elements of a plant system, the necessary maintenance activities related for that plant will be identified. There are three types of maintenance activities possible: scheduled, condition-based and failure-based. (UNI EN 13306:2003 “Maintenance – Terminology”¹²) For each of these activities, taking different strategies into account, an SLA will be formulated. The different indicators which come together in this single performance index are defined by the combination of guaranteed results (RG) and monitored results (RM) corresponding to each technological line.

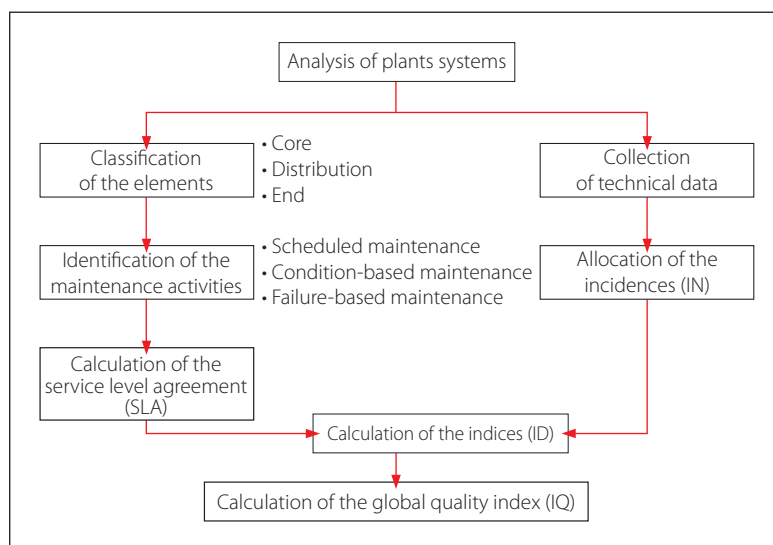
In addition to the SLA, the indicators have to be known in order to calculate the global quality index. Therefore, plant technical data (data sheets, operator’s handbook, maintenance instructions, etc.) has to be collated to allow the allocation of indicators. There are four types of indicators:

- Indicator of Well-being: degree to which a technological line influences well-being as perceived by the people in the buildings.
- Indicator of Image: the degree to which a technological line influences the image that the contract provider transmits to his customer and to the users.
- Indicator of Availability: the degree to which a technological line influences the availability of the infrastructure.
- Indicator of Safety: the degree to which a technological line influences the safety of the users.

Once the SLA and these indicators are known, it is possible to calculate the indices described below.

- Well-being Index: measure of the well-being perceived by the users.
- Image Index: measure of the image that the contract provider transmits to his customer and to the users.
- Availability Index: measure of the availability of the infrastructure.
- Safety Index: measure of the safety level of the infrastructure.

Figure 6: Functional chart of the plant result management model



By courtesy of Prof. Lorenzo Fedele

The combination of these different factors results in a value for the global quality index. This can also offer a way of taking into account economic factors, providing a figure which can be used in a price versus quality ratio.

For the health and safety of employees, it is important to pay particular attention to three of the four indices: the “index of safety” which estimates how the technological line influences safety of the users; the “well-being index”, which gives information about the level of well-being perceived

¹² UNI EN 13306, “Maintenance -Terminology”, UNI EN standard, 2003.



by employees; and finally, the “safety index” which addresses the safety level of the infrastructure. If the results of these evaluations show that employees’ health and safety might be endangered, it would obviously be important to take action.

Table 2 (below) gives a summary of the indices/indicators and specifies references, range and measuring method.

Table 2: Indices/Indicators for contract management

Indices/indicators	Reference	Range	Measuring method
Service Level Agreement	Technological Line	0-1	Calculated for each technological line as a measure of the variance between the value of the guaranteed result and the measured value of the result.
Indicators % (IN)	Technological Line and performance factor (e.g. Well-being, image, etc)	0-100 %	Assigned for each type of Technological Line and each type of performance factor based on the type of line and on several technical-identity characteristics of the line.
Performance Indices (ID)	Contract and performance indicator	0-100	Calculated for each performance factor as weighted average of the SLA of each line, assuming the % indicators as weight factors.
Quality Indices (IQ)	Contract	0-100	Calculated for the contract as weighted average of the partial indices.

Table 3 (below) gives an example of the model applied to a defence industry case study:

Table 3: Example of the model application

		QUALITY INDEX (IQ)			
		88			
		Performance Indices (ID)			
		Well-being	Image	Availability	Safety
		87	91	91	82
Technological Lines	SLA	INDICATORS %			
		Well-being	Image	Availability	Safety
LT 01	Heat Production	70%	35%	30%	25%
LT 02	Lifting/Elevators	15%	40%	25%	35%
LT 03	Electrical Distribution	15%	25%	45%	30%

Tele-maintenance Intelligent System

The second component, the Tele-maintenance Intelligent System, is a failure (Ka) and safety level (Ks) forecast tool. The system allows efficient planning and scheduling of maintenance tasks, sends warning signals whenever the forecasted level of reliability and safety drops below a determined threshold, and provides the control center with all the useful information it needs for a precise analysis promptly.



Moreover, the tele-maintenance system makes more effective management possible. For example, prompt maintenance interventions are easier to organise when the supplier of the maintenance service responsible for managing a large number of difficult-to-access plants systems has an overview of the work that needs to be done.

In short, the main objectives of the Tele-maintenance Intelligent System are:

- forecasting and monitoring plant reliability/availability [Ka];
- forecasting and monitoring plant safety levels [Ks];
- managerial optimisation (effectiveness and efficiency of the maintenance process).

The system also makes it possible to:

- support and optimise the planning and scheduling of maintenance operations
- maximize production and/or service performances
- minimize maintenance costs
- optimize plant performance
- improve service through more effective maintenance, prompt response to failure situations and follow-up preventative action when signs of poorer performance are detected
- increase safety for technicians and users by preventing failures which could lead to potentially dangerous situations

The system identifies and signals even intermittent failures so that technicians are easily able to target problems and solve them at the first attempt, thus preventing repeated failure situations.

A sub-system for the detection of the monitored parameters (functional parameters) and a sub-system for the processing of some of the monitored parameters are installed in each plant. All the information detected on each plant is sent to the control center by a signal transmission and conversion sub-system. The control center uses dedicated software to record the information in the individual plant identification file and schedules the maintenance operations, taking into account the plant safety level and the plant reliability forecast. The system can also send a signal to shut the plant down immediately if a shut-down is necessary for safety reasons. The control center is staffed by the maintenance provider.

Through the Tele-maintenance Intelligent System's data-gathering processes, the technical plant becomes capable of "learning" and of improving its operational efficiency. The sub-system for processing some of the data collected from the plant uses software tools based on the logic of artificial intelligence and neural networks, capable of forecasting the evolution of events and signalling the preventive maintenance needed to correct the problems it foresees.

The artificial neural networks allow the development of a user-friendly "intelligent" software tool for technical plant management optimization.

Designing the Tele-maintenance Intelligent System involved the following steps:

- identification of the technical characteristics of the plants and choice of which parameters to monitor
- design of the parameter-recording system
- definition of the sensor type and its characteristics
- design of the neural network and the diagnostics system
- design of the signal transmission system
- development of the prototype.



In particular, through the study of failure modes (FMECA method – Failure Modes Effects Critical Analysis Method) and through a risk analysis (conducted with reference to the method suggested by AISS – International Committee “Safety Machines” Method), events which determine the change of one or more properties of the system in a given time interval were isolated, and their possible effect on the plant and the immediate environment was evaluated. This made it possible to identify those critical conditions which could be monitored remotely, with particular attention being paid to each of the three plant types.

The monitored parameter detection sub-system was installed in each plant; it consists of an electronic control unit equipped with a microprocessor. The sub-system picks up the signals from the sensors installed in the plant, comparing them to the pre-selected parameters. The information is sent to the remote control center through data transmission systems such as a telephone line (by cable or GSM), the Internet, or a dedicated line (ISDN). The choice of the data transmission system depends on what technology is available to each individual plant and the remote control center.

The parameters are processed with the help of the neural networks. The following steps were involved in the design of the neural network:

- definition of the inputs and outputs of each type of plant;
- data collection and allocation of target values;
- definition of the neural network architecture;
- training of the neural network;
- analysis of the training results;
- testing of the neural network.

The following reliability/safety parameters were introduced:

1. K_s – plant safety index;
2. K_a – plant reliability/availability index.

The K_s index can have a value between 0 and 1 according to the scale of values given in Table 4:

Table 4: K_s range

K_s	Safety	Actions
0	Plant is safe	None
0.25	Plant is safe but to be kept under control	Check the parameters during the scheduled routine maintenance visits
0.5	Plant is safe but to be kept under strict control	Schedule specific controls during routine maintenance visits.
0.75	Plant requires attention	Schedule specific action to check the safety conditions and, if necessary, restore them.
1	Risk unacceptable	Shut down the plant and emergency action required.



The Ka index can have a value between 0 and 1 (Table 5):

Table 5: Ka range

Ks	Reliability/availability	Actions
0	Plant is reliable and available	None
0.25	Plant is reliable and available but to be kept under control	Check the parameters during the scheduled routine maintenance visits.
0.5	Plant is reliable and available but to be kept under strict control	Schedule specific controls during routine maintenance visits.
0.75	Incipient failure	Schedule specific action to check the safety conditions in order to restore the reliability and availability level.
1	Failure	Failure condition imminent; emergency action required on the plant to avoid shutting down the plant and reducing the plant availability time.

The Ka and Ks output values of each plant, as processed by the neural network, taken together with other monitored parameters detected by the plant control system, make it possible to create an intelligent plant maintenance system.

The system analyses the signals recorded from each plant on a regular basis (Ka, Ks calculated by their respective neural networks and the other monitored signals) and evaluates the “state of health” of the plant in question. When operating conditions are found to be less than optimal – estimated, if dependent on the analysis of the Ka and Ks values, or real, if derived from the other monitored signals – the system generates a list of maintenance actions required to restore normal operating conditions.

The process of selecting those actions takes into account the Ka and Ks values, the maintenance history of the plant and the state of the other monitored signals, using statistical and probability techniques. Once all the plants managed by the system have been analyzed and all the maintenance actions required have been selected, the subsequent processing will result in the general “scheduling” of the tasks taking into account the previously devised routine maintenance plan.

The system then draws up a detailed schedule of maintenance tasks and allocates them to technicians, taking into account constraints established by the user, such as:

- number of tasks to be carried out each day by each technician
- geographical location of the plants on which the tasks are required
- constraints of a contractual nature
- tasks already scheduled through previous processing
- tasks scheduled in the routine maintenance plan
- emergency situations (hospitals, hotels, etc.)

Results and evaluation of the project

The system was developed and tested in the field in cooperation with specialized companies. In order to fully test the system, it was tried out alongside the maintenance and management contracts for three different plant types:

- The lift technological line (lift plants);
- Heat producing technological lines (thermal plants);
- Electrical distribution technological lines (electrical plants).



The system application was particularly effective when the plant system was significant in terms of the distribution among a larger area, the number of plants and the nature of the different types of plant. It makes it possible to guarantee the total availability of the plants and to show, through the IQ index, that the results guaranteed during the contractual phase have been respected.

The Tele-maintenance Intelligent System makes this possible because it is a tool which can gather information from each plant at a remote location and, in particular, forecast failures and decreased safety levels and send warnings to the management organization.

The system makes high levels of management efficiency possible, delivering guaranteed results with a progressive reduction in management costs through the optimization and rationalization of technical maintenance activity and of other associated resources.

Finally, it is a tool that shares transparent management data of the plant systems between the management organization and the contract provider, helping to maximise customer satisfaction and progressively and systematically improve performance.

Transferability

This methodology and the systems it creates can easily be transferred to any company that needs to manage complex maintenance services, particularly when these services are carried out by contractors. The highest cost of the system is in the sensors required to collect data remotely, but most modern machines already have sensors on-board. Companies providing maintenance activities for different customers at different plants over a wide geographical area can use the system to achieve many goals. They can optimise their management, improve their own performance, increase safety and create better customer satisfaction.

The most important benefits are fewer failures that result in an interruption of operation, fewer emergency interventions and higher safety levels for maintenance staff and machine users.

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2.5.

CASE 4: RENAULT, ANALYSIS OF RISK SITUATIONS

FRANCE

Key points

- The main difficulty in risk analysis and assessment for corrective maintenance operations is the diversity and variability of these operations.
- It is possible to detect risks to which the operators may be exposed in the course of maintenance operations and look for preventive measures.
- Maintenance on live machinery involves high risk because workers need to perform operations on the machines without switching off the power supply.
- Solutions come from the floor: it is important to involve the workers, through discussions and communication, to achieve the best results.

Organisation: CRAM Normandy

Introduction

The main difficulty in risk analysis and assessment for corrective maintenance operations is the diversity and variability of these operations.

While direct observation of the work performed can be done easily for a fixed work station, observation of repair operations is difficult because of the diversity of the equipment and the differing types of malfunctions, diagnosis, repair operations and operating procedures.

However, in order to devise preventive measures, the risks have to be analysed. This analysis involves research on the work actually performed by various operators.

The method outlined here was proposed by a working group consisting of maintenance managers at companies in the Normandy region of France. It involved interviews with operators about the operating procedures they actually used. This information was then analysed to identify the risks to which they were exposed, and appropriate preventive measures were proposed.

Originally designed to improve safety in the fault-finding stage, it can also be used to design procedures for various stages of the repair process and is suitable for all maintenance operations, whether scheduled or not.

The Renault plant at Cl on (Seine-Maritime region) has used this method to improve the safety of its maintenance operations at machinery centres. They have been able to identify the most risky situations and make permanent improvements.

Management chose the machine centres because there are a large number – about a hundred – of them in this factory, spread throughout two different areas, the gearbox and the engine workshops. Machine centres use a recent technology that is “well known by workers”. The technology is being introduced across all areas of operation.

Protecting the health and ensuring the safety of all workers is a priority in the Cl on plant. A health and safety policy lays down objectives for continual improvement of working conditions on the site. Its main features include compliance with occupational



health and safety regulations, making management of safety and working conditions a major role of supervisors, provision of all necessary and appropriate resources and measures to support the policy, and inclusion of health and safety criteria in all decisions about products used, processes, layout and organisation.

Aims and objectives

The objective of the approach was to identify the risks to which operators may be exposed in the course of their maintenance operations, and to look for preventive measures.

The approach was carried out in 4 stages:

- Collect information on the current actual practice, personalised by operator, for each type of diagnosis on the work equipment in question;
- Group this information for analysis
- Submit proposals for preventive measures to operators;
- Implement the agreed measures.

A steering group was set up. Its members were chosen to include department managers from maintenance and manufacturing, engineers and technicians from the safety and working conditions departments and from the various workplaces involved in the machine centres.

Scope of the project

Corrective maintenance operations, often urgent and needing to be done immediately, can be a cause of accidents or near misses. The risks to which workers may be exposed during such operations include impact, crushing and electric shock. In Renault's Cléon plant, around 1,000 employees – out of a total of 5,000 – are involved in maintenance operations on the 10,000 machines on the site.

In 2003, the regional health insurance fund (CRAM) of Normandy suggested identifying and analysing the risks to which operators at the Cléon plant could be exposed during such operations. This would then make it possible to look for solutions.

The project was conducted in four stages: collection of information via interviews, analysis of the replies, proposals for preventive measures, and implementation of the identified measures.

It was important to remind managers and operators of the hierarchy of risk control principles and to stop them viewing personal protective equipment as the main protection measure. For this reason the SPO (Suppress or limit – Protect – Organise) accident prevention method, which promotes more comprehensive methods of controlling risks, was chosen by the CRAM and management of Renault's Cléon plant.

Stage 1: The interviews

Interviews with the operators took place over a period of about one month.

The process was conducted in the following phases:

- Choice of a machine centre
- Identification of personnel performing work on the selected machine centres
- Conducting interviews
- Compilation of results



The interviews were distributed among interviewers according to their own expertise. For example, maintenance technicians were questioned by an interviewer from the maintenance section who was familiar with the work they do day by day.

A guide was produced to assist the interviewers and give them a common set of questions:

- Why does a worker intervene? What operation (maintenance, adjustment, repair, etc.) are they required to do in the machine centre?
- With the help of the answers, fill in the interview sheet in (A).
- For each operation, ask the worker what the operating conditions are: technical and organisational requirements, etc.
- With the help of the answers, fill in the interview sheet in (B).
- Analyse each operation entered in (A) -- ask the worker whether he perceives any risks during the operation and, if so, what are they?
- With the help of the answers, fill in the interview sheet in (C).

There were no problems during this phase.

In all, 45 operations were identified. The interviews were able to pinpoint risky situations.

Stage 2: Analysis of operations

The analyses were carried out by the steering group.

The approach adopted can be summarised in 3 points:

- For each of the operations described by the interviews, ask the question: "why do the workers operate in this way?"
- Identify all the risks involved in each operation.
- Look for and propose preventive measures to counter the risks identified, using the SPO principle (Suppress, Protect, Organise).

For each task, a record sheet was created comprising three sections:

- Section 1- summarising the information from the interviews (see preceding example)
- Section 2- presenting the results of the risk analysis carried out by the working group.
- Section 3- proposing risk prevention solutions classified according to the SPO headings.

Table 6: Interview sheet

Interview (stage 1)		Analysis and search for preventive measures (stage 2)		
First section 1		Second section 2		Third section 3
How do you operate?	Perceived risks	Why is the operation performed in this way?	Identified risks	Preventive measures (SPO)

The problems highlighted by the interviews led the members of the working group to exchange information concerning the same equipment with other production plants, and it became apparent that some problems were identical in these plants.

Ideas for solving the problems were collected from the interviews and from the steering group during analysis of the results.



Stage 3: Proposing and validating preventive measures

Following these analyses, the group proposed preventive measures which were either technical or organisational. They were described to the operating personnel and tested. Some measures that were adopted, such as handling systems, also saved a lot of time on maintenance operations and were therefore immediately profitable.

Validation of the measures proposed by the group gave rise to a formal agreement in which everyone involved was able to offer their opinion about the effectiveness of the implemented solutions and follow-up measures for the initiative in progress.

Stage 4: Incorporating newly identified preventive measures into work practices

Actions were taken to consolidate the preventive measures:

- Performance of an investment cost study in order to acquire suitable tools
- Writing a standard operational maintenance sheet for operations on machine centres
- Integration of the identified measures into the engineering specifications.

Results and evaluation of the project

Tangible results appeared rapidly, such as use of scaffolding together with a hoist for raising heavy loads, and a trolley for the handling of electric spindles.

Solutions were also developed for operations on live machinery. While adjustments were being made, safety systems were often circumvented by using “hot sticks”, to perform operations on the machines without switching off the power supply.

The interviews showed that the operators were not aware of the risks involved in the work they were doing. They mentioned matters of ergonomics, such as carrying heavy loads and slipping, but were not aware of the risks while working with live machinery.

The company became aware of the risks involved in this practice through the work done to identify the problems by the steering group in Stage 2. Out of 45 identified operations, fifteen had been performed on live equipment and 10 of them were performed with downgraded protection. Now, through the analysis of the tasks, it had been shown that only three of the 10 operations required downgrading of the protection. In such cases, alternative preventive measures had to be defined.

As a solution, the “ISEPA” concept – “Intervention Sous Energie Avec Protection Alternative” (operations on live equipment with alternative protection) has been introduced. In effect this means using protective measures that were not devised at the machine design stage.

In the gearbox machinery workshop, for instance, various improvements have been made such as the installation of hatches providing access to the pressure monitors without entering the machining bay, and a step to reduce the risk of slipping when entering the bay.

The introduction of various improvements and a strong management commitment to take into account the real conditions of maintenance operations has changed the constraints under which operators work.

Improving safety has brought gains in time, ergonomics, comfort, safety and mental well-being. For example, the replacement of a spindle, a part weighing 80 kg, now requires 1.5 hours less than before which brings obvious economic benefits, but also significantly improves working conditions. Before the introduction of a trolley on



which they could be moved around, the spindles had to be carried at arm's length. The technicians were not aware of any particular risk in this practice.

This project has clearly shown that solutions can come from the workshop floor and that it is important to involve the workers, through discussions and communication, to get the best results.

It is also essential that there is a strong political will and management commitment to move things forward; this is the key to success.

As a next step, the company's senior management has set the line management the task of deploying identical approaches throughout the plant.

Renault's Cléon plant has summarised the benefits of this approach as follows:

- An "integrated" approach to safety
- A Human Resources function providing support for the maintenance department (guiding thread)
- Better knowledge of maintenance
- Experience sharing (old & young)
- Additional gains (reliability, speed, etc.)
- Constructive relations with the OH&S Department of the CRAM fund.

This experimental programme on machining centres has extended to the whole plant a programme to reduce maintenance operations on live equipment in "degraded safety" mode.

While the implementation of this type of programme may seem a heavy investment in time, the results achieved are not confined to operator safety. The programme brings significant improvements in productivity and reduced machine downtime, and promotes improvements in new equipment purchase specifications. It also encourages the development of healthy communication culture between maintenance and production personnel.

Transferability of the project

This method of action – a structured approach to maintenance risks – is transferable to other sectors of activity, and its success depends on the following factors:

- Involvement of the company's senior management is essential; support must also be obtained from the maintenance operators and the Committee For Health, Safety And Working Conditions (CHSCT)
- The application of the hierarchy of means of risk prevention in looking for solutions
- Checking that the proposed preventive measures do not cause other risks
- Interviewing all operators, since ways of doing things can differ from one person to another.
- Analysis of sheets and seeking solutions must be carried out in groups and the operators should play a major role in this.
- The interviews should be carried out by experienced people who know the machine and its risks.

Very often, after analysing the risks, simple and inexpensive solutions become apparent. The method improves the safety of maintenance operators as well as the working conditions in general.



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2.6. CASE 5: MAJOR OVERHAUL OF CONVENTIONAL THERMAL POWER STATION



Key points

- Major overhaul
- shut-down
- third parties
- safe maintenance

Introduction

Electrabel – the organisation

Electrabel forms part of GDF SUEZ, one of the world's leading energy providers, active across the entire energy chain in electricity and natural gas. The GDF SUEZ Group develops its businesses around a responsible growth model taking on the great challenges: responding to energy needs, combating climate change and maximizing the use of resources.

Electrabel is a market leader in the Benelux countries. Here the company sells electricity and natural gas, energy products and energy services to residential, professional and industrial customers. It also generates electricity and heat in a diversified production park. These activities are supported and optimized by portfolio management and trading operations of the GDF SUEZ Group on the European and international energy markets.

Electrabel supplies electricity and natural gas to six million customers in the Benelux countries, selling 97,000 GWh of electricity and 72,000 GWh of natural gas here in 2008 and employing 8,750 people in the region.



Different types of power stations are spread throughout Belgium and grouped into three zones; East, West and South. Zone East consists of six plants: Zandvliet Power, Mol, Kallo, Vilvoorde, Drogenbos and Langerlo.

The power station of Langerlo will be the topic of this case study.

Langerlo – the power station

Langerlo is a conventional thermal power station. This type of power station is defined by Wikipedia, the online reference database, as follows: "A thermal power station is a power plant in which the prime mover is steam driven. Water is heated, turns into steam and spins a steam turbine which drives an electrical generator."¹³

The process of generating electricity involves a complex series of consecutive steps, each step carried out in a different part of the station. In order to ensure that this process runs smoothly, efficiently and safely, regular maintenance of the station is necessary.

Two main types of maintenance are carried out: corrective maintenance – daily maintenance on request – and preventive maintenance.

Daily maintenance consists of smaller maintenance tasks which are recommended by the operators. Preventive maintenance is planned as a comprehensive overhaul every two years, and this requires a shut-down of the station while large sections of the station are being worked on. Every 8 years, a total overhaul is organised which involves opening the steam turbine to inspect and repair all its internal workings.

Significant resources – money, tools, materials and of course workers – go into each overhaul and therefore the process has to be very carefully planned.

Figure 7: Steam turbine and machine room at the thermal power station of Langerlo



Safety and health in Langerlo

Attention to safety is vital in a power station. Potential hazards include high steam pressure up to 100Bar and high tension up to 20kV; working at heights of up to 50m; working on big components and in confined spaces.

Electrabel is committed to provide a safe and healthy working environment in order to ensure the well-being of the employees.

Procedures at organisational level offer a framework for the practical implementation of the company's health and safety policy which is based on the principle of dynamic

¹³ Wikipedia, the free encyclopedia, consulted at 31 March 2009, URL: http://en.wikipedia.org/wiki/Thermal_power_station



risk management. All the steps involved in the risk management are described, as are the roles and responsibilities of all parties involved. The policy also outlines how to carry out risk identification and evaluation, using the Kinney method to compare different risks, establish priorities and compare different solutions.

The health and safety policy is implemented on the level of the power station. The line managers are responsible for risk management and the compliance with the health and safety regulations. The health and safety department from zone East ("Care" Department) supports the line managers with advice on health and safety issues during major overhauls.

Examples of Electrabel's initiatives to ensure a safe and healthy working environment include:

- Line managers are required to attend a health and safety course
- Information related to safety and health is communicated in monthly organised informal meetings called toolbox meetings
- Specialist tasks for which Electrabel has no expertise contracted out to organisations with relevant experience
- Working only with contractors who acknowledge the importance of safe and healthy working
- A risk assessment carried out for each task by the responsible foreman, using the Kinney method
- Preparation of work permit sheets, accompanied by safety regulations, for each part of the plant requiring maintenance, guaranteeing the safety of the area
- Use of a database – Hazapro – containing all Material Safety Data Sheets (MSDS) for dangerous substances
- All but five percent of the company's safety policy documents available to workers through the intraweb

Electrabel holds a VCA-certificate showing that the company complies with assessment criteria related to safety, health and environment.¹⁴

Aims and objectives

The primary purpose of the periodic overhauls in Langerlo power station is to ensure continuous generation of electricity and a safe working environment for the workers.

Of course, the management of Langerlo also aims to comply with all relevant environmental and health and safety legislation.

Before an overhaul starts, objectives are set:

- Creating a safe working environment in which no accidents happen
- Involvement of all important stakeholders – workers performing maintenance, operators, contractors, the Health and safety Department and the employer.
- Following the overhaul plan as closely as possible
- The number of tasks needing to be re-done must as low as possible because fewer reworks means work of better quality.
- A detailed checklist must be drawn up for each component on which work will be carried out to ensure it is working correctly once the work is completed.
- The budget, based on information from previous overhauls and the cost of materials and wages, must be adhered to as closely as possible.

¹⁴ <http://www.besacc-vca.be/VCA.htm>



Scope of the project

As said before, the organisation of a major overhaul requires excellent planning, well-established communication structures and a well-defined safety and health policy. It has to be said that such a project requires the cooperation of a large number of contractors. Of the workers employed for the overhaul, about 700 come from contractors and only 40 are full-time employees of Electrabel.

Each maintenance project follows a similar pattern or three major phases as outlined below:

- the preparation phase,
- the execution phase
- the evaluation phase/aftercare

Preparation phase

Preparation for the overhaul involves placing orders for tools, materials and new parts, preparing task descriptions accompanied by an SHE (Safety, Health, Environment) plan and developing a “plan of action”. This “plan of action” allocates time, workspace, people, money, tools, etc., to each different task.

The work group entrusted with the preparation of the maintenance work will also take a look at the reports of previous overhauls to enable better estimations of resources needed. This work group consists of the representatives of the health and safety department (Care Department) the production unit and the maintenance unit.

Another important task during this phase is the procurement of services Electrabel wants to outsource during the overhaul.

Before an overhaul starts, a “task description” is drawn up for each task. This description also contains an analysis of the task to reveal possible risks related to it, and a further risk analysis based on the Kinney method to assess the level of any identified risks. These risk assessments are performed by the responsible foreman who is usually one of the line managers. Measures to mitigate identified risks, prevent occupational accidents and manage the remaining risks are put in place. Possible measures include, for example, using forced ventilation or the provision of scaffolding.

Personnel planning is an important task. Contractors are engaged because the extent of the overhaul requires a large number of workers for a relatively short period of time, but working with third parties unfamiliar with standard company practice always creates additional potential risk factor. It is therefore necessary to guarantee good communication with such partners. Electrabel has an operational procedure for working with contractors which summarises the relevant health and safety regulations that contractors need to be aware of, and all the rules that apply specifically to the Langerlo site.

During the preparation phase a first meeting with the contractors is held, known as the “start meeting”. This meeting explains the housekeeping rules of the plant to the contractors. They are also given information about the overhaul and the actual work expected from them. The commitment of the contractors to work safely, and to provide their workers with all necessary tools and materials to perform the job in an efficient and safe manner, are also checked at this first meeting.

A second meeting with the contractors, known as the “kick-off”, also takes place during the preparation phase. This meeting allows the foremen from Electrabel and the contractor to make agreements about the content of each task, SHE regulations



and “hold and witness points”. “Hold and witness points” are situations in which the contractor immediately has to stop working. For example, when contaminated insulation is being removed, a hold point will be used to make sure that all contaminated insulation is removed before putting new one. At this second meeting it is again possible to check the commitment of the contractor to work safely and to provide its workers with the tools and materials they need to perform their jobs efficiently and safely.

Execution phase

While the work is being done, which normally takes about 4 to 5 weeks, various maintenance tasks will be performed and they are divided into several clusters. Conducting each cluster simultaneously requires excellent organisation and communication between different stakeholders.

Before a contractor gets permission to start a maintenance task, a third meeting is organised between the health and safety department and the contractor. Known as the “start task” meeting, it is attended by the foremen from both Langerlo and the contractor and is an opportunity to finalise all agreements about the maintenance tasks, to remind the contractor of the safety regulations and to check whether the work permit sheet is in order. The contract worker who will actually carry out the work also has to be present at this meeting. To make sure that these meetings fulfil their role, a support document explaining what agreements have to be made during the meeting has been developed.

When the contractor finally starts the work, he has to collect the relevant work permit sheet which certifies that the area of the station being worked on is safe. This is further confirmed by a green card attached to the work post in the relevant area. The green card is a signal for all workers that maintenance is being done at that specific workstation.

Machines are tagged with a red danger card when they are part of the workstation being maintained, and if turning them while maintenance work was underway would be dangerous.

For example, to make pump A safe to work on, pump B has to be shut down and pump C left open. While maintenance is underway, Pump B and C will be marked with a red card to show that these pumps must not be touched, while Pump A will get a green card showing that it is safe to work on. The maintenance worker will receive a work permit sheet that confirms these precautions.

The work permit sheet will also mention the safety regulations which must be observed for the actual task. With the work permit sheet, the contractor receives a checklist which he has to use to perform a short risk assessment before he starts maintaining that part of the plant. This last-minute risk assessment serves as a double check and decreases the risk of accidents.

Daily observation rounds are made by the Care Department and the line managers to check on the execution of tasks. There are also internal daily meetings to address possible problems such as delays, missing tools and materials, safety issues, accidents or incidents, unexpected extra work, difficulties with or between contractors, etc. All incidents and accidents are written down in a logbook. Accident reports from the contractors are included.

Evaluation phase

In the evaluation phase, conclusions are drawn from the way the project has progressed and by identifying problem areas which will need specific attention during the next overhaul.



Different topics are addressed in the evaluation report covering areas such as health and safety, communication structures, planning, cooperation with contractors, and so forth.

Special attention during the evaluation phase is paid to any area where it has been necessary to repeat maintenance work that has not been effective. It is very important to avoid further unscheduled and costly shut-downs of the power plant before the next overhaul is due, particularly since other power stations won't be prepared to compensate for the unexpected shortage of power.

If, during the evaluation, it seems that some maintenance tasks have not met the required standard, an investigation is organised to find out what went wrong, addressing questions such as whether the failure has been caused by human error, by the use of the wrong materials or by an inherent fault or characteristic of the machine.

The answers to such questions will be recorded in the evaluation report so that further failures can be prevented during the next overhaul.

Results and evaluation of the project

The result of a major overhaul is better productivity and improved safety of the power station.

The overhaul is considered 100 percent successful only if no accidents have occurred during the work, if all important stakeholders have been involved, if productivity has improved, if the budget and all aspects of the overhaul plan were respected, if there has been no need to re-do work, and if all the criteria defined in the preparation phase have been met.

It is difficult to produce specific figures that demonstrate the incremental improvements in safety and accident prevention enjoyed as a result of this system since, by its very nature, the procedure is designed to be flexible so that it can be slightly modified wherever necessary each time an overhaul is carried out.

There are factors that make it a real challenge to comply with the criteria defined in the preparation phase:

- During the overhaul about 700 of the 740 workers are contractors. A significant proportion of these workers do not speak either the official language of the region or English. This makes it very difficult to communicate with them about the content of the task and the hazards to which they will be exposed.
- As these overhauls are very large projects, planning must start several months in advance. In the meantime, the power station is still running and it is always possible that during this period additional areas of the power station are discovered to be in need of maintenance.
- During the execution of a maintenance task, workers might be confronted with additional work that needs to be done because unexpected problems are peculiar to closed systems.
- Contractors might hinder each other when doing their respective jobs. It's important that the health and safety department or the line managers intervene very quickly when such problems occur in order to search for appropriate solutions.



Of course there are also some factors that contribute to the success of these projects:

- Electrabel has developed an effective three-phase communication structure which creates enough time for the partners to exchange all information needed to perform the maintenance task efficiently and safely.
- Thanks to good follow-up during these projects, the work group can rely on information from previous overhauls to make correct estimates of the time, costs, and numbers of workers needed for the next project.
- All the power stations in Zone East, to which Langerlo belongs, exchange experiences so that they can learn from each other.
- An effective method that clearly identifies both safe and dangerous parts of a workstation minimises the risk of dangerous situations during maintenance work.

Transferability of the project

Since every large industry is confronted with the problem of periodical maintenance shut-downs, other companies using large-scale machinery or closed systems can apply the information available from Electrabel's experience of overhaul procedures.

Throughout all the phases of the overhaul, safety is an important issue. Risks are minimised through performing more than one risk assessment, at different times and by different persons and taking appropriate measures. All organisations facing high-risk situations should implement several risk assessments, reducing the accident risk as much as possible.

The communication structure applied by Electrabel to its cooperation with contractors can be used by all types of organisations working with third parties. Three meetings, each with a specific part to play in the process, allow Electrabel to discern the attitude of the contractor towards health and safety at work. By meeting with the contractor three times before work begins, important information can be repeated, reducing the risk of the contractor failing to understand what is required and allowing enough time for the contractor to ask questions.

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Sources

Interview with Kim Lieten at 24 July 2008

Attending: Karen Muylaert from Prevent, Kim Lieten, Dirk Heirwegh, Marc Caethoven, Frank Gerinckx from Electrabel

Website Electrabel Belgium, consulted at 31 March 2009; URL:
http://www.electrabel.be/homepage_corp/homepage.aspx

Wikipedia, the free encyclopedia, consulted at 31 March 2009, URL:
http://en.wikipedia.org/wiki/Thermal_power_station



CASE 6: MAINTENANCE PRACTICE IN THE PRINTING INDUSTRY

2.7.

UNITED KINGDOM

Key points

- A number of organisations within the print industry were surveyed to gauge their maintenance practices
- Those organisations that have good maintenance practices state that they achieve business benefits
- Organisations with a maintenance plan are able to perform better than those without such a plan
- There are a wide variety of practices across the industry – only 65% have a maintenance plan and even fewer of these are satisfied with what they have been able to accomplish with the help of such a plan
- Good maintenance facilitates health and safety compliance
- Good maintenance minimises accidents
- Operators use safe work practices

Organisation: Health & Safety Laboratory

Introduction

Within the printing industry effective maintenance is essential to ensure that the optimum performance of equipment is sustained and productivity is consistent. However, many printers are still reactive in their approach to maintenance and so only focus on equipment when a breakdown occurs. The project wishes to promote maintenance practices that printers can use regardless of size or sector, to both improve their productivity and competitiveness, and to reduce potential injuries and accidents caused by faulty equipment.

Background

In 1998, several organisations within the printing industry came together to form a cross-industry Web Offset Champion Group. The group's main purpose was to promote generic best practice within the web offset printing industry and thereby improve productivity, quality and safety within organisations.

The present project aims to promote good maintenance practice among organisations in order to increase productivity and profits, and consequently reduce accidents and improve and promote safe work practices. This is an important aspect for businesses to pursue as research has shown that there is a clear link between productivity, reliability and maintenance.

Aims and objectives

The overall aim of this project was to promote good maintenance practice within the print industry. This involved highlighting the financial benefits, in terms of increased productivity, that could be gained from such practices. Specifically, it was essential:

- To raise the awareness of good maintenance practice within the printing sector



- To identify those generic and practical principles that are important in improving maintenance practices
- To demonstrate those factors that contribute to effective planned maintenance programmes and understand how equipment performance can be optimised through more effective maintenance
- To identify opportunities to help predict equipment failure
- To communicate best practice to both printers and suppliers

Scope of the project – What was done and how?

The evolution of maintenance and the printing industry

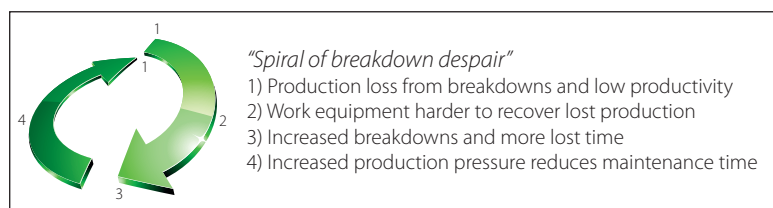
The development of maintenance strategies and techniques are comparable to the developments that have occurred within health care. The focus has progressed from reacting to the breakdown to promoting the preventive, then to engaging in the predictive and finally to accepting the pro-active, as illustrated in table 7.

Table 7: Development of maintenance strategies compared to healthcare strategies¹⁵

Period	Strategy	Human health care	Machine “health care”
< 1950	Breakdown	Heart attack	Large budget, correct when broken
< 1970	Preventive	By-pass surgery	Periodic component replacement
> 1970	Predictive	Heart disease detection	Condition monitoring, fix early
> 1980	Pro-active	Cholesterol & blood pressure monitoring Root cause diet control	Performance monitoring Contamination control TPM (Total Productive Maintenance)

However, the printing industry still uses the 1950s approach of fixing it when it breaks, which reduces productivity as the organisation is captured in a spiral of “breakdown despair”. See Figure 10.

Figure 8: Spiral of breakdown despair¹⁶



It is important to recognise that, as a stand-alone activity, maintenance is not enough to ensure that aims of improved productivity, performance and fewer accidents are achieved. Maintenance must be accepted as part of the entire operating

environment, and the various overlapping techniques that are available to improve performance are shown in Figure 11. However, an organisation should choose the technique that is most suited to its culture and environment, especially in small and medium enterprises (SMEs), where resources may be constrained.

¹⁵ Claypole, T. and Wells, N., 2005, Productivity Maintenance in the UK Printing Industry. London: Vision in Print. p. 30

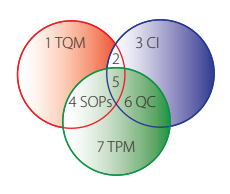
¹⁶ Source: Claypole, T. and Wells, N., 2005, Productivity Maintenance in the UK Printing Industry. London: Vision in Print. p. 30



Figure 9: Techniques to improve performance¹⁷

An Internet-based survey was used to obtain data from 86 organisations, to gain an understanding of maintenance practices across this sector in the UK. The questionnaire was very detailed and consisted of the following four sections:

- 1) Total quality maintenance
- 2) Cross-functional teamwork
- 3) Continuous improvement
- 4) Standard operating procedures
- 5) 5Cs (clear, configure, clean & check, conform, custom & practice)
- 6) Quick change development



- **Section 1: Classifying Questions** (e.g. number of hours the presses were in operation, availability of maintenance staff, ISO 9000 certification);
- **Section 2: Current Maintenance Status** (e.g. views on maintenance, the cleanliness of the working environment, the role of the operators in the maintenance process);
- **Section 3: People Power** (e.g. the integration of the staff into the maintenance/productivity process);
- **Section 4: Key Performance Indicators** (e.g. KPIs that are used, extent of benchmarking with other companies).

The respondents were mainly commercial printers (55%), small businesses (45% employed fewer than 50 people, and only 17% employed more than 250), with slightly more than half having dedicated maintenance staff (55%).

Processes and Equipment

A large majority of the organisations (91%) had in-house pre-press with 77% of them using Computer-to-Plate (CTP)

- 13% retained film processing
- 14% relied solely on film

The majority of the organisations (98%) had post-press finishing equipment.

The majority of them were able to process printing jobs completely in-house as they have a guillotine (70%), a folder (one-third) or a saddle stitcher (one-third).

Some organisations have progressively introduced maintenance programmes into their working environments since 1997, and this reflects a widespread focus on achieving a higher level of productivity and increased competitiveness.

Those organisations that had maintenance programmes in place had fewer press stops, a higher throughput, less waste, more consistent quality and improved safety.

Problems faced

The survey found that even though most of the respondents (99%) believed that effective maintenance improved productivity, only close to two-thirds of these organisations (64%) had a maintenance plan. Of those with a maintenance plan, just over one-third were small in size (≤ 50 employees). This may indicate that smaller organisations may not be as willing to implement a maintenance system due either to a lack of resources, or a lack of understanding of the importance of maintenance.

¹⁷ Source: Claypole, T. and Wells, N., 2005, Productivity Maintenance in the UK Printing Industry. London: Vision in Print. p. 30



Success factors

It is important to ensure that workers from all parts of an organisation are involved in any actions, from senior management to all other employees.

In terms of strategy, a top-down directive is needed to improve productivity and maintenance is an integral component of this. Initiatives can range from formal strategies to integrate maintenance into a formal manufacturing strategy, to informal “common sense” approaches where maintenance is seen as an obvious necessity.

It is essential to integrate maintenance as a key productivity element into a manufacturing strategy, and that all staff are informed about the ways in which maintenance can be improved and how it can, in turn, improve the company’s performance.

Management, motivation, training and selection of people are the single highest success factor. In the last 20 years there have been over 100 studies demonstrating that companies with long-term success are those that optimise employee involvement – some studies identify up to 30% higher productivity, less absenteeism, fewer accidents etc. Specifically, employees need to be motivated and trained and organisations should select those staff who have the right skills and attitudes. The attitude and behaviour of staff is important, and these may need to be changed to foster a team spirit and make it possible for the staff to have a sense of “ownership” of the equipment.

Results and evaluation of the project

The respondents may not be typical of the wider industry as close to all of them (99%) believed that effective maintenance improves production. Further, close to two-thirds (60%) are accredited with ISO 9000.

One finding was that 40% of the organisations did not employ dedicated/specialised maintenance staff, with 75% of them employing 5 individuals or fewer. Rather they tended to rely on internal specialists or operators who had limited time to dedicate to maintenance, or on external services. Further, they employed multi-skilled maintenance staff or a combination of multi-skilled and mechanical maintenance staff, which suggests a stronger focus on electronic and hardware problems than on those that involve the mechanics of the press and post press equipment.

Transferability of the project

The maintenance practices advocated in this project are easily applied in a variety of industries in any country. They are based on practices that are neither sector-, country- nor language-specific. There is an element of “common sense” inherent in these practices, in that proactive rather than reactive solutions should be sought.

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Sources

Claypole, T. and Wells, N., 2005, Productivity Maintenance in the UK Printing Industry. London: Vision in Print.

URL: <http://www.visioninprint.co.uk/uploads/documents/VisionInPrint10433Best%20Practice1.PDF>

SNAPSHOT 2: EFFORTS TO REDUCE ACCIDENTS RELATED TO REPAIR AND MAINTENANCE OF FARMING EQUIPMENT IN IRELAND

2.8.

Case details

- Short title of case: Reducing accidents related to repair and maintenance of farming equipment
- Year of first publication by Agency: not yet published
- Organisation – The Irish Health and Safety Authority (HAS)

The action taken

The Irish Health and Safety Authority (HAS) has issued a Code of Practice after consultation with the statutory advisory committee on safety and health in agriculture (Farm Safety Partnership) and with the consent of the Minister of State at the Department of Enterprise, Trade, and Employment. It came into effect on 1 November 2006.

The aim of the Code of Practice is to improve the level of safety and health in the agricultural sector, the occupational sector which has the highest fatality rate in Ireland. About 200 incidents involving machinery and equipment result in serious injury each year. People at risk include those operating and maintaining the equipment and others close by:

- Six farm deaths between 1996 and 2005 were directly related to repair work.
- Most of these deaths were due to people being crushed under inadequately supported vehicles or machinery.
- Hazards during machinery repair include: crushing, entanglement, loss of limbs, electrocution, injuries to the eyes and feet, and noise-induced hearing loss. Repair equipment may pose a risk due to heat, metal particles or sparks.
- The National Farm Survey shows that about 10% of all farm injuries occur when people are struck by tools or implements.

The Code of Practice incorporates a risk assessment document and a “Safe System of Work” plan. In chapter 10, maintenance and repair of machinery is dealt with. Risk assessment and the organising of machinery repair and maintenance is explained in detail covering:

- workshop construction



- lifting equipment
- power tools
- welding
- compressed air/tyres
- personal protective equipment (PPE)
- hygiene
- further information on workshop equipment

The results achieved

At the end of 2006 HSA distributed this code of practice to every farmer in the country. In 2007 a major safety training programme for farmers to introduce them to the Farm Safety Code of Practice was developed and launched. More than 11,000 farmers are now receiving training each year. The HSA is focusing on inspections and promotional campaigns in agriculture.

In 2007, deaths in the agricultural sector dropped to an all-time low of 11 fatalities over the previous 12 months. In the first nine months of 2008 16 fatal accidents had been recorded. However, over the last five to six years the fatality rate has dropped by approximately 20%. HSA and other concerned partners are intensifying their efforts in the hope of further reducing these figures.

Further information:

Code of Practice for Preventing Injury and Occupational Ill Health in Agriculture:
http://publications.hsa.ie/getFile.asp?FC_ID=436&docID=209 (accessed 10/2008)

Safe System of Work Plan:
http://publications.hsa.ie/getFile.asp?FC_ID=437&docID=209 (accessed 10/2008)

Risk assessment document:
http://publications.hsa.ie/getFile.asp?FC_ID=438&docID=209 (accessed 10/2008)

Statements by the Health and Safety Authority, 15th August 2008 and 23rd September 2008:
http://www.hsa.ie/eng/News_and_Events/Press_Releases_2008/Safety_initiatives_launched_at_National_Ploughing_Championships.html

http://www.hsa.ie/eng/News_and_Events/Press_Releases_2008/Health_and_safety_chief_concerned_at_fatality_rate_in_agriculture.html

Summary of Workplace Injury, Illness and Fatality Statistics 2006-2007:
http://publications.hsa.ie/getFile.asp?FC_ID=568&docID=293 (accessed 10/2008)

Annual Report HAS, 2007:
http://publications.hsa.ie/getFile.asp?FC_ID=567&docID=292 (accessed 10/2008)



CASE 7: SAFE ACCESS SYSTEM USED FOR THE MAINTENANCE OF A POWER SUPPLY LINE NETWORK

2.9.

SWITZERLAND

Organisation: Nordostschweizerische Kraftwerke AG, (NOK)

Introduction

NOK was looking for ideas to improve safety for workers climbing up pylons and lattice masts to perform maintenance tasks.

During a work group meeting of Switzerland's power supply industry NOK learned about the newly developed HighStep-System. It appeared that this system had the potential to reduce accidents related to the climbing of masts and pylons considerably.

Aims and objectives

NOK started to test the system in 2004 with the aim – after successful testing and possible adaptations – of introducing it as a standard system within their company.

Scope of the project – What was done, and how

When NOK learned about the newly-developed equipment they contacted the manufacturer. The HighStep-System had originally been developed to provide safe and ergonomic access and egress to high buildings. Its main feature is a load-bearing rail installed permanently on the structures that need to be accessed (buildings, pylons, windmills etc.). The rail is made of a special alloy that does not require maintenance and is suitable even for harsh environmental conditions such as strong sunlight, low temperatures in mountainous areas or the corrosive stress in coastal regions.

To move up and down the rail, the worker needs a portable climbing gear which does not take up much space and can easily be carried from workplace to workplace, preventing the misuse of the system and any unauthorised access to the structures. The climbing gear can either be manually or machine operated. In the latter case it is battery powered.

The basic model consists of two pedals, the so-called "steppers" which are used in a similar way to normal climbing irons, but far more safely because the pedals are firmly attached to the rail and the feet. The personal restraining belt of the user is attached to the rail with a carabine hook and locked in place. In contrast to ladders, the length of each step can be chosen by the climber. The mechanism is activated by raising the heel. When the heel is lowered again, the stepper stops and gets locked to the rail. Because the steppers offer firm support, breaks can be taken at any time.

At normal speeds climbing up and down, the safety harness follows the movement automatically. If the downwards movement is too fast, e.g. in the case of a fall, a safety pawl automatically locks onto the rail and reliably prevents a fall.



Figure 10: Climbing up a NOK lattice mast using the HighStep System and a manually operated “stepper”



Source: HighStep System

The movement by the powered semi-automatic equipment can be compared with climbing stairs, but the tread height can be chosen individually. When a foot is raised, the pedal on same side follows automatically, driven by a small motor, until the foot is lowered again. By alternately raising and depressing their feet, users climb upwards with minimum effort.

When climbing down, the weight of the body is used to move downwards as in a lift. A charging device recharges the batteries on each descent. The equipment can also be moved by remote control, which is a big advantage if two or more persons have to climb up, because it can then be brought down without a person operating the equipment directly and the person above can still continue with the work.

Figure 11: HighStep System with attached powered semi-automatic equipment



Source: HighStep System

With this system, users are always secured in several ways. Their feet are firmly attached to the climbing gear, which is also firmly connected to the rail. It is therefore impossible for the foot to slip, as can happen with a ladder or climbing iron. With the manual climbing gear users also have to secure themselves by attaching their safety harness to the rail.

In 2004 NOK began testing the system and had rails installed on several of its structures. Their landline mechanics tried out the basic mechanical models. Then the system was also implemented at a certain area in the mountains, where new power cables were laid in order to extend the range of the tests. The tests highlighted the need for some small improvements, such as the fitting of additional cams to the steppers after it was discovered that a grease film on the rail, caused by spilt sun screen, could cause a slide downwards of some 30cms.

After this, NOK used the system in another area where power cables were laid in the Swiss region of Mittelland.

Results and evaluation of the project

After NOK had tested the HighStep system thoroughly, some improvements were suggested and implemented. The company regards the system as a reliable construction providing multiple safety features. It can be upgraded where necessary and misuse by unauthorised persons is highly unlikely since the equipment needed to climb it are always with the mechanics.

In 2007 NOK decided to make the HighStep System its standard climbing system.

So far no statistical data demonstrating the improved safety offered by the new system is available but the company expects to reduce the number of accidents and injuries related to climbing up and down masts and pylons to zero.

NOK has established that the system also provides economic benefits – the workers need considerably less time and energy to execute their tasks.

Studies by the Swiss Federal Institute of Technology (ETH) in Zurich have shown that the movements made by the human body when using the climbing gear are ergonomically optimal, minimising the potential for musculoskeletal injuries during climbing.



Transferability of the project

This system for the safe access and egress of maintenance workers to pylons, windmills and tall buildings can be bought and applied worldwide.

Further information

The project was organised by NOK, and involved the manufacturer of the system:
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 Tel. 0041-56-200 38 69, martin.weber@nok.ch,
 Website: <http://www.nok.ch/>

SNAPSHOT 3: SAFE MAINTENANCE CONCEPT FOR THE ÖRESUND FIXED LINK

2.10.

DENMARK

Source: Öresundsbron

Organisation: Öresundsbro Consortium**Introduction**

Accident figures were already low for the construction phase of the impressive steel and concrete bridge and the long underwater tunnel which connects Denmark and Sweden across the Oresund. This was thanks to a comprehensive proactive approach to safety and health issues (see Agency website link below) while the Danish fixed link was being built across the Great Belt. A strong political determination to reduce the number of occupational accidents as much as possible was an important starting point.



Aims and objectives

Figure 12: The Oresund bridge



Source: Oresundsbron

After the bridge and the tunnel had been erected, the consortium wanted maintain this excellent safety record, using the lessons learned during construction to develop a system for the safe maintenance of the link.

This system included measures aimed at raising awareness of health and safety rules and procedures among all personnel, including maintenance staff working on the bridge line and the tunnel. They had to be able to act in a safe manner and ensure good quality of work.

Scope of the project – What was done

The consortium developed compulsory safety courses for all personnel who have access to the bridge line and the tunnel to carry out maintenance. In addition,

the system requires detailed planning to be carried out before any execution of maintenance work on the link begins.

The safety courses last a total of four hours, and no personnel can work on the link until they have completed them. Instruction includes safety films taken on site and covers detailed planning of all jobs, including the consideration of safety issues, in order to be able to deal with all unexpected situations which may arise during the execution of the work. The system satisfies the strictest occupational health and safety regulations of both Denmark and Sweden.

Safety procedures and the instructions to go with them are available to everyone involved, either via the Internet or in safety booklets. Supervision of all operations through camera coverage of the link is carried out 24 hours a day.

The results achieved

The number of accidents remains very low. There are frequent audits and checks on the spot to verify that the rules are being followed. The safety courses are also modified as jobs and circumstances change.

A major factor in the success of the programme, in the consortium's view, is the cooperation between the health and safety coordinator, the staff and maintenance personnel working for contractors.

Transferability

This type of safety training programme can be used in any construction or maintenance setting to train personnel and to develop and maintain correct health and safety working practices. It does need to be adapted to take into account conditions at specific construction sites and the nature of the tasks that need to be done, and to satisfy local regulations.



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CASE 8: AIR FRANCE INDUSTRIES: CREATING A VIRTUAL TOOL TO PLAN IN ADVANCE FOR REAL-WORLD DEFECTS

2.11.

FRANCE*Organisation: Air France KLM***Introduction**

Air France KLM operates in three main businesses: passenger transport, freight transport, and servicing and maintenance services under the name Air France Industries.

Air France Industries is made up of a number of distinct organisations, one of which is the so-called "Engine" facility that focuses on the servicing of turbojets for the Air France KLM fleet and other customers.

As new commercial jumbo jets such as the A380 enter the aircraft market and jet engines become increasingly large, maintenance workshops must meet these new demands by increasing their handling capacity.

In 2004 Air France Industries reorganised one of its maintenance workshops at Orly airport, part of its Engines business.

Engine servicing takes place in three stages:

- One unit (unit 2) is responsible for initial engine dismounting to remove several modules.
- Other units (unit 3, unit 4, unit 5 and unit 7) are responsible for dismantling the modules into parts, then re-assembling them after treatment. Each unit is specialised in a particular type of module for all types of engines.
- Finally, one unit is responsible for cleaning the modules (chemical and mechanical scrubbing), inspecting them (non-destructive testing by ultrasonic or eddy current methods, for example) and then restoring them to those units in charge of reassembly.

Air France Industries took advantage of an opportunity to re-vamp one of these engine maintenance workshops provided by the moving of a department from the Orly site to Villeneuve-le-Roi, freeing up a significant work space. It was also necessary to replace industrial equipment that had become obsolete.



This work was carried out as part of the “Prisme” programme for industrial rationalisation of existing engine areas, and the new workshop had to be able to receive jet engines 3.5 metres in diameter, whereas the equipment had previously been designed for engines 2.2 metres in diameter.

At the same time, certain production units that had been on different sites now had to be grouped together coherently on this one site. All this involved the installation of larger machines, enlarging the traffic aisles and setting up suitable lifting and handling equipment. The area available was 8,000 sq. m broken down into 70 units, each unit consisting of 20 to 30 office items, machines, handling equipment, and so forth.

As part of this reorganisation, risk prevention and safety questions were re-examined on site. Air France Industries wanted to limit the number of areas where pedestrians had to use the same pathways along which machinery was moved and so needed to reorganise the internal and external traffic plans.

To summarise in a few figures, the “Prisme” project represented:

- a budget of €20m;
- an area of 8,000 sq. m to be reorganised;
- 1,030 people involved in “Engine” operations, of which 700 were affected by the reorganisation;
- approximately 250 engines handled by the “Engine” workshop each year, each engine refurbishment taking about 60 days’ work.

Aims and objectives

Air France Industries applied to the Ile-de-France regional health insurance fund (CRAMIF) for help with the project. It was proving difficult to assess the 2D drawings and identify any production, safety and ergonomics issues.

Moreover, Air France Industries wanted to involve all the personnel affected by the reorganisation in the process of designing this new workshop to enlist their support for the changes and enhance risk prevention.

The solution chosen by the partners involved in this project was the creation of a three-dimensional interactive computer model, and for this the partners asked for the help of the French national research and safety institute INRS.

The aim, then, was to make a tool that would make a 3D project visualization available to everyone involved and which would make group work possible.

Scope of the project – What was done, and how

To carry out this project, the organisation called on the CRAMIF, which had already provided OSH services for chemical treatment equipment of Air France.

The INRS provided its support for the simulation project. The planned numerical simulation tool, consisting of software showing the future workshop viewable in 3D, had to fulfil two objectives: to enlist the support of employees for the changes by providing them with a detailed view of their future work area which 2D drawings did not allow, and to identify any safety, ergonomic or production issues before the changes were made.

The INRS therefore developed a tool specific to the needs of Air France Industries. Using in-house computer modelling expertise, a preliminary model was produced to help establish the specifications. The idea was to show that such a tool was feasible,



offering a realistic representation of the space and performing well when it was used by planning groups and individual workers.

The difficulty was to produce a model that would be as realistic as possible, showing the maximum data, while at the same time remaining fluid in its operation and easy to work with. To this end, objects were to be composed of simple shapes (cubes, spheres, cylinders) wherever possible.

The design work began with:

- Identification of the objects to be simulated with the help of a representative from each of the 3 units
- Metric and photographic identification of these objects
- Collection of available drawings of the building, of planned changes to the building, and the machines chosen for the new locations
- Translation of the 2D drawing into a 3D model incorporating the objects
- Validation of the model and its interactions with the managers of each of the 3 units
- Finally, deployment of the model.

An interactive three-dimensional simulation was created. This required the modelling of:

- a building;
- 50 specific machines;
- 40 handling devices (trolleys, pallet jacks, etc.);
- 50 items of furniture (benches, cabinets, racks, etc.).

These models made it possible to form 70 units each consisting of 20 to 30 items.

For the simulation to work, a number of technical constraints had to be considered. The simulation was based on elaborated structures for the various constraints. Production of this model required two months' work and the cost of the simulation was €20,000.

The INRS used experience drawn from the computer gaming universe to produce this collaborative tool. Each employee had to be able to access it at his work station. Working on a tool of this scale was a first for the INRS, and was very instructive.

Following this preliminary stage, production of the finished model was handed over to an outside service provider. The simulation was recorded on CDs that were then distributed to the workshop employees.

Everyone was thus able to take a virtual tour of their future work area. Feedback showed the model was well-received by the personnel.

One month after distribution of the CDs, meetings were organised by each processing unit to gather comments. This information was summarised and analysed by a project monitoring group.

Results and evaluation of the project – What was achieved?

Before the beginning of the Prisme project, a large number of staff had reservations about the project and the large scale changes it involved.

The virtual model was a great help in furthering understanding of the project. The ease with which the model could be used enabled everyone to visualize themselves in their future working environment. By comparison with hard-copy drawings, the



3D model gave a better understanding of the new layout and helped highlight inconsistencies.

Being able to view movements within the workshop made it possible to detect and correct certain ergonomics and safety problems in the proposed layout of the premises, such as a poorly located column and doors opening in the wrong direction.

The main difficulties identified concerned traffic lanes and difficult access to certain work stations because storage areas nearby for bulky parts were not large enough.

However, the decision to use a computer model was taken at a late stage in the project and limited the benefits that could have been derived from it. Air France Industries nevertheless regard the experience as positive and it plans to introduce the use of this type of simulation for all future projects.

Working conditions at the re-designed premises have been improved, in particular in safer circulation around the premises and safer access to work areas for maintenance workers.

The model will continue to be used by the Safety Manager – while the actual layout mirrors the simulation – to train new recruits about the operation of the workshop and raise awareness about possible risks.

Transferability of the project

This method is applicable to all types of industry and all activities in any country.

In the future, Air France Industries plans to use the same approach in its future projects.

Moreover, this collaboration proved profitable for the partners brought in to assist Air France Industries and led to further thinking on the subject at the INRS. A three-year study is now in progress using similar tools in the bakery trade, in cooperation with the “Institut National de la Boulangerie-Pâtisserie” (National Bread and Cake Baking Institute).

Further information

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CASE 9: SAFE MAINTENANCE OF HYDRAULIC SYSTEMS

2.12.

GERMANY

Organisation: Accident prevention and insurance association for the metal working industry ("Berufsgenossenschaft Metall Nord Süd")

Introduction

The number of hydraulic components used in machines has been increasing since 1950. Modern hydraulic systems operate at higher pressure than earlier versions and their hydraulic elements are often combined with electric or electronic parts which make automated production machines and systems ever more complex. Their operators and maintenance workers face an increasing risk arising from accidental machine movements, uncontrolled leakage of hydraulic fluids, the need to deal with an electricity, working in confined spaces, components coming apart under high pressure, and noise. There are also the risks related to insufficient organizational preparation before maintenance activities begin.

Aims

There are national occupational health and safety regulations and accident prevention regulations intended to prevent occupational accidents and diseases related to the maintenance of hydraulic systems. The BG information 5100 (BGI 5100), providing detailed information on the specific risks related to hydraulic systems, was first published by the German social accident insurance, "Deutsche Gesetzliche Unfallversicherung (DGUV)" in 2007. First and foremost, it is designed for the employer and is to support him in the implementation of his obligations defined by the regulations as well as to identify ways for preventing occupational accidents and work-related health risks and diseases. It also addresses operators and maintenance workers conducting work on machines and systems with hydraulic equipment. It contains description of hazards and measures for preventing risks as well as advices for carrying out maintenance work in a safe manner.

Scope of the project – What was done and how

- Publication of the BGI 5100

The aim of BGI 5100 is to improve occupational safety and health of those involved in maintaining hydraulic systems. The information brochure was issued by the "Deutsche Gesetzliche Unfallversicherung (DGUV)" and prepared by the committee of experts "Mechanical engineering, manufacturing systems, steel constructions" (Fachausschuss "Maschinenbau, Fertigungssysteme, Stahlbau, FA MFS". It focuses on the maintenance of machines and systems with hydraulic components. In 2008, BGI 5100 was translated into English.

- Development of a course based on the BGI 5100, published in 2007

The training course "INHY – Instandhaltung Hydraulik" (Maintenance of Hydraulic Systems) is based on the BGI 5100 and is delivered to those working on or maintaining machines and systems with hydraulic components by the accident prevention and



insurance association for the metal working industry (“Berufsgenossenschaft Metall Nord Süd”).

The course communicates the contents of the BGI 5100 and the corresponding information from the Committee of experts – “Mechanical engineering, manufacturing systems, steel constructions”. Altogether 21 courses are run each year at the training centers of the “Berufsgenossenschaft Metall Nord Süd” in Germany. The courses last for three days and include one and a half days of detailed information on hydraulic maintenance. Approximately 25 workers from various companies participate in every course.

The contents of BGI 5100 are presented by two trainers: a safety inspector with in-depth knowledge of accidents and all relevant laws, rules, regulations, and standards on hydraulics and machinery, and a hydraulic specialist with specific experience in maintaining hydraulic systems and with knowledge of relevant applications, components, and systems. The course includes practical examples of dangerous situations and discussions on specific topics which are particularly relevant to participants, including dealing with specific hazards. As a result a wide range of practical experience is exchanged between attendees.

Results and evaluation of the project / What was achieved

In addition to the information offered by the trainers different approaches to the dealing with specific hazards are discussed among the participants. Moreover, participants are made aware of sources of further information such as BGI 5100, information brochures from the FA MFS, and on-line resources such as links to information provided by the manufactures of various hydraulic components. Furthermore, in the hope of creating a lasting information exchange network, attendees are encouraged to exchange contact data with fellow students.

All the information offered can be used on a daily basis by those working on or maintaining machines and systems with hydraulic components.

According to safety representatives’ and professionals’ reports to the committee of experts due to the interventions more attention is paid to the manufacturers’ specifications as well as to preventive maintenance activities related to hydraulics.

Safety instructions and qualifications schemes are adapted in accordance with BGI 5100.

In order to reduce time pressure and the stress maintenance workers are exposed to nowadays, maintenance procedures – as recommended by BGI 5100 – are often planned in advance. Documentations, data specifications are provided for the workers and it is thought about how to isolate the place of the failure beforehand. In order to help find faulty parts, a checklist for trouble-shooting is included in the appendix of the BGI 5100.



Figure 13: Possibilities to reduce Stress in Maintenance Activities at Work



Figure 14: Hydraulic Maintenance

It was also reported to the committee of experts, that, awareness of occupational safety and health risks has been increased by the publication of the BGI 5100 and its associated course. Whereas occupational risks caused by electricity hazards were the main focus of concern about the safety of those working with machines which had hydraulic components, BGI 5100 has also highlighted the hazards related to hydraulics.

Increased awareness among maintenance workers providing maintenance is demonstrated by the observations of several health and safety officers: machine and system operators are more often asked to shut down machinery or to set up scaffolding for maintenance activities in order to minimize risks. In particular, supervisors learning about BGI 1500 report to the committee of experts that they have often have been unaware of the risks that staff dealing with hydraulic equipment are exposed to.

Transferability

The BGI 5100 publication and the associated course are easily transferable to any company where the hydraulic systems of production machinery have to be maintained. However, specific provisions for different applications (e.g. maintenance in the mining industry, maintenance of aircrafts, etc.) have to be taken into account, as do the requirements of national legislation and regulations in other European countries and manufacturers' instructions.



Source: BGI/BGM



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2.13. CASE 10: SUBSTITUTION OF DANGEROUS SUBSTANCES IN REPAIR AND MAINTENANCE WORK

DENMARK



Source: CatSub

Organisation: CatSub

Introduction

Highly dangerous substances such as dichloromethane are still in use particularly in repair and maintenance work because they guarantee fast and efficient paint stripping and cleaning.



Aims and objectives

The CatCub Internet catalogue is intended to be an “inspirational” source of possible solutions to the problems of using hazardous substances, suggesting less hazardous or hazard-free substitutes which work just as well. The quality of each example is assessed by its provider although some of the examples are also assessed by independent specialists. It is always possible that there may be other solutions besides those presented in the catalogue and therefore users will have to judge for themselves whether a solution will suit their needs or working environment, or perhaps consult their own advisors. The aim of the catalogue is not to favour certain products at the expense of others. Suggestions of new substitutions for possible inclusion in the catalogue are welcome.

Scope of the project – What was done, and how

The CatSub website at www.catsub.eu is a publicly accessible database itemising more than 300 examples of dangerous substances which can be successfully replaced by less hazardous or hazard-free products. In some cases it is also possible to avoid chemicals altogether by using alternative processes. Examples are submitted by companies, occupational health services and other institutions. Many of the examples deal with maintenance and repair work in different industries.

The website offers both free text search and search by industry sector. Registered users can comment on contributions. A number of experts and professionals are authorised to enter new examples. Anyone who would like to enter new interesting examples can request for access under info@catsub.dk. CatSub currently publishes its database in four languages; Danish, French, English and German. Some examples are only found in one of these languages while others have been translated into one or more of the other languages.

In 2003, financial support from the Danish Working Environment Authority and the European Agency for Safety and Health at Work made it possible to develop the system. More recently the Danish Environmental Protection Agency and the French AFSSET financed the addition of environmental substitutions to the catalogue as well as translations.

The web site has been developed by Lone Wibroe, pharmacist and project manager, Grontmij | Carl Bro and Peter Quistgaard, chemical engineer and IT development manager, Alectia a/s. The management of CatSub is also in the hands of Lone Wibroe.

Two examples regarding maintenance and repair work are presented here in more detail:

■ 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. However, this product is a very fine powder and caused dust problems and it too could create 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 of saving time, since the machinery does not have to be taken apart

- Removal of acrylate residue when coating optical fibres at OFS Fitel Denmark

Connecting fibre optical 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. Since they were not satisfied at all with the replacement, they then tested NMP (N-methylpyrrolidone). However, they discovered that NMP has a strong irritating effect on skin and eyes and there is a limited evidence that it may cause fertility disorders at a medium level of exposure. According to the Danish Working Environment Authority, WEA's list, NMP can cause nerve damage at the level of SRI 2, which means 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.

Results and evaluation of the project: what was achieved?

The CatSub is a much appreciated tool. For example, the use of lead-free solders instead of old-fashioned lead solders has spread to many companies thanks to the information on suitable substitutes offered through CatSub. The resource is used by many workplaces, large and small. Links to CatSub are offered by many websites in Denmark and across the world operated by government, authorities, unions, employers, and many other organisations in order to encourage the substitution of hazardous chemicals.

LEGO and OFS Fitel confirm that the substitution processes used by them and outlined on the CatSub database are still applied in their respective companies, and this demonstrates that the new cleaning agents and processes involved are not only safe for their staff but also economically viable.

As a result of substitution, exposure of workers – including those involved in maintenance processes – to hazardous substances, has decreased.

Transferability

The examples of substitutions can be used in all industry sectors and all sizes of workplaces in any country. This should however be done after thorough testing and taking into account national legislation. All interested parties may offer their contributions to the database. The development of further language versions is possible.

Further information

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SNAPSHOT 4: HOW TO PROTECT WORKERS FROM ASBESTOS RISKS

2.14.

ITALY

Organisation: NuovaQuasco, Via Morgagni, 5 to 40100 Bologna, Italy

The issue under discussion

The issue under discussion is how to raise awareness and train construction workers about the risks of asbestos.

This project was developed to help construction workers understand current regulations about the handling of asbestos and to improve compliance with these regulations.

As a part of the project, some teaching and educational tools were developed. The package was intended for employees carrying out building maintenance at shipyards, where there was a risk of exposure to asbestos.

Aims and objectives

The main objective was to provide a flexible training package including plenty of images intended to attract attention of learners and make sure construction workers aware of the key risks and the most suitable preventive measures needed to carry out their work safely. A secondary objective was to develop an interactive self-learning test for technicians and employers. The test is specific, job-related and checks knowledge of the correct methods of working with asbestos. It also suggests incorrect risk control methods that students have to correct.

The actions taken

The project included the creation of a training package for technicians and employers consisting of a manual and a CD-ROM.

The training package includes case studies, with photographs of construction sites, suggesting best-practice measures to prevent risks, and highlighting situations that must be avoided.

The manual consists of three different parts. The first presents concepts and definitions applicable to risks related to reconstruction or refurbishment work involving asbestos.



In this section the risks and damage caused by asbestos and the best preventive measures are discussed. The second part describes the safe working procedures and the contents of the work plan required by current regulations. The third part offers a self-learning interactive test; the wrong answers given by the reader carry him back to the relevant sections of the manual.

The CD-ROM has a similar structure. The first part presents concepts and definitions related to risks of dealing with asbestos and describes the preventive measures to be implemented. The second part describes the safe working procedures for dealing with asbestos and how to complete the work plan required by current legislation. The third part offers a similar interactive test as described above.

The results achieved

The courses created great interest amongst construction workers especially the presentation of solutions for handling asbestos as well as the explanations of current regulations and how to comply with these. The concept has also been used in training programs at universities.

Transferability

The developed training concept covers the situation in Italian shipyards. A transfer to other sectors and countries would need to consider possible construction differences and differences in national legislation.

Further information

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2.15. CASE 11: TAKING RISKS WITH ASBESTOS: WHAT INFLUENCES THE BEHAVIOUR OF MAINTENANCE WORKERS?

UNITED KINGDOM



Source: IES (HSE), UK

Introduction

Asbestos is a very dangerous substance if not dealt with correctly. Many tonnes of asbestos were used in building materials until as late as 1999, such as asbestos cement,



and much of this is still present in the built environment. Asbestos is contained in a wide variety of different products and can be difficult to identify. Often those most at risk of exposure are unaware that this is the case.

Breathing asbestos fibres can lead to various asbestos related diseases, ARDs. These are mainly cancers of the chest and lungs, and are the single greatest cause of work related fatalities in the UK. As a result of their past exposure to asbestos materials, around 4,000 people in Great Britain die each year¹⁸.

If material containing asbestos is disturbed, the asbestos fibres can be released and breathed in. If these fibres lodge in the lungs they do not dissolve and can work their way to the outer surface of the lungs leading to several diseases, some of which are fatal. The conditions caused by asbestos exposure include:

- Asbestosis – an irreversible scarring of the lungs that causes a decrease in elasticity. It is an industrial disease that is associated with high levels of exposure to all types of asbestos in the past.
- Lung cancer – there is an increased incidence of lung cancers in those working with asbestos. Moreover, smokers who are exposed to asbestos fibres have an increased risk of contracting the disease.
- Mesothelioma – a cancer of the lining of the lungs or digestive tract.

It is unclear exactly what levels of exposure cause these diseases but it is known that the more asbestos fibres are breathed in, the greater the risk to health. Other factors that may affect the risk of developing ARDs include the duration of contact and the fibre type (mineral form and size distribution). Other factors that may play a role in the development of these diseases include the chemicals that individuals may be exposed to, their age, sex, diet, family traits, lifestyle (e.g. smoking), and general state of health.

According to the Health and Safety Executive of Great Britain (HSE) there can be a long delay between the very first exposure to asbestos and the onset of the disease: anywhere between 15 and 60 years¹⁹. In recent years fatalities have occurred among those formerly employed in occupations in which exposure to asbestos materials was most intense, including shipbuilding, railway engineering and asbestos product manufacturing. Only by eliminating or minimising exposure of those who are now at the greatest risk – e.g. carpenters, joiners, shopfitters, plumbers, electricians etc. – will future cases of ARDs be prevented.

Aims and objectives

The aim of the research is to find out why maintenance workers do not always follow HSE guidance, and to identify ways of encouraging workers to follow the guidance in the future. To explore this, workers were encouraged to discuss their attitudes, awareness, knowledge and behaviour around asbestos. More specifically the interviews covered the following topics:

- Workers' occupations, types of work undertaken and whether they work in the domestic or non-domestic sectors.
- Their perceived contact with asbestos-containing materials (ACMs) in their work.

¹⁸ HSE, *Why is Asbestos dangerous?*, web article <http://www.hse.gov.uk/asbestos/dangerous.htm> (accessed June 2009)

¹⁹ HSE, *Background Facts on Asbestos*, web article available under: <http://www.hse.gov.uk/asbestos/general-info.pdf2> (accessed June 2009)



- To what extent workers are informed of the location of asbestos when visiting a work site.
- Training and refresher courses received.
- Levels of knowledge and awareness of HSE guidance on good practice.
- Attitudes to asbestos risks and to working correctly with ACMs.
- Key organisations/stakeholders that influence maintenance workers.
- Workers' favoured means of receiving work-related information.
- Sources of guidance on working with asbestos and individual reactions to existing asbestos guidance.
- Influence of colleagues and others on individual attitudes, awareness and behaviour.
- Financial and other barriers to engaging in good practice.

Workers were invited to share their personal experiences of working with asbestos, how they dealt with it, how they felt about the situation, and other related issues. They were also asked to rate how knowledgeable they felt they were about a range of asbestos-related issues. Four options were provided: (a) You know about it and understand it pretty well; (b) You know a little bit about it but are not confident you know enough; (c) You don't know but feel you should, and (d) You don't know and you don't need to know.

Scope of the project – What was done, and how

There were 60 interviewees, all of whom worked in the construction industry. Potential participants were identified through around 30 intermediaries (e.g. training providers, suppliers, recruitment agencies, employers, trade bodies and trade unions). In addition, around 3,000 sole traders were sent a letter with an opt-in slip attached, which they were asked to send back if they were interested in participating in the research. All participants were given a £20 gift voucher on completion of the interview, and interviews were conducted on respondent's work premises or in their own homes at a time convenient for them. Each interview lasted between 20 and 90 minutes. These interviews were all fully transcribed and analysed.

The aim of this research was to provide insights into the knowledge, attitudes and behaviours of a wide range of workers of varying ages, experiences and from different trades. It does not necessarily represent the building and maintenance sectors as a whole, but can provide an overall picture of the issues related to asbestos risk and potential barriers to changing behaviour.

Success factors – What was achieved?

What is needed to overcome barriers to safe behaviour? The study showed that there are a complex range of factors that influence individual behaviours. All of these need to be considered. Only then can training or information sharing be effective.

Although no direct procedure or intervention was proposed, the report identified a range of issues that affect an individual's safe behaviour around asbestos. These results may be used to optimise future trainings and instructions. The issues can be broken down into four main categories:

- technical issues relating to the complexity of messages about asbestos, its effects and how to deal with it effectively
- psychological issues concerning an individual's attitudes towards risk, health and the specific risks posed by asbestos



- cultural factors such as pressures from employers, clients, co-workers etc, which are largely driven by economic as well as social pressures
- control factors, namely how much individuals feel that they are in control of their work environment These are related to the nature of the employment contract an individual has, and their labour market capital

Attitudes towards behaving safely are the result of two adverse forces: the negative impact of not behaving safely against the positive benefits of doing so (i.e. whether the economic or social costs are outweighed by the health benefits). The prevailing safety culture and the attitudes of co-workers/family/employers are also clearly important. These, together with an individual's sense of control, determine whether they intend to behave safely or not. However, in order to translate the intention to behave safely into practice, it is important that employees have sufficient knowledge of appropriate preventive measures.

The finding of this report highlights the importance of addressing all aspects of the psychological process and safety culture when considering risk-taking behaviour in relation to asbestos. This is of the utmost importance when trying to promote full adherence to HSE safety guidance by both workers and employers or when developing optimally effective training packages and prevention and management initiatives for workers and employers. However, to date the findings of this report have not been systematically integrated into the further development of existing training packages or preventative initiatives. As a result there is limited data about the practical application of the report's findings.

Transferability

The method used to gather information is easily transferable to other sectors or member states. Some of the findings of the study may be peculiar to the UK, although most of the findings are likely to be widely applicable.

Further information

The report and the work it describes were funded by the HSE. Research was conducted by the Institute for Employment Studies (IES).

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2.16. CASE 12: SOLUTIONS TO REDUCE STRESS IN OCCUPATIONAL MAINTENANCE



GERMANY

Organisation: Accident prevention and insurance association for the metal working industry ("Berufsgenossenschaft Metall Nord Süd") (Karl-Thomas Wenchel and Prof. Dr.-Ing. Peter Hartung)

Introduction

According to the standards DIN 31051 and DIN EN 13306 the following activities are considered to be maintenance:

Maintenance includes all technical, administrative and managerial actions during the life cycle of an item – a workplace (building), work equipment, or means of transport – intended to keep it in, or restore it to a state in which it can perform the required function, protecting it from failure or decline. Maintenance activities can include:

- inspection
- monitoring
- testing
- overhaul
- measurement
- replacement
- adjustment
- repair
- modification
- rebuilding
- fault detection
- servicing.

These maintenance activities are associated with diverse hazards that may adversely affect workers' health. Particularly during corrective maintenance, workers are exposed to psychosocial hazards such as high job demands and time pressure that may have negative consequences on health and safety. The exposure to such stress-generating factors may lead to an increase in occupational accidents and may also in the long term trigger occupational diseases among maintenance workers.

Statistics for fatal accidents reflect the high level of risks associated with maintenance activities: about 21 % of fatal occupational accidents are related to maintenance tasks, exceeded only by the transport and traffic sector which accounts for 42 % of work-related fatalities (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, 2006). The exposure of maintenance workers to high levels of risk is also confirmed by the accident prevention and insurance associations ("Berufsgenossenschaften"). According



to their statistics, 20% of all fatal occupational accidents are related to maintenance or corrective maintenance activities.

In order to reduce the levels of risk related to maintenance work at a German automobile manufacturer, the accident prevention and insurance association responsible for the metal working industry ("Berufsgenossenschaft Metall Nord Süd") was asked for help.

Aims and objectives

A risk-reduction workshop was devised, directed at preventing or reducing the exposure of maintenance workers to risk factors with adverse effects on both short-term and long-term health. In order to achieve these aims, the awareness of both workers and their managers about the risks involved had to be increased and feasible solutions developed.

Scope of the project – What was done, and how

To achieve these aims, a two-day workshop was held for workers at a German automobile manufacturing company. The workshop was run three times and each time around 15 employees from lorry production department took part. Two moderators led the workshop, but the primary method of training was through group discussion and presentation.

The workshop content was carefully structured. At the beginning, three maintenance accidents were described by the moderators. Maintenance workers were then asked to think about their work, focusing on critical and safety-relevant situations that might give rise to occupational risks of various kinds during maintenance activities.

Their observations were summarized and presented on specific boards and they were asked to propose solutions and discuss various approaches to the prevention or reduction of the risks they had identified. No managers took part in this phase of the workshop to ensure that the workers' view were not influenced or inhibited by their presence.

Instead the managers concerned were invited to participate in the final session of the workshop during which the results of the workers' discussions were presented to them by the two moderators. Then, through a joint critical appraisal involving both workers and managers, the proposed approaches to reduce or prevent risk were discussed.

Success factors – What was achieved?

The workshop raised workers' awareness of the occupational risks they are exposed to and gave them an opportunity to discuss and develop strategies to prevent or reduce those risks.

Workers agreed that maintenance work is often unpredictable, involving quick responses to technical emergencies with an inevitable time pressure. This is often aggravated by difficult working conditions such as poor access to maintenance areas, heat, noise and working in confined spaces.

While discussing risk factors with managers responsible for maintenance, it became clear that risky behaviour by workers performing maintenance tasks could often be seen as compensatory behaviour intended to ease time pressures. Maintenance workers reported that time pressures were a typical, everyday part of their daily



working lives, particularly where malfunctioning machines or systems were seriously disrupting production or in case of a breakdown.

Maintenance workers were also exposed to risks caused by a lack of organisational and technical preparation. They reported that they often had to work under difficult conditions, such as testing machines that were still running or working while protective devices were switched off. Other risks identified included unintentionally activating control devices and working alongside dangerous substances.

When machinery or systems failed, maintenance staff was often forced to improvise when the proper spare parts were not available, under pressure to restore normal production as quickly as possible. As a result, reported the workers, further failures and breakdowns were inevitable.

Finally, they reported, insufficient instruction and inadequate operation charts caused accidents and put them at risk of accidental injury and long term ill health.

If they are to do their jobs well, maintenance workers should not be exposed to further job strains in addition to those that are inherent in their work and cannot be avoided, such as machine failures and time pressure.

Yet additional sources of stress were frequently reported by the maintenance workers. One of the sources arose from the fact that the number of employees responsible for maintenance in recent years had been reduced. As a result breakdowns could not always be dealt with immediately and in some cases workers had voluntarily come into work on Sundays, in order to clear the backlog of maintenance tasks before the start of a new working week.

They also reported that preventive maintenance programmes had been steadily abandoned over the previous decade which, although cutting costs in the short term, was the root cause of more frequent machinery and system failures which were likely to incur higher costs in the long term.

Maintenance workers also believed that designers paid too little attention to how easy or difficult it might be in the future to maintain or repair machinery. Difficulties accessing areas that needed attention frequently became apparent when worn parts had to be replaced.

Another concern voiced by the maintenance workers was that maintenance tasks were often assigned to external service providers who seldom had the adequate know-how. Inadequate maintenance carried out by these workers could lead to additional maintenance costs in the long term.

Finally, workers felt that communication and the exchange of information between them and their managers should be improved. Poor communication was demonstrated when the managers joined the workshop for its final session and it became apparent that managers were not aware of many of the risks identified by the workers. It is of the utmost importance that both workers and managers are aware of all potential risks.

Time pressures associated with machine and system failures certainly cannot be eliminated but they can be reduced by the establishment of what is known as a "mitigation plan". In the first instance, the manager describes the task to be done in a meeting attended by all workers who will be involved in the process. Specific tasks are discussed and final decisions made by the managers to cover every situation which might arise during the maintenance work. The creation of this mitigation plan gives workers the confidence to be able to handle the situation.



Transferability

The methodology used is easily transferable to any company, sector or member state where maintenance activities are carried out.

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SNAPSHOT 5: TRAINING BASED ON COMPREHENSIVE GUIDELINES TO IMPROVE HEALTH AND SAFETY IN WATERWAYS MAINTENANCE WORK

2.17.

ITALY

Organisation: Nuova Quasco, Via Morgagni, 5 – 40100 Bologna, Italy

The issue under discussion

In order to further improve the health and safety of maintenance workers on river embankments, the Inter-regional Agency for the River Po, AIPO, developed and



applied a new training concept. The project was based on comprehensive guidelines for the application of health and safety regulations, detailed descriptions of work processes and related preventive measures. AIPO technicians were involved in drawing up descriptions of the various work processes. This particular project focused on designers, the director and work safety coordinators at AIPO.

The action taken

The basic project consisted in providing training, both in the classroom and the workplace, for technicians involved in maintenance work. The most important module of this training familiarized technicians with comprehensive guidelines, consisting of:

- a general section explaining health and safety rules and giving guidance about how to establish a safety plan
- an introduction to a database describing one hundred specific work processes and their related safety measures, using technical drawings in AutoCAD format
- supporting documents (“coordination models”) to co-ordinate preventative and protective measures

The technicians tested all elements of the guidelines in case studies.

The training project involved all employees of AIPO’s technical staff from four different regions: Piemonte, Lombardia, Veneto, and Emilia-Romagna.

Aims and objectives:

The aim of the project was to promote good health and safety practice in public works by three means:

- providing specific examples of safety measures for the maintenance of river embankments through a database illustrating the work process with technical drawings
- providing guidance about how to establish a safety plan as required by Italian safety and health legislation for construction sites by referring amongst others to a database containing examples of technical drawings, which include preventive measures, checklists and guidance on the regulations
- training technicians to become safety coordinators on site

The results achieved

Of great interest to the technicians was the database and its technical drawings showing how preventive measures could be taken on site during maintenance work. Health and safety advice integrated into technical drawings was a new concept for them.

Transferability of the project

The methodology used in the preparation of these tools, their related databases and guidelines, is easily transferable to any business sector and EU Member States wanting to train technicians in this way.

Further information

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Website: <http://www.regione.emilia-romagna.it/amianto/news.htm>



CASE 14: A SOURCE-ORIENTED STRATEGY TO REDUCE WORKPLACE RISKS DURING THE MAINTENANCE OF TRAINS

2.18.

THE NETHERLANDS



Organisation: NedTrain

Introduction

In 2006 the company NedTrain started building a workshop for high-speed trains in the Watergraafsmeer area near Amsterdam. NedTrain specialises in the maintenance, cleaning and overhaul of rolling stock and the servicing of components such as bogies and wheels, engines and entire trains. The company also modernises entire train interiors and installs complicated security systems. In the near future, NedTrain will be in charge of maintenance work for high-speed trains for the Dutch railway, Nederlandse Spoorwegen (NS). As high-speed trains have special maintenance requirements, the workshop has to be custom-built. The maintenance of high-speed trains will be a particular challenge for NedTrain because the logistical planning required will be stringent. All maintenance activities will be scheduled to be carried out over night and must be completed by the following day, so that the trains can immediately re-enter the network. NedTrain's main priorities are to prevent accidents and to guarantee safety for all its employees. Only by doing so can NedTrain operate efficiently and complete maintenance assignments within the given timeframe.

Aims and objectives

NedTrain set out to build the new workshop with the ambition of offering technological innovation and boosted safety levels to its employees. The company needed a maintenance plant able to tackle future challenges and with a high degree of flexibility.

NedTrain's goals for the prevention of industrial accidents can be summarised by the following question: "What kind of source-oriented measures can NedTrain introduce in the design phase – both in the structure of the building and in the maintenance process – to minimise occupational risks and thus prevent disruption of the maintenance process as much as possible?"



Figure 15: The Workshop



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Scope of the project – What was done, and how

The design of the building

The parties involved

Henk Pasveer, project manager of the new workshop, formed a “sounding board group” to assist in the design and construction of the site, made up of various employees from all NedTrain sites across the Netherlands. Their views were a fundamental part of the brainstorming phase for the construction of such a workshop. Employees and management jointly carried out a risk assessment, a crucial step in the design phase, and the employees provided useful advice on the new equipment. They were mainly interested in good posture at work. NedTrain always regards it as important to involve mechanics in the purchase of equipment.

Throughout the entire design phase of the project, the following parties were consulted: the contractors, the suppliers, ProRail (owners of the land), the Amsterdam council, the Environmental Planning service, the works council and finally, the employees. As the new site is located in a residential area, Henk Pasveer also presented the local residents with the development plans.

A flexible building with a view to the future

The new NedTrain workshop is the largest building with a synthetic facade in the Netherlands. NedTrain also opted for a neutral environment inside the building, allowing its occupants to add the touch of colour that the workshop needed.

From design to construction, the process took a total of three years. The workshop is 232 m long, 45 m wide and 9 m high. At the moment the maximum length of a train is 200 m but by making the workshop 32 m longer than necessary it is hoped that the workshop will be able to accommodate trains of the future which may be longer.



The workshop is also very flexible. It can accommodate a workforce of 250. The office walls can be moved and the canteen can be turned into a restaurant providing hot meals. Just outside the workshop there is also space for a passing point and a public train station to be built.

A number of innovations have been introduced in the workshop design to boost employees' safety:

- Avoiding heavy physical labour:
- an Automatic Guide Vehicle (AGV) prevents mechanics lifting heavy loads as much as possible. NedTrain designed this lifting robot which automatically deposits all the necessary maintenance equipment and material, collected from the warehouse during the day, in the right place ready for when mechanics start work at night. Thanks to built-in floor sensors, the loaded pallets carrying the materials are placed on the correct marked rectangles alongside the trains. When work is completed, the AGV takes any waste material back to the warehouse.
- Derailing incoming trains in case of danger:
- Stop-Derail-Blocks (SDBs) are blocks of steel on the rails just outside the workshop. They prevent a train from entering the workshop when another train is being serviced, derailing the incoming train so that it comes to a halt.
- Increasing the safety of work at height and at depth, and preventing electrocution danger – hoisting cranes, platforms and centralised operating systems:
- NedTrain has developed a number of solutions to make works at high altitude and on the wheels safer. More intensive train roof works require stricter safety measures. Consequently, NedTrain found the following solutions. A centralised operating system is placed along each rail which is connected to the SDBs, the door operating panels and the wheel set changing installation – a pit from which the wheels are replaced). This centralised operating system has been awarded the CE label. It requires the employee who needs to work on top of a train to first remove the key from the centralised operating system. This automatically disconnects the electricity-powered overhead wire, activates the SDBs and operates the workshop doors.

Figure 16: Stop-derail-blocks



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The employee then places the key in the hoisting crane, a type of moving platform which creates an enclosed working floor on the roof. The great advantage of this system is that many people can simultaneously work on the same train. In the hoisting crane is a black bag containing a safety belt with which workers can secure themselves at height. Between the rails, there are deep pits from which employees can easily work underneath a train. These pits are equipped with platforms which can be lifted and moved around within the pit.



Figure 17: Hoisting crane



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- Safe route to work – central tunnel:
- Mechanics can safely access their work stations via a tunnel under the workshop and the rails. As they walk through the tunnel they are also immediately in the middle of the workshop and this also boosts efficiency.
- General staff safety: instruction cards and PPE (personal protective equipment): NedTrain ensures that only authorised personnel are granted access to the workshop. Employees are also given instruction cards with detailed safety procedures. The employees must also wear personal protective equipment appropriate for the general environment and for the task they perform.
- More visibility in the workshop – automatic dimmer lighting and LEDs:
- The workshop is very well lit. As a result, the mechanics feel they are always working in daylight, even at night. Thanks to special built-in ceiling lights, sensors and the glass walls, lighting is increased or decreased according to the natural illumination. To optimise performance in the pits, LED lighting was built-in along the rails.
- Guaranteed constant temperature – radiant heat:
- The temperature in the workshop varies from 16°C to 18°C. It is regulated through radiant heat pipes attached to the ceiling. The radiant heat compensates for the cold breeze generated by incoming trains. Several walls are equipped with an adjustable thermostat. Incoming trains always lower the temperature. To minimise this heat loss as much as possible, NedTrain installed draught bags along the workshop doors. They can be inflated around the train to minimise the temperature loss.
- Recognising dangerous objects through colour:
- The building was given very neutral colours – black walls with glass. All hoisting cranes and equipment such as the AGV, travelling gantries and computer tables are brightly coloured. Henk Pasveer abides by the principle that the people, the trains and the equipment add a touch of colour to the environment.
- Shielding noisy spaces – the underfloor wheel lathe and insulation:
- In the workshop there is a room separated from the rest of the site. In this room is the machine needed to dismantle the wheels for profiling, a process necessary for



a train to continue operating at high speeds. As the wheel lathe produces a high level of noise, it is separate from the rest of the workshop and has a soundproof booth with an operating system which makes it possible for the mechanics to operate the wheel lathe at a distance, thus protecting their hearing. The room has been built opposite the workshop to ensure it is as far away as possible from the residential area and its walls are covered with special insulation to minimise reverberations.

- Ventilation of the workshop – domes:
- The ceiling has built-in domes, which can be opened by remote control to ventilate the workshop.
- Expelling odours – built-in outlet pipes:
- Cloths lockers are equipped with a special outlet pipe to expel lingering odours. The showers and the tiling were selected based on the employees' wishes and tastes.
- High voltage risks – emergency shutdown: There are emergency shutdown systems along the rails to shut down the high voltage lines in case of emergency.
- Personal computers: mechanics are still working with a shared computer, which provides an overview of the tasks to be performed but in the future every employee will be given a personal portable computer with a phone to enable wireless communication via the wireless network in the workshop.
- Private high voltage substation: the workshop has its own substation to generate power. The power from the overhead wire can be increased from 1.5 kV to 25 kV. This is necessary because national and international trains require a different voltage. Rail 4 has a shiftable overhead wire to avoid electrocution.

NedTrain's prevention policy

All employees and managers are obliged to attend the yearly training on occupational health and safety topics, such as prevention of industrial accidents or safe handling of materials. There is one prevention advisor at the new workshop.

Assessment of the effectiveness of the health and safety measures used at the new workplace is not yet possible because no statistics are available for the number of occupational accidents at the new workshop.

Success factors – What was achieved?

Thanks to the design of the new workshop, all types of trains can be serviced in it. The building can accommodate more workspaces and more staff. The workshop is flexible and can be adjusted according to needs of the company and technological innovations. Consequently, NedTrain can expand its customer base and guarantee its own future.

The equipment in the workshop was designed to improve employees' safety and health. NedTrain sought inspiration in other European countries and subsequently designed a model adapted to its mechanics' needs. Henk Pasveer refers to this principle as applied innovation.

During the entire process, various parties, such as internal and external OSH experts, managers and employees, were involved. The workshop was created through joint brainstorming of all these parties, particularly the employees.

NedTrain is a universal maintenance company. NedTrain takes into consideration innovation in safety and technology. By increasing its employees' safety, the company will reduce the number of occupational accidents, thus increasing NedTrain's productivity and efficiency.



Figure 18: Rails with LEDs



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Costs

The new workshop in the Watergraafsmeer area near Amsterdam cost € 47 million, of which not more than € 3 million were spent on safety and preventive measures for the maintenance staff (rough estimate).

Results and evaluation of the project – Room for improvement

In general everyone is very satisfied with the new workshop and the implemented safety measures. Mistakes are still made because mechanics are being required to work with new equipment and new customers in a new environment. However sufficient thought has gone into safety equipment for the employees although it is still too early to assess

these innovations because the workshop is not yet operating at full capacity, and the HiSpeed trains have not yet been included in the maintenance process.

Transferability

NedTrain is a universal maintenance company. The workshop – with its flexible interior – is suitable for the maintenance of all future types of trains. This is where the foundation is laid for new concepts and techniques, through which NedTrain hopes to inspire other maintenance companies.

The guiding principles behind the design of this workshop can be utilised by any company from all sectors in any country.

Further information

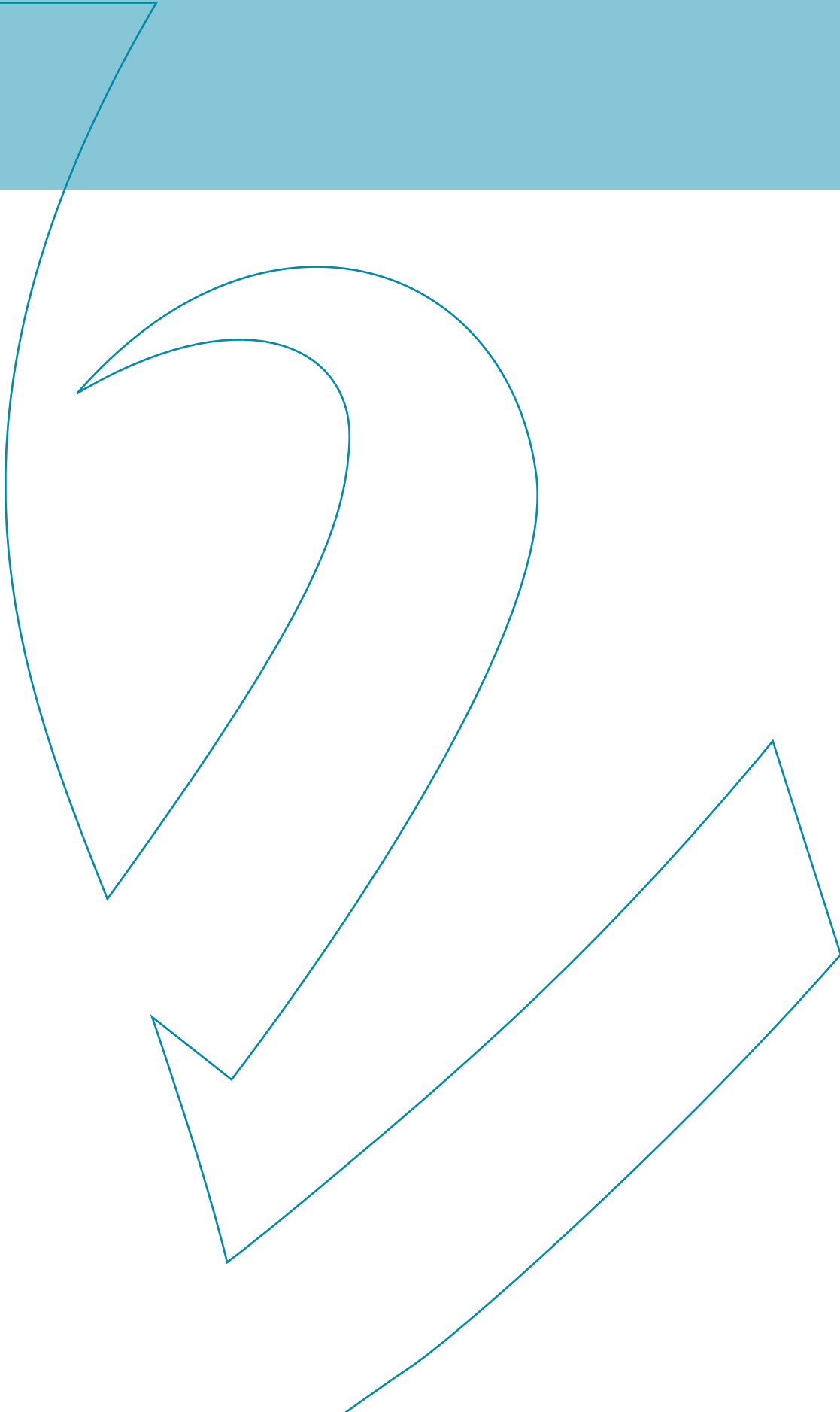
Contact details

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1. *“Bevorderen van bronmaatregelen voor arbeidsrisico’s in de praktijk. Een praktische aanpak om structurele verbeteringen van arbeidsomstandigheden op de werkvloer te realiseren”, TNO – Knowledge for Business 2007.*
2. Fieldvisit Prevent Brussels to NedTrain in Amsterdam, interviews with project manager and architect of new workshop.

3.

CONCLUSIONS



3.1. LESSONS LEARNED FROM GOOD PRACTICE

Buildings and structures that are not maintained regularly eventually become unsafe not only for the people who work in them, but also for those who enter them and even pass by them. Machinery that is poorly maintained or not maintained regularly may make working conditions unsafe for operators and create risks for other workers, and may even cause business losses. While maintenance is absolutely essential to ensure safe and healthy working conditions and prevent harm, the maintenance work itself involves exposure to several hazards for the maintenance worker.

It is the responsibility of each employer to protect their workers against possible work-related hazards. This report has shown that many European employers and employees, insurers and authorities have developed a number of new and innovative approaches to the tackling of hazards associated with maintenance work. In the following chapters we want to have a closer look at the reasons why their interventions were successful. The factors crucial for the successful prevention of risks during maintenance work will be identified.

3.2. GOOD SAFETY AND HEALTH MANAGEMENT IS AT THE HEART OF SAFE AND RELIABLE MAINTENANCE

Several examples presented in this report show that careful planning of preventive maintenance is a crucial element to minimize the risks for the maintenance workers themselves, for other workers and for the public. Several companies have set up management systems to ensure in-depth planning and coordination of work, assessing risks for maintenance tasks, effective communication between production and maintenance staff, ensuring training and checking the competence of all involved, putting in place safe systems of work, and the effective scheduling of maintenance to minimise downtime while ensuring that sufficient time and resources are available for the activity. Often the general management systems include OSH procedures as well as quality assurance procedures.

Romec, an organisation in the UK offering maintenance services, has developed a comprehensive health and safety management system that complies with the British Occupational Health and Safety Assessment Series, (OHSAS) 18001 Standard. This system contains safety procedures, safe systems of work and around 400 generic risk assessments covering all products and routine tasks within the business. To support the procedures, behavioural safety initiatives have been set up for the staff by the management. The risk assessments are linked to safe systems of work descriptions. The system undergoes continuous development, improvement and evaluation.

The University of Rome, the national Italian Committee for Maintenance and the Italian Institute for Occupational Health and Prevention has developed a remote-controlled maintenance system for the management of technical plants. This system makes it possible to detect malfunctions and the lowering of safety standards and send alerts to the operator. This type of control system is very useful when several



plant items are distributed across a large area and maintenance is outsourced to specialised companies.

The British Printing Industries Federation promotes good maintenance practice in order to increase safety, productivity and profits. This project demonstrates some factors that are a key part of successful maintenance practice:

- Employees from all parts of the organisation should be involved, from senior management to maintenance workers.
- A top-down decision is needed to improve productivity, and maintenance is integral component of productivity
- It is essential to integrate maintenance into a manufacturing strategy as a key element of productivity, and to make sure that all staff is aware of the role of maintenance in improving the company's performance.
- Employees need to be motivated and trained and should have the appropriate skills and attitudes.

Electrabel in Belgium has developed a management system for major overhauls of the power plant. The plan consists of three steps and safety is an important issue throughout the whole process. The communication structure creates enough time for all parties involved to exchange the information needed to perform the maintenance task efficiently and safely. Overhauls always conclude with a follow-up meeting so that the experience can be used as the basis for estimations for overhauls in the future. The plan also includes a few safety nets that minimise the risk of dangerous situations during maintenance work.

Setting up of an OSH management system that includes maintenance has clearly proved to be a successful approach to safe maintenance. A management system of this kind ensures the comprehensive organisation of all key elements such as communication, training, risk assessment, safe systems of work and continuous improvement.

RISK ASSESSMENT OF MAINTENANCE TASKS

3.3.

Assessment of risk for maintenance operations is an especially difficult task because of the various uncertainties of such work processes, such as being called unexpectedly to repair broken down machines or discovering unforeseen causes of a machine breakdown. A number of companies have developed special tools to deal with these challenges. One of these cases (Renault) demonstrates how the maintenance workers themselves were involved in the process of the risk assessment through specially-constructed interviews, how these results were carefully evaluated and how the proposed preventive measures were validated. Although it is always good practice to involve the employees in the process of risk assessment, this case clearly demonstrates that for maintenance operations it is all the more necessary to involve in the process those who will carry out the work. Without their input, it is difficult to identify all hazards, analyse all the various aspects of the work and situations that might arise, and to decide on the most effective and suitable methods to control the risk involved.



Risk assessment is also an important part of the management plan for overhauls at Electrabel. In the preparation phase of the overhaul, risk assessments are done for each task. During the execution phase, each worker receives a work permit sheet including a form which requires them to carry out a last-minute risk analysis before starting the maintenance work, and is done in addition to the in-depth assessment. Again, maintenance workers are involved in the risk assessment process but in addition they have to perform a second risk analysis themselves.

At BASF in Germany, the consignment notes (“Begleitscheine”) system was introduced for maintenance works. The consignment note gives an overview of the results of the risk assessment for a particular job and summarises the special risks that might be involved. It specifically states which dangerous substance – and how much of it – might be in the installation, and how it should be dealt with if any residues remain. The consignment note has to accompany components and pipes at all times, from the moment they are taken from their mountings to be taken to the workshop until they are re-mounted.

3.4. PREVENTION THROUGH DESIGN – ELIMINATING HAZARDS AT THE DESIGN STAGE

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 (machinery and equipment).

The report contains several examples of considering maintenance during the design phase.

In the example presented by the Polish National Research Institute (CIOP-PIB), a reeling machine was fitted with a stop mechanism that included an automatic hazard detection system in order to prevent any unexpected start-up of the machine during maintenance work. Considering future maintenance issues while the machine was being designed helped eliminate a hazard and minimise the potential of injury while the machine was being serviced or repaired.

Safety and health hazards are often created by poor workplace design. A special case of considering maintenance during the design phase is presented in two other examples – the design of workplaces where the maintenance of airplanes and of trains takes place.

Both examples emphasise that the workers who will have to do the maintenance jobs should participate in designing workshops to ensure not only improved health and safety but also the smooth running of the maintenance work. In one of the cases (Air France) staff were even able to use a virtual model to allow them scrutinize, move around in and assess their future work area before it was built.

Including analysis of specific requirements of tasks that would be performed in the building prevents a number of hazards from being “built in” to new workshops, eliminating, for example, some of the ergonomic risk factors involved by making sure that sufficient space is allotted to specific tasks. Other issues that can be considered at this stage are guaranteeing safe access to work areas, or separating particularly noisy procedures from the general workshop of to limit workers’ exposure to noise.



REPLACING HAZARDOUS SUBSTANCES TO ELIMINATE OR MINIMISE HAZARDS

3.5.

The Danish CatSub organisation has established a publicly-accessible “substitution catalogue” itemising many of the hazardous substances used often in maintenance tasks. The catalogue, which can be searched by free text input or industry category, identifies hazard-free or less hazardous replacements for many of these substances.

Each example of a substitution is documented in detail and includes contact details of the contributor who can be approached for more information. These substitutes have usually been identified through a long process of trial and error by company technicians and workers who have actually used them, often for some years, before being included in the data base, suggesting that the examples are cost-effective too.

Substitution of hazardous substances with hazard-free or less hazardous substances is a legal requirement but compliance can be difficult, often because of technical requirements of the processes. CatSub provides an urgently-needed platform for the exchange of information based on real-world experience and experimentation, so that companies can make choices based on reliable evidence and, in return, contribute their own examples of effective substitutes.

TRAINING AND INFORMATION AS SUPPORTIVE MEASURES

3.6.

Attending to the design of buildings and machines, setting up a safety management systems and developing a risk assessment procedure for maintenance work provides a sound basis for safe maintenance, but employers should also make sure that maintenance workers possess the appropriate knowledge and skills to perform their work safely. Some cases presented in this report discuss this issue.

A key part of the general maintenance concept for the underwater tunnel across the Oresund from Denmark to Sweden is that all workers in charge of maintenance tasks must attend safety courses before they are allowed to work at the site. These courses cover detailed planning of all jobs, including safety issues. All safety procedures and instructions are made available to workers either via the Internet or in safety booklets.

There are frequent audits and checks on the spot to verify that the rules discussed and learned during the training are followed. Moreover the courses are adapted as jobs change. A major factor in the success of the initiative, in the view of the consortium, is the cooperation between the health and safety coordinator, the staff and the contractors’ maintenance personnel.

An Italian organisation, NuovaQuasco, created a manual and a CD-rom to assist maintenance workers carrying out work which may involve asbestos by providing information on the topic and presenting safe working procedures. The manual and CD-rom present information on the risks, the possible consequences of exposure



and examples of preventive measures that have to be taken when there is a risk of exposure to asbestos.

The same organization also developed a training program for the maintenance of waterways which aims to raise awareness of safe behaviour and to educate workers about the prevention of accidents. This particular project was aimed at the designers, management and work safety coordinators of the interregional agency for the river Po.

The umbrella organisation of the German accident insurers DGUV published BG Information 5100, a publication which contains detailed information on how to prevent risks while servicing hydraulic systems, and developed an associated training course.

An expert panel from the insurance organisation evaluated the impact of the publication and course, and concluded that awareness of safe procedures in this field has been raised and more attention has been paid to preventative maintenance on hydraulic parts and systems. The panel also analysed the evidence gathered so far and have included further improved safety instructions in the BGI 5100.

Familiarity with hazards and awareness of their potential consequences, coupled with information about the methods available to eliminate or reduce them, leads to improved compliance with safety rules and the reduction of the numbers of accidents and work-related illnesses. At the same time it is important that workers performing sometimes highly-complex maintenance tasks are competent, and that their professional skills are appropriate for the job and are kept up-to-date with new developments in technology.

3.7.

TACKLING THE STRESS FACTORS AFFECTING MAINTENANCE WORK

Recognising that one of the important risk factors in maintenance is stress, BG MET, one of the German accident insurers for the metal sector, organised a workshop about this topic. Participating were the employees and managers of companies doing maintenance work.

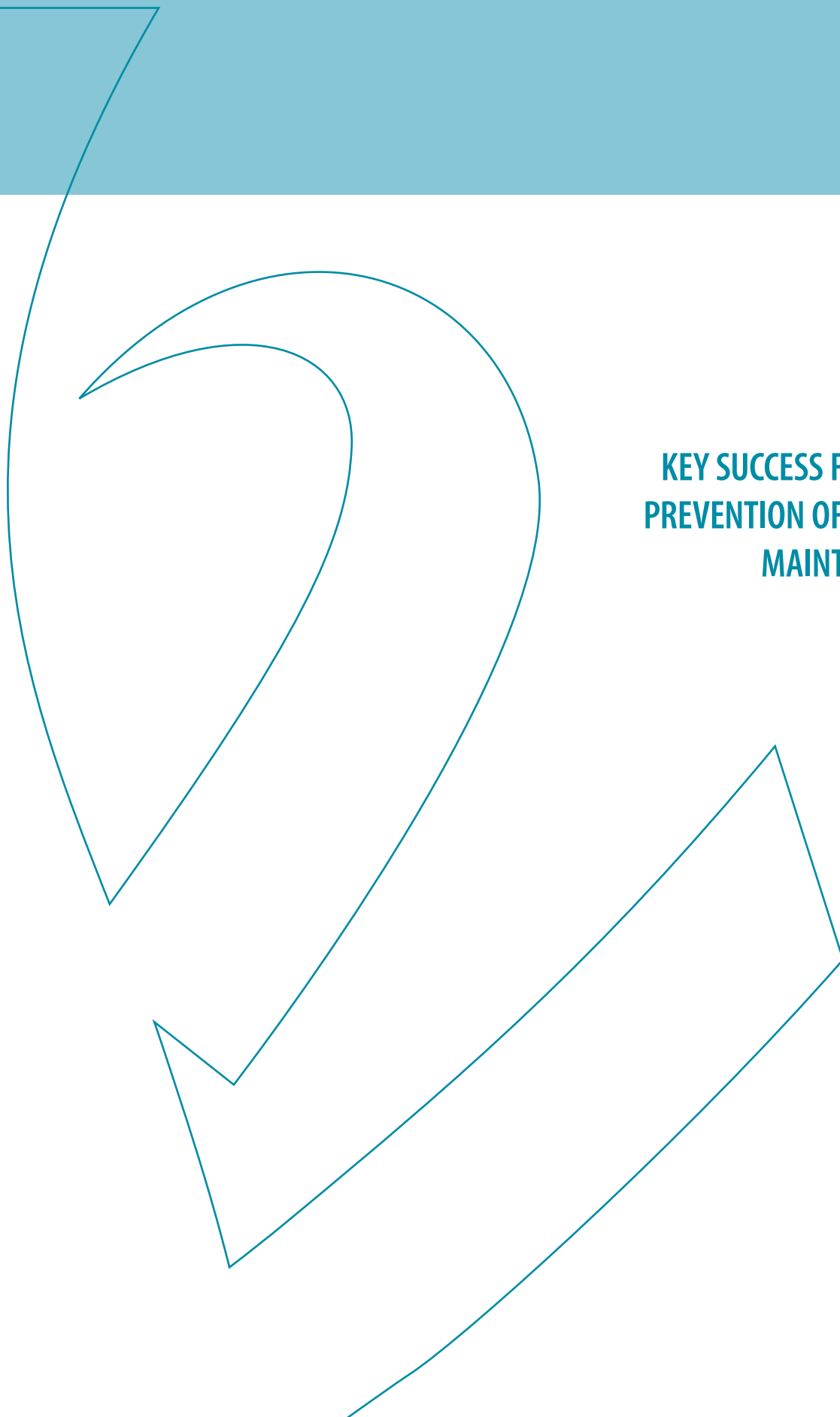
It was established that workers charged with maintenance tasks are very likely to be exposed to stress. The risk factors include time pressure, reduced staffing levels due to retrenchments, lack of preventive maintenance, machines and systems with poor maintainability, lack of specific know-how among external service providers (outsourcing) and insufficient communication between workers and management.

Managers participating in the workshop have gained a better awareness of the issues affecting maintenance workers' stress level. This has resulted in a mutual understanding and better communication between managers and workers and initiated new approaches not only to the reduction of stress-inducing factors but also to the reduction of other occupational risks.



4.

KEY SUCCESS FACTORS IN THE PREVENTION OF RISKS DURING MAINTENANCE WORK



When analysing the case studies, key success factors – the reasons why an intervention results in a lasting, sustainable improvement – can be identified.

Management support and safety culture in the organisation

For every initiative that taken to improve safety and health during maintenance work, it is essential to have the commitment and support of the management.

They have to demonstrate their commitment by action and attitude, e.g. by the allocation of resources to safety and health initiatives and by the status given to safety and health versus costs and production. In this area, they should be leading by example. The management takes final decisions, so it is important that they are convinced of the importance of health and safety initiatives and appreciate the business advantages that these may bring. Where maintenance work is done by contractors, for instance, safety and health requirements should be included in the contract specifications and be one of the performance assessment criteria.

Involvement and participation of the employees

It is important to involve workers in the maintenance management during the whole process, from planning to the final evaluation. Active employee participation in S&H management is important to build ownership of safety at all levels and exploit the unique knowledge that employees have of their own work. Quite often they already know and can suggest practical ways of eliminating or mitigating the risks.

In addition, involving employees is an important way of gaining their acceptance of changes and encouraging compliance with the rules.

A well-conducted risk assessment

Before starting any maintenance work, a risk assessment should be carried out. Workers should be involved in the initial risk assessment. They may also need to conduct further assessments during the task. Participation in the first assessment and guidelines about how to conduct a risk assessment during the planning stage would allow workers to gain a better understanding of the process and conduct their own additional assessment of the risks involved.

Preventive measures according to the prevention hierarchy

Preventive measures can be identified and implemented based on the results of the risk assessment. It is important to apply the prevention hierarchy (elimination – substitution – engineering – administrative controls – use of personal protective equipment) at all times. When hazards cannot be completely eliminated, risks should be minimised by other measures. These may include engineering controls, such as enclosing the process, local exhaust and safety guards, and safe systems of work including lock-out procedures and work-permits.

Training and information are of crucial importance – they provide the employee with the knowledge needed to perform the maintenance task safely.



Combination of preventive measures

Safety measures are more successful when used in combination. For example, conducting risk assessments, implementation of safety procedures and safe systems of work should all be backed up with behavioural safety initiatives, training and information so that safety becomes second nature. Examples of such initiatives include participation of workers in all stages of risk assessment and planning of the activity, and workshops to raise awareness of specific hazards.

Safe work procedures and clear guidelines for maintenance work

A well defined workflow for each maintenance task needs to be prepared and it has to be made sure that the results of risk assessment and safe work procedures are clearly communicated and understood. Procedures need to be in place for unexpected events. These procedures might, for example, prescribe the need for a new risk assessment before work restarts, or consulting with another worker or a supervisor. Part of the safe system of work should be to stop work when faced with an unforeseen problem or a problem exceeding one's own competence.

Effective and continuous communication

All relevant information related to the maintenance work which is necessary to perform a task safely and correctly should be shared between all parties concerned. This includes not only the workers and contractors directly involved in the maintenance task, but also those likely to be affected by it or who may be working in the immediate vicinity. Important information includes the results of the risk assessment, safe work procedures, details of any necessary protective equipment, how to report problems, and how to report completion of the task/s. The extent and means of communication should be decided on during the planning stage of maintenance work.

Continuous improvement/development/learning from others

Safety and health performance during maintenance operations should be continuously evaluated and improved based on audits and inspections, the results of risk assessment, incident, accident and near-miss investigations and the feedback from employees, contractors and OSH personnel.

Safety courses to inform and make aware

Workers performing maintenance tasks, including contractors, should be competent in their professional areas of responsibility. In addition to the necessary professional skills, they should receive a safety & health training, and be informed about the hazards related to specific jobs and about the safe working procedures. There is a legal obligation for employers to provide information and training on health and safety to all employees who need it, including temporary staff and contractors.

This can be done by providing manuals and guidelines, but also by providing safety courses. During these courses maintenance workers can be trained in recognising risks



and the use of suitable preventive measures. It is important to make the occupational safety and health requirements of every task easy to understand.

A common understanding of hazards and safety precautions shared by management, workers and contractors, coupled with safe work practices, is part of the safety culture of the organisation.

Maintenance included in the comprehensive health and safety management system

Maintenance tasks and their health and safety aspects should be an integral part of a company's comprehensive health and safety management system, including all the elements mentioned above. Such a system is characterised by continuous development and improvement. When new hazards or work practices are introduced, new risk assessments should be carried out.

The system allows for efficient planning, performance, check and improvement of both preventative and corrective maintenance tasks. It defines safety procedures, work procedures for different types of maintenance tasks, communication structures and risk assessment procedures.



5.

**REDUCING THE RISKS:
SOME PRACTICAL
RECOMMENDATIONS**



In the previous chapter the factors that determine the lasting success of the initiatives described in this report have been presented. By taking all these factors into account, any maintenance project will have a greater chance of being completed safely and successfully.

Some specific, practical recommendations for dealing with different types of hazards are presented in this chapter. The recommendations are based on the case studies discussed in the report. This is not an exhaustive list and many other measures are possible.

It has to be remembered that the first step is always to carry out a risk assessment. Based on the results, preventive measures and/or recommendations can be identified and implemented. Workers and contractors should be involved in the identification and analysis of risks and the development and implementation of preventive measures.

There is a legal obligation for employers to provide information and training on health and safety to all employees who need it, including temporary staff and contractors.

As outlined in the previous chapter workers performing maintenance work, both employees and contractors, should not only be skilled and competent for the tasks they have to carry out, but should also receive all the information and training necessary to perform their work safely. Care should be taken that the scope of the tasks does not exceed the skills and competence of the workers and/or contractors performing them.

Hazard/situation	Recommendation
Exposure to chemical substances during maintenance of pipes, machines, etc	<ul style="list-style-type: none"> ■ Substitute the dangerous substance used in the process by a hazard-free or less dangerous one. The CatSub website provides information on possible substitutions. ■ Setting up safe systems of work ■ Emptying and flushing storage tanks or pipes, setting blind discs during dismantling. ■ Use of appropriate protective equipment during maintenance work.
Working with (sub) contractors	<ul style="list-style-type: none"> ■ Develop an appropriate and effective communication structure covering all parties concerned ■ Make sure that the job order or contract contains information on the potential hazards, the measures that have been taken to eliminate or limit them, those precautions that still need to be taken, and safe behaviour ■ Inform the contractor's maintenance worker/s about in-house safety procedures, as well as any risks related to the task and preventive measures that have been taken. This should be part of general induction procedure. ■ Inform employees about the presence of contractors and the tasks they are performing.
Unexpected start-up of machines	<ul style="list-style-type: none"> ■ Purchase, design or manufacture only machines that are easy and safe to maintain. Make sure that machines have a stop mechanism or isolation switch so that it is impossible for the machine to start while maintenance work is underway.



Hazard/situation	Recommendation
	<ul style="list-style-type: none"> ■ Develop and apply safe systems of work including permits to work, lock-off procedures. ■ Make sure that safe systems of work are communicated and understood by the workers when maintenance work is being done, all machines are tagged if they that must not be used or switched while work is underway. This requirement should be communicated not only to workers performing maintenance tasks but also to all other employees in the area. It should be included in the safety training.
Lack of knowledge and awareness of safety issues among workers performing maintenance work	<ul style="list-style-type: none"> ■ There is a legal obligation for employers to provide information and training on health and safety to all employees who need it, including temporary staff and contractors. ■ In addition to the necessary professional skills, workers should receive a safety and health training, and be informed about the hazards related to specific jobs and about the safe working procedures. ■ Workers should be involved in the risk assessment and the development of preventive measures. ■ They should be trained to perform maintenance tasks safely.
Physical strain	<ul style="list-style-type: none"> ■ Design or purchase equipment and introduce work practices that eliminate or reduce physical strain. ■ Provide maintenance workers who have to lift or move heavy loads with a hoist, or with other lifting or transporting equipment ■ Minimise carrying distances. ■ Ensure that there is enough space to do the work ■ Provide training on how to perform maintenance work ergonomically
Working at height or climbing structures	<ul style="list-style-type: none"> ■ Consider maintenance in the design stage ■ Ensure that, where appropriate, an edge protection system is in place. ■ Make sure that workers climbing and working at height are secured and protected against falls at all times. ■ Investigate whether it is possible to use a mechanical lifting device to eliminate the need to climb, such as a “cherry picker” or an elevating work platform, or whether there is a system that can be introduced to minimise the risks during the climbing phase – the HighStep-System introduced in this report is one such system. ■ Make workers aware of the danger and make sure they understand the importance of the protective equipment they have to wear, that they know how to use it properly and that it is maintained and replaced as required. ■ Include in the training information details of any health problems that may affect a worker’s ability to work safely at height, and the reporting protocol.



Hazard/situation	Recommendation
Exposure to asbestos	<ul style="list-style-type: none"><li data-bbox="770 275 1388 331">■ Always ensure that all are aware of the presence of asbestos so that the necessary measures can be taken.<li data-bbox="770 338 1388 421">■ Make sure workers performing maintenance tasks are aware of the risks and know how to protect themselves and others.<li data-bbox="770 427 1388 519">■ Develop and apply safe work practices and communicate them to workers; provide appropriate tools and protective equipment.



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In order to improve the working environment, as regards the protection of the safety and health of workers as provided for in the Treaty and successive Community strategies and action programmes concerning health and safety at the workplace, the aim of the Agency shall be to provide the Community bodies, the Member States, the social partners and those involved in the field with the technical, scientific and economic information of use in the field of safety and health at work.

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