

MAGAZINE

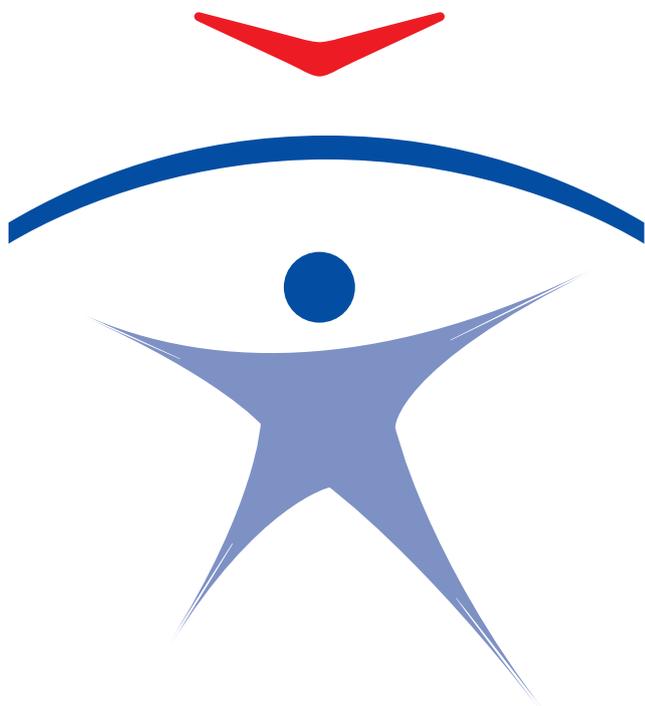


HEALTHY WORKPLACES
A European Campaign
on Safe Maintenance

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Foreword

The theme of the European Agency for Safety and Health at Work's (EU-OSHA) Healthy Workplaces Campaign 2010-11 is 'safe maintenance'. Why was this theme chosen for the campaign?

The Community strategy 2007-12 on health and safety at work sets the ambitious goal of achieving, by 2012, a 25 % reduction in the rate of accidents at work and calls upon the EU-OSHA to focus its efforts to raise awareness and promote and disseminate best practice to a greater degree on high-risk sectors and SMEs.

Maintenance is not a sector, but it is a high-risk activity carried out in all sectors and all workplaces. The figures and major accidents show that 10 to 15 % of all fatal accidents at work and 15 to 20 % of all accidents are connected with maintenance.

Maintenance is critical to ensure continuous productivity, to generate goods and services of high quality and to keep companies competitive; but regular maintenance is also essential to keep equipment, machines and the work environment safe and reliable. Lack of maintenance or inadequate maintenance can lead to dangerous situations, accidents and health problems, or even major disasters. There are plenty of examples of what can happen if maintenance is neglected or not carried out appropriately.

Maintenance has to be done, but it has to be done in a safe way. The figures on maintenance-related accidents and exposures show that there is room for improvement.

To support the Healthy Workplaces Campaign on Safe Maintenance, EU-OSHA produced a wide range of material for all those involved in maintenance. This information, a large part of it in 24 languages, is provided free of charge (<http://osha.europa.eu/en/topics/maintenance>).



This magazine brings together articles to give a wide perspective on the safety and health aspects of maintenance. The articles demonstrate the wide range of maintenance-related issues that have an impact on maintenance safety and more generally on safety and health at work. These include, among others, maintenance organisation, maintenance planning, risk assessment, human behaviour, chemical safety, design, subcontracting maintenance, communication and training, and inspection of personal protective equipment.

We hope that the magazine will provide useful information to facilitate managing safety and health risks associated with maintenance.

Christa Sedlatschek
Director, European Agency for Safety and Health at Work

For more information on the Safe Maintenance Campaign see:
<http://osha.europa.eu/en/campaigns/hw2010/>

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1.	Improving understanding of maintenance organisation to ensure safe maintenance activities in companies	France	French National Institute for Research and Safety (INRS)	Maintenance organisation Root causes of accidents Outsourcing
2.	Safety in maintenance: errors and human factors	Italy	Italian National Committee for Maintenance (CNIM) University of Rome 'La Sapienza', Italian National Committee for Maintenance (CNIM)	Maintenance safety Human factors
3.	Incidents in maintenance: their link to the tasks, special characteristics and proposed measures	Greece	Hellenic Maintenance Society	Maintenance Incident causes Inherent risks
4.	A well thought-out maintenance programme increases safety	The Netherlands	Dutch Maintenance Society (NVDO)	Maintenance programme Safety critical elements
5.	Excellence in risk assessment and well-being at work	Finland	Ministry of Social Affairs and Health	Maintenance Well-being at work Risk assessment
6.	Chemical safety during plant shut-downs	Finland	Technical Research Centre (VTT)	Maintenance Chemical safety Shut-downs
7.	Occupational risk prevention in a context of subcontracted maintenance	France	French National Institute for Research and Safety (INRS)	Maintenance Subcontracting Risk assessment Prevention plan
8.	Measures to improve cooperation between operators and maintenance staff	Germany	Federal Institute for Occupational Safety and Health (BAuA)	Maintenance Cooperation between operators and maintenance staff
9.	Audiovisual Catalogue of Critical Situations: a powerful training tool	Spain	Spanish pulp and paper industry	Maintenance Hazardous operations Training
10.	Integrating maintenance into design: the machinery directive sets goals	France	French National Institute for Research and Safety (INRS)	Maintenance Machinery design Isolation Machinery directive
11.	A maintenance site designed for safety	Belgium	STIB J. Brel depot	Maintenance safety Prevention through design
12.	On the way to safe maintenance	Belgium	Belgian Maintenance Association VZW (BEMAS)	Maintenance safety Reactive maintenance Preventive maintenance
13.	MFA survey on the topic: employment safety for maintenance workers in Austria	Austria	MFA	Maintenance safety Planning Procurement
14.	Guidelines for inspecting the physical condition of industrial safety helmets	Poland	CIOP-PIB	Inspection Safety helmets

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1. Improving understanding of maintenance organisation to ensure safe maintenance activities in companies

Introduction

Maintenance activities are identified as critical to operators of health and safety. Maintenance is associated with 10 to 15 % of fatal occupational accidents, and 15 to 20 % of all accidents, according to the European Agency for Safety and Health at Work (2010). Moreover, maintenance operators are more specifically exposed to a wide variety of hazards with potential consequences to their health, and these may lead to multiple occupational diseases.

As emphasised by Reason and Hobbs (2003), maintenance activities receive little attention and few prevention studies are effectively dedicated to these activities (Ray & Batson, 2000). In general, it is still difficult to know the number of maintenance workers and to identify them in occupational accident and disease surveys and statistics. Moreover, most relevant studies have focused on hazards (such as physical, biological and chemical) relating to maintenance environment and the equipment used, or on hazards relating to isolation and energy dissipation and restarting. Few studies have been aimed at investigating the relationships between maintenance organisation and safety. The French National Institute for Research and Safety (INRS) therefore proposes not only an engineering, but also an organisational approach to this issue.

Importance of maintenance organisation

The proposed organisational approach to maintenance is based on both the Reason and Hobbs model of organisational accidents (2003) and on the maintenance management model proposed by Hale et al. (1998). These approaches consider that risks have root causes in maintenance work organisation and in the system at large (Figure 1). Origins of unsafe events can thus be traced back to latent conditions within 'normal' maintenance work achievement, and maintenance work organisation and policy. This approach can be implemented in a variety of hazardous technologies to guide accident investigations and monitor prevention measures (Reason & Hobbs, 2003).

This type of model has, for example, been used to explain the Piper Alpha explosion (Reason & Hobbs, 2003). This disaster,

in which 167 workers were killed, was caused by a leak from the main oil line to the shore. A pump was tripped, while a pressure safety valve had been removed from the relief line of that pump. An investigation of the root causes of this disaster, based on this type of organisational approach, showed that there were latent malfunction conditions in the permit to work, the shift handover and the operator coordination systems, and these were aggravated by high workload- and time-related pressures.

An accident sequence may therefore begin at maintenance policy level. The latent malfunction conditions created are subsequently transferred along organisational paths to the real maintenance achievement conditions.

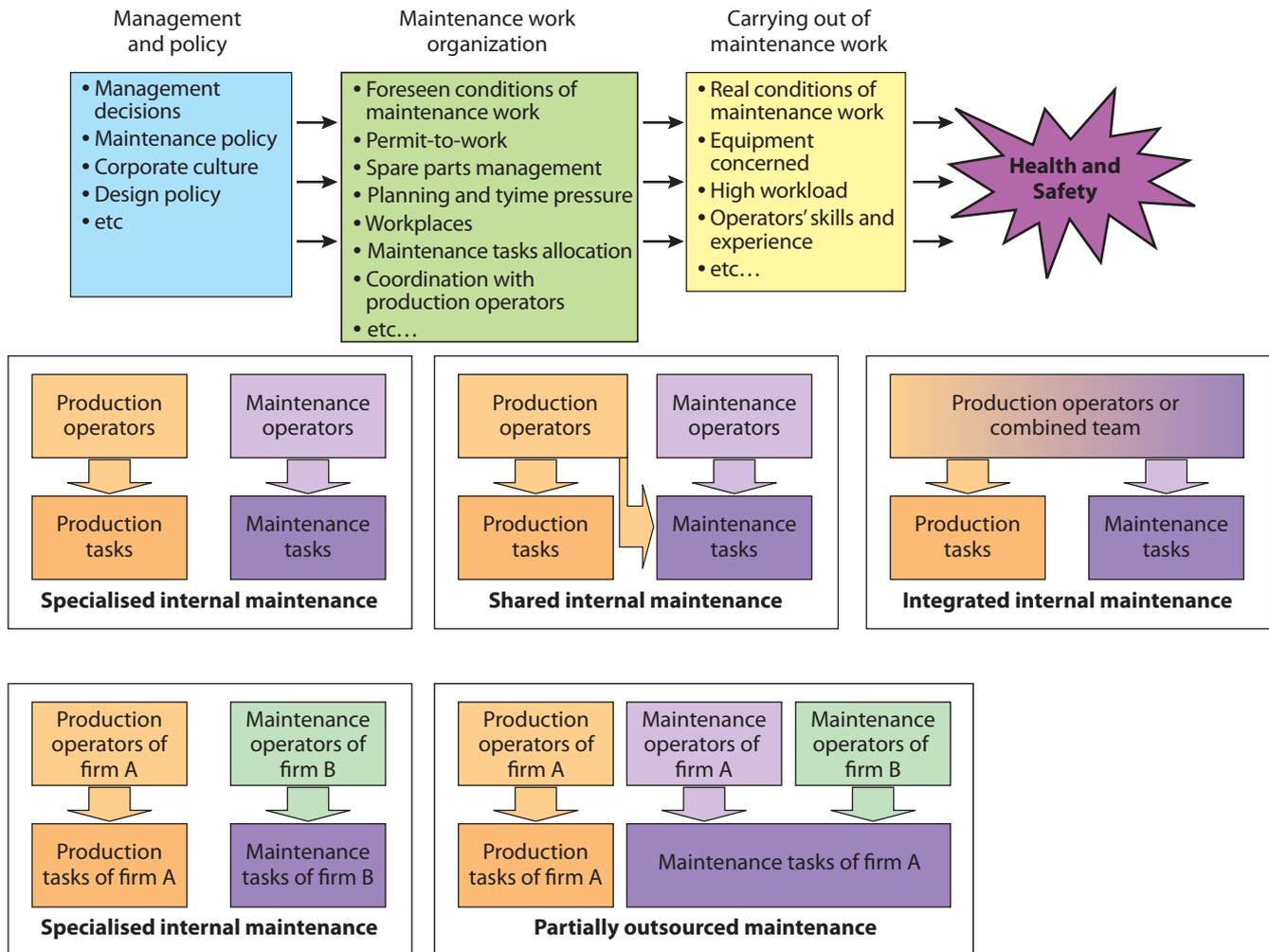
In this organisational approach, we consider that maintenance activities are critical to the health and safety of maintenance personnel because of their environmental, technical, organisational and time-related context. Moreover, this approach takes into account different context-related dimensions, so it allows us to consider that maintenance activities may also be critical to other workers, in particular, equipment users or production operators (Grusenmeyer, 2005). As Figure 2 reveals:

- maintenance and production functions have the same object, for instance equipment or installations;
- immediate aims may be different (function to produce, shut-down to maintain), but contribute to a common goal;
- these two functions are mutually dependent: on the one hand, optimum equipment maintenance (up state of the latter) contributes to optimum production; on the other hand, equipment operation modifies the characteristics of the latter and they therefore determine the maintenance activities to be performed.

These relationships between the maintenance and production functions explain why:

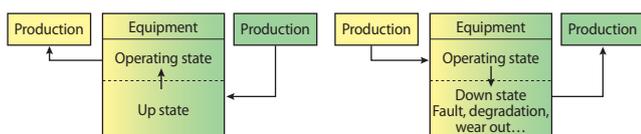
- some accidents may be related to maintenance failings, such as insufficient, inappropriate or late maintenance. The equipment or installation may become dangerous for maintenance and production personnel if maintenance is not carried out sufficiently often (Male, 1998);

Figure 1: Organisational approach to maintenance



- other accidents may also be related to equipment operation. For example remote operation equipment may contribute to putting maintenance personnel into dangerous situations (equipment not in optimum condition);
- finally, accidents may result from coactivity of production and maintenance operators (for example repair work during equipment operation).

Figure 2: Functional relationships between maintenance and production



Maintenance organisation developments

In addition to the functional relationships between maintenance and production, this type of approach enables us to consider the organisational relationships between all personnel involved in maintaining the relevant equipment. Account-

ing for maintenance organisation is all the more essential since there has been considerable development in this area in recent years. In particular, developments in maintenance tasks allocation have been significant, on the one hand, within companies and, on the other hand, beyond companies (for instance outsourcing and subcontracting).

Traditionally, allocation of maintenance tasks within companies has been specialised (Figure 3). In other words, maintenance tasks used only to be carried out by internal maintenance personnel, which might have been multidisciplinary or specialised (for instance electricians, mechanics and electronics technicians). Nowadays, maintenance tasks allocation may be:

- shared: carried out by both maintenance staff and production staff; or
- integrated: performed by production staff or by a combined team of maintenance and production operators (see Figure 3).

Moreover, maintenance tasks may be totally or partially outsourced or subcontracted. In this case they are carried out at least partly by operators external to the company that owns the equipment (Figure 4).

Figure 3: Maintenance tasks allocation within a company

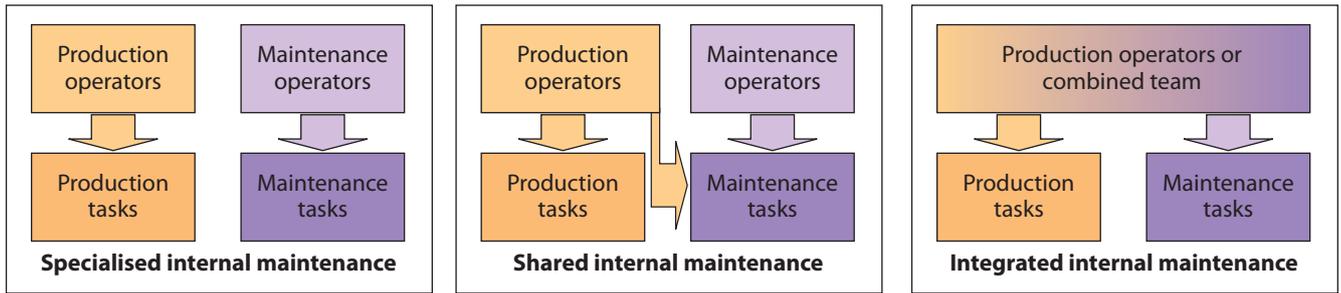
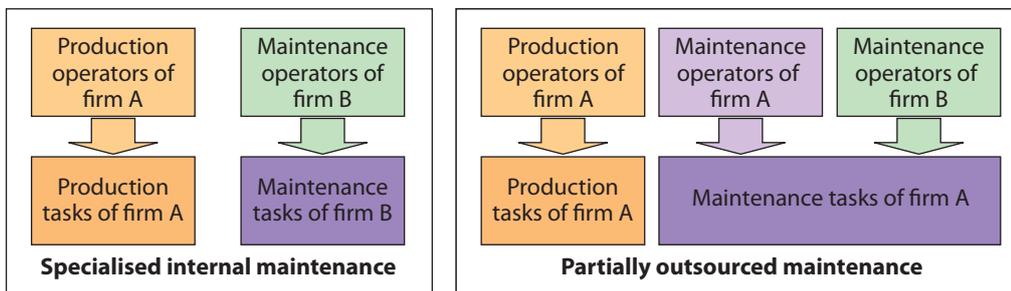


Figure 4: Maintenance tasks allocation beyond the company



Thus, in France, maintenance is one of the most commonly outsourced functions in industry. According to the SESSI (French Industrial Research and Statistics Authority, 2008), only 2 % of industrial companies with at least 20 employees carried out maintenance themselves, and 96 % of these companies outsourced maintenance tasks at least partly in 2005 (Table 1).

Table 1: Distribution of French industrial companies with at least 20 employees according to their purchases of maintenance and general services (SESSI, 2008)

50 %	Purchases of maintenance and general services and internal maintenance and general services
44 %	Only external (outsourced) maintenance and general services
4 %	No maintenance and general services at all
2 %	Only internal maintenance as well as general services

Consequences of maintenance organisation developments on health and safety

These developments in maintenance organisation have consequences on operator health and safety.

Modified boundaries between maintenance and production occupations (such as a shared internal maintenance organisation) may, for example (Grusenmeyer, 2002):

- increase coactivity situations or the risks associated with combining tasks achieved by different operators;

- increase the production operator workload if operation shut-downs are not scheduled for performing routine maintenance tasks;
- lead to confusions in maintenance tasks to be carried out by production operators (for example temporary repairs instead of cleaning the equipment) if these organisational modifications are not supported by the company.

Outsourcing of maintenance activities may affect external operator health and safety if:

- the work environment is insufficiently known;
- task representation is fragmented (for instance operators do not know what has been performed prior to their own operations);
- external personnel is improperly received and there is no real follow-up of its operations;
- there is no internal maintenance interlocutor with specialist knowledge of the relevant equipment, and other matters.

Outsourcing may also affect internal maintenance staff (Grusenmeyer, 2010) due to:

- difficulties in conserving specialist know-how, and thus in monitoring activities carried out by external staff or in informing them;
- incorrect assessment of the true condition of equipment or installations because of the many outsourced maintenance operations;
- equipment being temporarily repaired by internal maintenance staff (so equipment is not in optimum condition) because external maintenance operators are not immediately available.

Certain questions therefore need to be asked in relation to a safer maintenance organisation, such as:

- Are the maintenance organisation modifications sufficiently supported by the company?
- How are the maintenance tasks really allocated among the different operators (production employees, internal and external maintenance staff)?
- Is the maintenance task allocation of each employee known by all concerned?
- Do these different employees know and meet each other?
- What are the means of coordinating of their different operations?
- How are their respective maintenance activities organised?
- Is the real time schedule for the various operations easily known by the different employees?
- Could this operational time schedule lead to coactivity situations?
- Who are the internal maintenance interlocutors within the firm?
- Who follows up the activities carried out by external personnel?
- Who can be contacted if an unforeseen event occurs when performing maintenance operations?

Finally, this INRS research is aimed at better understanding in-company maintenance organisation by observing real situations to understand their consequences on operators' health and safety and to, thereby, make such activities safe.

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2. Safety in maintenance: errors and human factors

Maintenance work is increasingly scrutinised when industrial accidents or disasters of one sort or another happen. Just to mention a recent news event, it appears very likely that the effects of the tsunami that occurred in October 2010 in Indonesia, causing the death of more than 300 people, could have been mitigated had it not been for maintenance problems.

The Indonesian agency for the assessment and use of technology stated that two buoys off the coast of the Mentawai islands, a fundamental link in the tsunami alarm system, were out of service. These were designed and installed after the devastating tsunami in the Indian Ocean that struck the country in 2004, to give people living in coastal areas sufficient time to escape the waves. However, with the buoys out of service the population was not warned about the tsunami. The Indonesian deaths confirm the relevance of maintenance activities for safety ends and, as recent history shows us, is one of the many cases in which harmful events are made worse by maintenance errors.

However, when we talk of 'safety in maintenance' we clearly refer to the specific dangers of maintenance activities, also bearing in mind accident statistics for working environments. These statistics show that in some European countries 20 % of all industrial accidents relate to maintenance activity, and in some sectors this percentage rises to more than half. In Europe 10 to 15 % of fatal industrial accidents can be traced to maintenance operations. Finally, it should be stressed that maintenance is an essential instrument for preventing hazards in the workplace.

The observations above reflect the complexity of maintenance activities, which, due to their nature, present particular challenges compared with other work. Some of these relate to the characteristics of maintenance activity, for instance non-repetitive actions, non-standardised actions, working on systems that remain operative, or actions that are often improvised.

Other challenges relate to organisational and management aspects. These include lack of coordination, inadequate maintenance planning, lack of procedures/instructions, or lack of personnel. Others relate to the working environment, for instance restricted and inadequate spaces, or areas where other work is going on.

Finally, there are challenges relating to human performance, such as trusting to one's own experience and diagnostic and manual capabilities, underestimating dangers, or lack of training and information. In addition, reliability requirements and maintenance-related principles are not always taken into consideration in the design phase and in the planning of work systems in general.

Therefore, it is useful to illustrate some of the approaches that are effective for improving safety during maintenance activities and performing maintenance activities that are effective safety-wise. The following is based on the concept that the occurrence of an accident is the result of a chain of events that are unacceptable at any level of the system in which the undesired event takes place.

James Reason's theory on 'latent errors' states that an accident happens only in particular situations, where 'holes' are aligned and allow opportunities for the accident to happen — the so-called trajectory of accident opportunities. These 'holes' relate to both active and latent errors. It is thus necessary to make improvements in respect of these two types of errors. Active errors relate more to the human factor, which cannot be totally eradicated because they are a part of human nature, while the latent errors are caused chiefly by organisational and operational shortcomings.

Consequently, in order to obtain improvements it is necessary to target latent errors and problems most related to human factors. The analysis and evaluation of hazards makes it possible to identify problems leading to latent errors and the most effective measures to be adopted. The importance of identifying all potentially dangerous situations caused by the interference, presence or deployment of external personnel (in the case of outsourcing) should be stressed. The analysis of accidents and near-accidents should be included in the evaluation of hazards, using reactive-type methods, such as incident reporting and root causes analysis. A proactive approach should also be used to identify problems and eradicate them from the system before the accident occurs, in order to identify critical points and to design safe systems.

With regard to problems relating to human conduct, and in order to identify effective actions, it is useful to briefly describe

some findings of studies, theories and researches on human error. Many of these findings were developed in the international civil aviation industry, especially following the crash of a BOEING B737 on 28 April 1988, flown by the company ALOHA Airlines.

These accidents have made it possible to study in depth, with regard to aircraft maintenance activities, the influence of human actions on accident dynamics. This research has identified the 12 most common causes, the 'Dirty dozen' (Table 1) of errors committed by maintenance engineers:

1. Lack of communication
2. Complacency
3. Lack of knowledge
4. Distraction
5. Lack of teamwork
6. Fatigue
7. Lack of parts
8. Pressure
9. Lack of assertiveness
10. Stress
11. Lack of awareness
12. Norms

Table 1: The 'dirty dozen' and their 'safety nets'

The dirty dozen	Safety nets
<p>1. Lack of Communication Verbal or written communication, or a combination of the two.</p>	<p>(a) Use logbooks, worksheets, etc. to communicate and remove doubt. (b) Discuss work to be done or what has been completed. (c) Never assume anything.</p>
<p>2. Complacency An insidious cause, which, with the constant repetition of many maintenance inspections, can cause or contribute to an error in judgement.</p>	<p>(a) Train yourself to expect to find a fault. (b) Never sign for anything you did not do.</p>
<p>3. Lack of knowledge It is a common cause of an error in judgement. When coupled with the 'can-do' attitude of most maintenance personnel, it becomes even more probable.</p>	<p>(a) Training. (b) Use up-to-date manuals. (c) Ask a Tech. Rep. or someone who knows.</p>
<p>4. Distraction This cause is thought to be responsible for about 15 % of all maintenance errors. Someone leaves a task (both physically and/or mentally) for any reason and returns thinking that they are further ahead with the task than they actually are.</p>	<p>(a) Always finish the job or unfasten the connection. (b) Mark the uncompleted work. (c) Lockwire where possible or Torqueseal. (d) When you return to the job always go back three steps. (e) Use a detailed check sheet.</p>
<p>5. Lack of teamwork This cause is often tied in with lack of communication but can be responsible for major errors. With maintenance often involving a multitude of workers, good teamwork becomes essential.</p>	<p>(a) Discuss what and how a job is to be done and who by. (b) Be sure that everyone understands and agrees.</p>
<p>6. Fatigue It is a very common cause because, until it becomes extreme, people are usually not aware that they are tired. They are even less aware of what the effects of fatigue are.</p>	<p>(a) Be aware of the symptoms and look for them in yourself and in others. (b) Plan to avoid complex tasks at the bottom of your circadian rhythm. (c) Sleep and exercise regularly. (d) Ask others to check your work.</p>
<p>7. Lack of resources No matter whom the maintenance worker reports to, there are times when there is a lack of resources and a decision must be made as to whether to ground the aircraft or let it go.</p>	<p>(a) Check suspect areas at the beginning of the inspection (b) Order and stock anticipated parts before they are required. (c) Know all available parts' sources and arrange for pooling or loaning. (d) Maintain a standard and if in doubt ground the aircraft.</p>
<p>8. Pressure Few industries have more constant pressure to see a task completed. The secret is the ability to recognise when this pressure becomes excessive or unrealistic.</p>	<p>(a) Be sure the pressure isn't self-induced. (b) Communicate your concerns. (c) Ask for extra help. (d) Just say 'No'.</p>

The dirty dozen	Safety nets
<p>9. Lack of assertiveness There may come a time when something is not right and the worker will have to be assertive in order to ensure the problem is not overlooked.</p>	<p>(a) If it's not critical, record it in the journey logbook and only sign for what is serviceable. (b) Refuse to compromise your standards.</p>
<p>10. Stress Stress is part of our every day life. We must avoid it becoming excessive.</p>	<p>(a) Be aware of how stress can effect your work. (b) Stop and look rationally at the problem. (c) Determine a rational course of action and follow it. (d) Take time off or at least have a short break. (e) Discuss it with someone. (f) Ask fellow workers to monitor your work. (g) Exercise your body.</p>
<p>11. Lack of awareness This often occurs to very experienced maintenance personnel who fail to think fully about the possible consequences of the work they are doing. A specific failure might not be covered by the instructions manual but resolving it might only be a matter of common sense.</p>	<p>(a) Think of what may occur in the event of an accident. (b) Check to see if your work will conflict with an existing modification or repair. (c) Ask others if they can see any problem with the work done.</p>
<p>12. Norms This last cause is a powerful one. Most people want to be part of the 'in crowd'. Norms develop within such groups, which dictate how people behave.</p>	<p>(a) Always work as per instructions or have the instructions changed. (b) Be aware that 'norms' don't make it right.</p>

Studies have also highlighted the human factors that can most influence the behaviour of individuals. These can be broken down chiefly into two categories.

The first includes factors common to all individuals: attention, perception, memory, sleep, fatigue, boredom, repetitiveness and work monotony, working conditions, ability to concentrate, aptitude for continuity of work and application, personal security or insecurity, decision-making ability, state of health.

The second category relates to specific factors: motivation, work satisfaction, specific dislike of colleagues and superiors, or relationship problems with them, frustration at work, worries in the personal or family or economic spheres, physical and mental pathologies, personality disorders.

In view of the above, it is useful to undertake, as has been happening for years in complex sectors, specific training and information initiatives for all personnel who perform maintenance activities, both at an operational level and in terms of organisation and management.

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3. Incidents in maintenance: their link to the tasks, special characteristics and proposed measures

EU statistics reveal that incident indices in maintenance are higher than in other work categories. In combination with the extensive six-year research project by the author, this article interprets the results linking them to the maintenance sector's special characteristics. The article points out some problems related to existing European regulations and standards and their implementation. Finally, a group of measures is recommended that are being successfully applied to a very small extent by mainly multinational companies.

The selection of the subject of the 2010–11 campaign of the European Agency for Safety and Health at Work is not random; the latest European Risk Observatory report revealed that maintenance is associated with a higher safety and health risk than other types of work. Statistics are not an end in themselves, but with further analysis useful conclusions can be drawn to achieve continuous improvement. Such an analysis, combined with the author's extensive research, is presented below.

What is maintenance?

For most readers the term is self explanatory; however it is necessary to clarify certain aspects of maintenance. First of all there is more than one type of maintenance, and these include:

- Preventive maintenance (PM)
- Condition-based maintenance (CBM)
- Predetermined maintenance (PDM)
- Corrective maintenance (CM)
- Deferred maintenance (DM)
- Immediate maintenance (IM)

The analysis of these is beyond the scope of this article, but the type of maintenance applied is essential as it affects health and safety in terms of exposure of maintenance personnel to hazards, as analysed later.

Furthermore, there is usually a tendency to consider as 'maintenance' purely technical tasks, such as disassembly and replacement of spare parts, lubrication, and repair of a spindle, etc. In practice, maintenance has a much wider spectrum involving numerous additional tasks. These include:

- the choice of appropriate tools,
- the choice of appropriate chemicals,
- preparing areas (evacuating non-involved personnel, traffic control and putting up signs),
- preparing machinery or areas for shut down,
- transporting spare parts (manually or in industrial vehicles),
- preparing the necessary safety precautions (for instance PPE, lockout-tagout, energy depletion, training);

as well as start up works such as:

- test or trial runs,
- resetting safety devices,
- ensuring proper signs are in place,
- final pre-delivery trial runs,
- full area restoration and housekeeping,
- handling maintenance waste.

Maintenance also includes working in dedicated restricted areas such as machine shops, metal-body shops, pump houses, test chambers and similar.

Who is involved in maintenance?

Maintenance involves a large number of jobs: not just machinists, electricians and engineers but also painters, drivers, cleaners and many more. To simplify, all maintenance personnel including management are referred to as maintenance personnel.

Incident causes

Maintenance personnel are exposed to all kinds of hazards: heights, degraded floors, hot, cold or sharp surfaces, moving parts, tools, equipment, industrial trucks, pressurised systems, electromechanical installations, obstructions, stored and transported loads, pests, microorganisms, noise, vibration, ignition sources, to name just a few.

In its statistical report the European Risk Observatory showed that maintenance personnel are more exposed to noise, vibration, UV radiation, radio frequencies, environmental conditions and chemicals.

In a research conducted by the author into the Greek industry, the following results were reported by maintenance personnel themselves, regarding the causes of incidents (accidents and near-accidents).

Direct causes (*linked to first-line personnel*):

- Defective equipment
- Unexpected movement of machinery or equipment
- Lack of housekeeping
- Violation of safety rules
- Bantering
- Non-use of PPE
- Acting without authorisation

Immediate causes (*linked to supervisory personnel*):

- Hastiness
- Saving effort
- Lack of attention or focus
- Familiarisation with danger
- Insufficient job specifications

Managerial causes

In order to find the root of the above causes the author divided management failure into three categories: 1. lack of a safe system of work; 2. lack of effective communication (for instance training or meetings), 3. lack of effective enforcement.

The research showed that:

- the combination of all three causes appeared to contribute to 30 % of the incidents;
- the combination of 1 and 3 contributed to 24 % of the incidents;
- training did not contribute significantly in the incident chain mechanism, which is an expected result as analysed below.

The research also revealed that:

- the full implementation of a safe system of work, communicating this system to the employees (through training, short talks, meetings, slogans and campaigns, for example) and its enforcement through close supervision would prevent all accidents (statistically there is a 5 % residual risk due to human factors);
- enforcement in combination with a safe system of work would be the most effective combination preventing 50 % of the incidents.

Cause–effect analysis in relation to the maintenance works' special characteristics

The results should not come as a surprise if we consider the inherent characteristics of the repair and maintenance tasks.

1. Lack of housekeeping

Maintenance works are inherently disorderly and dirty. Maintenance personnel use tools, sprays and lubricants that take up most of the floor space around their work area. When disassembling machinery is involved, the situation gets worse. During maintenance, the floors can become very slippery and covered in tools, spare parts, chemical containers, cloths and other equipment, increasing the risk of an incident. In some cases, as in building renovation works, this situation is inevitable.

Therefore, maintenance personnel are more exposed to risks related to lack of housekeeping, such as slips, trips and, possibly, falls. Lack of housekeeping also increases fire risk since maintenance involves the use or the release of flammable chemicals (such as solvents, lubricants, Volatile Organic Compound, or VOC fugitive emissions) in combination with hot surfaces and open flames.

2. Inherent risk and know-how

Although common sense is a basic requirement, most maintenance works need some expertise as well. Consequently, maintenance personnel need technical secondary (or other similar) education with additional hands-on training to familiarise them with specific work, workplaces and equipment. Even in cases where maintenance is restricted to commercially available equipment and machinery (from copiers to vehicles) a degree of specialisation is essential. With the present rate of updating machinery and technological progress, expert know-how is an absolute prerequisite for technicians to be able to work efficiently, safely and consistently.

Maintenance personnel are usually so well trained that, in some cases, they are involved in upgrading the safety systems already in place. This is why training does not substantially reduce risk levels, but acts only as a catalyst. This should improve safety, but it may also create adverse conditions.



By courtesy of HSE Committee of Hellenic Maintenance Society

Maintenance personnel must remain totally focused on their task, something that may prove difficult. Distractions, such as environmental conditions, bantering, stress, time pressure, noise and so on always increase the incident risk. Often maintenance personnel use equipment without safety devices in place, which results in higher risks especially during test runs when it is not certain that the equipment will function properly.

Finally, while training provides or augments the level of expertise, scientific developments do not stop. There are still conflicting opinions on the degree of risk when exposed to certain radiation frequencies; threshold limit values (TLVs) of hazardous chemicals are revised biannually, and the risks involved in the use of new nano-materials are largely unknown.

3. Repeated tasks

In a variety of cases maintenance works include repeated tasks, as mentioned above, when maintaining commercially available hardware. Technicians become extremely familiar with the performed tasks but that leads to familiarisation with the dangers involved which in turn leads to complacency. It is a basic ergonomic principle that the human brain reacts less effectively in emergency situations when the daily tasks are monotonous. Additionally, and in combination with the misperception that know-how protects from all dangers, maintenance personnel develop overconfident behaviours, leading to the violation of safety rules to save time and effort.

4. Non-productive work

Safety is linked to prevention. Unfortunately, corrective maintenance is more prevalent than preventive maintenance in production companies. Maintenance is rarely part of the production plan and is mostly considered a waste of time. As a result of this maintenance, personnel work under stress to complete the tasks in a very limited time and under constant pressure, on pieces of machinery that are not always well maintained. Procedures are not followed, maintenance technicians often improvise and the quickest methods are used at the expense of their own safety. A consequence is that the maintenance schedule, when present, rarely includes testing the safety gear (for instance safety switches, light curtains, sirens, emergency buttons, signs and interlock switches) that are an integral part of the equipment, and which have a limited operational life.

5. Complexity and collateral risk

As outlined in the previous paragraphs, usually maintenance work is not self-explanatory but includes complicated procedures with a predetermined order. Safety procedures must be completed step by step, to minimise the workers' exposure to hazards. For example, switching off a piece of equipment or closing the valves of a pipeline does not mean the equipment or the installation is in a zero-energy state. The energy may be accidentally released and cause severe injuries. Most

machinery have springs under tension, pressurised pistons, hot parts or charged capacitors while pipelines may transport hot and/or pressurised and/or reactive chemicals. An additional precaution must be implemented so that this residual energy will not be released during maintenance work. Maintenance personnel are exposed to risks because protective devices are either removed, bypassed, or rendered inert. Safe maintenance procedures are seldom studied or improved, and are often not implemented. Safety practices are usually well known but they are deliberately ignored, so maintenance personnel are directly exposed to risks to which operators are later exposed during normal operation since the safety devices are not in place.

European specifications and practice

There is an extensive list of specifications (such as directives, guidelines and standards) presented on the EU-OSHA site (<http://osha.europa.eu>) which attempts to set a framework for a safe maintenance environment. The author's experience, though, indicates that the following issues must be additionally addressed and resolved to reduce safety and health risks for maintenance personnel.

- A common misunderstanding is that the CE marking alone provides full protection against all risks. Even if this were true, which it is not, most pieces of machinery undergo so many conversions that the CE marking is rarely valid.
- Risk assessment is a requirement, but most studies rarely include non-regular works, such as repair or maintenance.
- New machinery and equipment are required to be accompanied by manuals including maintenance procedures; however, no such manuals exist for older machinery still in operation. Even recent purchases might not be accompanied by the appropriate documentation, while in several cases this documentation is not available.
- In spite of the fact that it is implied, there is no robust reference on the application of a detailed Lockout Tagout (LOTO) procedure comparative to the United States' Occupational Safety and Health (USA-OSHA); and there are no detailed line breaking procedures (which is the equivalent LOTO for pipelines).
- In the 2007 update of the safety management system BS OHSAS 18001 in the section 4.4.6 (operational control), where the safety procedures are specified, a clarification that maintenance should be included was removed. Although the revised BS OHSAS 18002 implementation guide has a more detailed reference to maintenance works, this document is rarely referred to by the companies; as a result, the status of maintenance works was weakened.

Recommended measures

The following measures are implemented in big multinational companies with great success; this effort was a long-lasting one until the necessary culture was created. However, the majority of companies are either small- or medium-sized with limited resources and manpower, therefore only strict legal

and technical requirements will make implementation of these measures feasible.

1. 5S housekeeping

In the framework of this article we shall only mention that this Japanese system is based on establishing lean manufacturing and visual stimuli principles in a production facility area through improving housekeeping and demarcation. It demands involvement of all hierarchy levels and has multiple advantages: it minimises production time while improving safety. The system is so flexible that even if its principles are not fully implemented, a facility can just apply the housekeeping, orderliness and cleaning procedures as part of the maintenance specifications.

2. Safe methods of work

Owing to the complexity and diversity of maintenance work each organisation must develop, and have available, specific and analytical safe work methods for all repair and maintenance activities including the start-up and commissioning phases. A mandatory LOTO and a line breaking procedure or technical specification consistent with the basic principles outlined in the USA-OSHA control of hazardous energy standard would be extremely helpful, especially for small- and medium-sized companies. In these procedures emergency situations should also be prescribed. Checklists of all safety devices denoting their type, location and function, and the inspections and testing frequency should be applied to all maintenance works in every piece of machinery and equipment.

3. Management culture

Another misconception about maintenance is that it is a non-productive process. Thus, maintenance personnel are constantly under pressure to reduce machinery shutdown times, to minimise area and installation restoration times and other constraints. Organisations must consult with and incorporate maintenance in their production planning in order to allow sufficient time for preventive maintenance, and this cost must be included in the product cost. Any maintenance procedure with anti-preventive rationale compromises the safety of maintenance personnel and operators.

4. Enforcement and training

Maintenance personnel are trained and hence possess an advanced expertise but, for the reasons mentioned previously, they often willingly or unwillingly violate the safety procedures. Close supervision and enforcement are imperative in order to shape mindsets that in turn create a supervision-free, fully safe environment. Constant training and education based on recent technological and scientific developments are also necessary in order to maintain the technicians' expertise. Supervision and enforcement should focus on unsafe behav-

iour recognition mainly relating to distractions, hastiness and saving effort.

The above results and recommendations were presented and discussed at the May 2010 European Federation of National Maintenance Societies (EFNMS) Conference in Verona, at which the Health and Safety Committee also convened. Members agreed these problems were common throughout Europe, and that common action plans could be developed around the set of measures proposed.

Conclusion

Maintenance works entail inherent risks that cannot be covered in the framework of a training programme for technicians. The nature of the tasks performed bears special characteristics, such as complexity, diversity and emergency conditions, while their importance is largely underestimated. As a result maintenance personnel, having no other option, willingly work under adverse conditions and substandard safety practices. The European regulation framework exists but it must be more specific and strict in order to also be applicable to small- and medium-sized companies. These issues and practices are a common phenomenon throughout Europe and taking measures requires a wide, immediate, coordinated and decisive action with the cooperation of maintenance employees, management, institutions, state organisations and scientific bodies. The choice of the campaign is fully justified as long as the intensity of the actions does not fade when the next campaign subject is selected in 2012.

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4. A well thought-out maintenance programme increases safety

Enormous improvements have been made in the field of safety in industry in recent years, with maintenance playing a crucial role. By mapping out your risks at a detailed level and using them as a basis for your maintenance programme, your business can prevent a host of unwelcome situations.

Attention to safety in industry has increased sharply in recent years, due partly to the 2005 explosion at the BP refinery in Houston, where 15 people were killed and 170 employees injured. The accident led to the well-known Baker report, in which BP's safety measures were severely criticised. The environmental disaster after the recent oil leak in the Gulf of Mexico, which led to increased government pressure on industry to demonstrably guarantee safety, will increase attention to safety even more in the coming years.

Other sectors are also under government pressure to improve their safety standards. For example, in 2008, the Health Care Inspectorate in the Netherlands gave healthcare institutions two years to demonstrate that they were working more safely. In recent years, thanks to these stricter safety regulations, organisations have become increasingly aware of the various aspects of safety. More and more often questions are being asked, such as: What is the nature of my surroundings? Am I in a residential area or an industrial estate? How do my processes operate, and what could go wrong? Nevertheless, too many accidents that could have been prevented still occur. There is still a considerable gap between thinking about safety and its firm implementation.

Maintenance is a vital component of the implementation of safety. According to the so-called Bow-tie model, two categories of assets can be identified in every business. These are assets that play a role in causing an incident and assets that help to avoid serious consequences. You have to pay careful attention to the assets in both categories. You need to identify the risks and work with a maintenance programme that helps to avoid these risks.

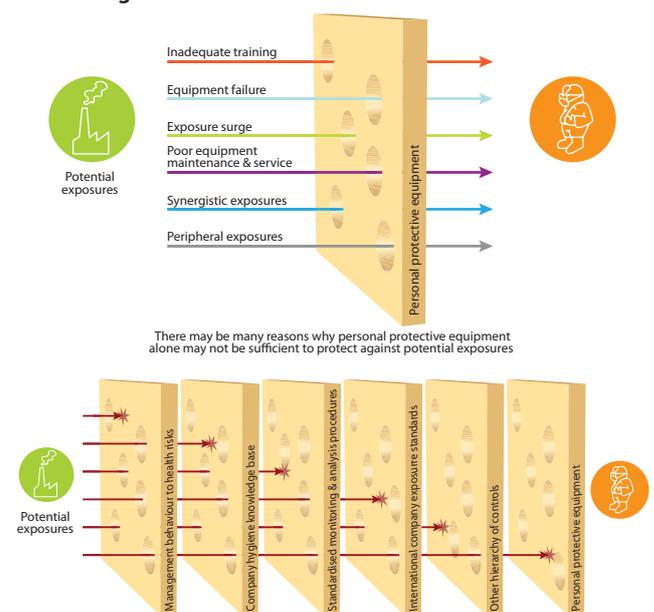
The Dutch Maintenance Society (NVDO) supports its members in setting up their maintenance programmes on the basis of safety risks. The reasons for this can vary. It may be that legislation and regulations require that safety must be demonstrable. Sometimes there may have been inspections, an internal audit may have brought points for improvement to light, or an inci-

dent may have taken place. Of course, without the help of its members the NVDO cannot respond to the demand. One of its members, MaxGrip, a maintenance consultancy firm has demonstrated its risk management-based approach in recent years. A number of major clients in the oil and petrochemical industry have been guided in the process towards improving safety with the help of better-planned maintenance. The approach of this global company is made up of five steps.

Step 1: Identification

The first step is to identify the equipment that is critical for safety: the safety critical elements (SCEs). The Swiss cheese model is a useful tool for this purpose. To briefly explain, before an incident becomes an accident, it has to pass through various barriers, all of which have safety critical elements. If these elements are functioning well, an incident is nipped in the bud or even avoided completely.

Swiss cheese model: a model used in the risk analysis and risk management



Source: <http://sustainability.bhpbilliton.com>

However, if there is a leak in the barrier — like a hole in a Swiss cheese — then the incident is given the chance to escalate further; the more holes, the greater the chance of an accident, or even a disaster.

It is therefore essential to map out assets and identify any gaps. In some sectors that is a significantly intensive step, in health-care, for example. Hospitals and other healthcare institutions often have a large amount of equipment that is not registered anywhere; the failure of a device such as an infusion pump can have major consequences. It is therefore essential to take this first step effectively and thoroughly in order to understand what the risks are, and so rule out hidden dangers.

Step 2: What if?

Once it is known what equipment represents an SCE, step 2 follows. This involves identifying the consequences of the failure of these assets, with the help of a failure mode effect and critical analysis (FMECA). The software programme Optimiser+ forms the backbone of this step. Optimiser+ is the primary tool for every maintenance and reliability engineer. It is an ideal tool for carrying out criticality analyses and drawing up maintenance plans.

Optimiser+ is complementary to a company's maintenance management system. A company's asset register can be imported into it, and the maintenance plan drawn up in Optimiser+ can be exported to the company's maintenance management system (such as Maximo, SAP PM, Infor EAM or Ultimo). In addition, the system offers the possibility to calculate the effects of maintenance plans and in this way see what the result of the maintenance plans will be in terms of availability, safety, number of malfunctions and associated costs.

In this step we therefore guarantee the available knowledge and experience in Optimiser+. The library function of Optimiser+, in which the specifications of a wide range of assets is recorded, makes it possible to speed up this step and efficiently and effectively identify all risks. This forms the basis for the ongoing development of the maintenance programme.

Step 3: Into practice

In step 3, theory is converted into practice. The outcomes of the FMECA are translated into the maintenance programme. In other words: what maintenance do you need to do to reduce the likelihood of an incident or reduce its effect? It is essential to examine both of these aspects. Sometimes the likelihood of a particular component of your installation failing is almost zero, but the consequences could be enormous. This is the case with nuclear reactors, for example. In other cases the chance of failure is greater, but it has negligible consequences. The trick is to find the optimum balance in your maintenance programme. In theory it is possible to exclude every risk of failure, but in most cases this is unaffordable. For this reason a good maintenance programme is never based on safety alone, but also takes account of other business goals.

Optimiser+ is highly suitable for searching out this optimum, because it offers the opportunity to roll out scenarios. What would happen if I changed the maintenance period of a particular installation from three to five years? Would the risk increase? If so, is it still an acceptable risk? And what would this mean for my other business goals? By going through these scenarios, you can bring your maintenance programme to the optimum level.

Step 4: Taking action

This ultimately leads to establishing maintenance actions in a maintenance management system such as SAP, Infor EAM or Maximo. And then the fourth step begins: the implementation of the maintenance as established in the programme. The technology department of the company — in collaboration with its subcontractors — begins with the implementation of the maintenance as established in the maintenance management system. For this step, the more detail established about the standard with which the asset must comply, the better. Take the fire extinguishers on an oil platform, for example. How often do they need to be checked? Or how many millimetres of wear can a valve have before safety is at issue? By establishing this, you make safety an objective reality rather than leaving it to a human and therefore subjective judgement. Safety means 'knowing what you have to do' and 'knowing how to do it'. You need to know that you have to lubricate a valve, and how to lubricate it.

Just as in step 3, this is done in dialogue with the users and/or engineers of the relevant equipment. They provide their contributions by considering, with expert colleagues, why equipment is critical, how it can fail and what the effect of this failure would be. The input of users/process engineers is essential here. They also discuss what can be done to prevent failures and how this should be established in operating instructions incorporating the specifications of the equipment.

Step 5: Feedback

Step five consists of feedback from the field. What has been the result of the maintenance? What has actually been measured? Did the valve close or not when we tested it? The answers to these questions have to be processed effectively, so that any follow-up actions can be planned and the maintenance management system can be refined still further. OBS/CMMS specialists can configure systems such as SAP or Ultimo in such a way that feedback is possible within the system, and even that notifications are automatically generated in the event of abnormalities. In this way checks are not only carried out on paper, but are also immediately recorded in a system. In addition, effective registration can lead to insights into how well or poorly equipment is performing. Studies can then be carried out to identify causes of failures, and proposals for solutions can be formulated.

In recent years, NVDO member MaxGrip has developed maintenance programmes that contribute to increased safety for

dozens of multinationals as well as smaller companies. The effects vary depending on the company involved. For larger companies in the oil industry, for example, where safety has been a key issue for some time, these are sometimes only miniscule steps. Nevertheless, alongside the factual side — identifying SCEs and ruling out risks — an elusive aspect of safety still remains. Despite the fact that these days employees in industry have all been made aware of the importance of safety, they do not always act accordingly. They push the limits: 'the valve jammed last time too, but no accident occurred then'. Or routine creeps in: 'I was at this plant to carry out maintenance last week, so I don't have to report that I'm here again'. Safety stands or falls on awareness. You know that it is

important, but you get swallowed up in the issues of the day. Nonchalance might creep in, for instance if you answer your mobile phone while you are carrying out maintenance work; or you have replaced a component with one with different specification and have failed to update your records. First and foremost, safety means sustaining a high level of alertness on all levels.

The Dutch Maintenance Society, NVDO, consists of approximately 1 700 members out of Industry, Infra, Fleet, Consultancy and Real Estate. NVDO, PO Box 138, 3990 DC Houten (<http://www.nvdo.nl>).

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5. Excellence in risk assessment and well-being at work

All types of maintenance work have increased in modern society due to advanced infrastructure and general affluence. A further development is that much of this work has been outsourced to smaller contractors and maintenance service providers, causing the ostensible statistical effect that the service sector has become more 'dangerous' in terms of serious accidents or fatalities, according to Finnish statistics. However, some large firms have specialised in maintenance operations and they can considerably contribute to safety by developing and disseminating good safety culture to their partners.

Maintenance services are varied: they may range from tree surgery to road works, from resurfacing baths to warehousing and cold storage. Consequently, the health-related hazards may include indoor air problems in moisture-damaged buildings, blood-borne pathogens, defective tool-related hazards, noise, explosive environments and so on.

While it is generally believed that up to 85 % of manifest hazards can be avoided or eliminated, thanks to state-of-the-art techniques, it appears these techniques are not always used.

The modern concept of wellbeing at work is all-encompassing. It relates to the physical environment, all work-related hazards, organisation of work and tasks, relationship with colleagues, personal health and work ability and even family-related strains. This article gives an overview of the application of the concept in relation to maintenance work.



© Kari Riisa

Safety card

Probabilistic aspects of task safety

Specific maintenance tasks may be outsourced because of their inherent dangers, infrequent demand, the need of special instruments or skills and other reasons. This makes the scene of the task widely varying from the point of view of the contractor. Even work in very similar industrial plants may be completely different because of differing circumstances, such as plant characteristics, previous maintenance, weather conditions or time pressure. This makes the safety planning probabilistic with uncertainty in the risk evaluation. Due to the circumstances it may be impossible to evaluate hazards and risks without visiting the worksite.

Errors in maintenance work

Even skilled people can make fatal errors. Their role in accidents may be analysed by the well-known skill–rule–knowledge (SRK) model developed by Dr Jens Rasmussen. The model describes three typical levels of performance. At the first level, behaviour is under the control of practiced skill routines, at the second level, it is guided by implicit or explicit rules and at the third level, performance requires conscious application of knowledge. For the reasons above, all three performance levels may result in errors more frequently in maintenance than in the routine production or service work.

It seems that skill-based errors are the most common, and according to the literature, they may be predominant in the early hours of the day. Skill-based errors are followed by procedure violations, rule-based errors and lastly knowledge-based errors. These aspects should be remembered when planning for example night shifts.

Team members

Maintenance workers often work alone or in teams of two or three members. In many countries, they are generally not members of an industrial trade union, and their work ethos may differ from other wage earners. Psychological safety climate even in these small teams is, however, crucial. Psychological safety climate reflects the employee's perception of the priority or value of safety, while most organisations require safety as well



Isolation point: cabinet for key(s) to locks used in isolation and place for the isolation instructions

as productivity of their employees. At its best, the safety is conceptualised by a common set of rules with the individual's favourable perceptions. This includes safety behaviour. It not only regulates the employee's actions but it also helps to contribute to an environment that supports safety.

Paradoxically, highly professional workers can initiate errors by breaking procedural rules in order to gain time or for financial reasons. This is often done by adapting the rules to local circumstances at the expense of standardised procedures. Professionalism may also create blind spots based on previous successes. Corner cutting also prevents the flow of critical information about unsafe conditions to other team members.

Professionals may also create subcultures with their own jargon and other communication habits not known to others or to by-standers. While reinforcing the team's internal coherence it might cause warnings or alerts to go unheeded if they are not understood. The subculture may also ignore the use of protective equipment, be it noise protection or safety harnesses or safety helmets.

Individuals may have health conditions, such as asthma or other respiratory ailments that make them vulnerable to environmental conditions, for instance moisture-related problems in building maintenance. Therefore, individuals may develop coping strategies for working in risky environments. These may include attitudes and work habits. However, the first universal rule is that one should not undertake tasks which might result in injuries or death. Most professionals have the 'do and don't' guidelines of their jobs, but they must maintain their vigilance as well. They must use the appropriate safety equipment and keep work gear in order. They must also take into account weather conditions, traffic, by-standers, public order and similar conditions.

Future views

Maintenance by outside contractors is here to stay. Maintenance workers are highly skilled professionals but they may at the same time be prone to hazards and risks as described above. An all-encompassing concept of wellbeing at work tries to reconcile the individuals and the teams they belong to, the minimisation of danger and the successful completion of tasks. Well-being at work — including work safety — should be integrated directly in management systems. This can only be achieved through the cooperation of all actors at the work site.

Everybody needs to be reminded of safety rules from time to time. It is impossible to be on maximum alert at all times, so work procedures have to be created to correct small errors and avoid fatal ones.

A portable electronic prompter can be devised that gives advice in specific situations. Clinicians already have decision support programmes and electronic tools to avoid errors. They are especially useful when a best treatment protocol already exists. The same could be true for maintenance operations that are regulated or have standard operation procedures. Modern technology would allow the development and use of this type of prompters.

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6. Chemical safety during plant shut-downs

Introduction

Major chemical installations are designed to run for months without any stoppages but well-planned maintenance shut-downs are necessary to avoid unwanted disturbances at the plants. A shut-down is here defined as a scheduled event wherein the entire process unit of an industrial plant is shut down for an extended period for a revamp and/or maintenance. Other terms for plant shut-downs include plant turnaround and plant outage. According to our definition, a plant turnaround is the management process of a plant shut-down, the plant shut-down being the execution phase of the plant turnaround procedure. Plant outages, in turn, might be long or short, partial or complete, and they do not necessarily involve any substantial maintenance work.

The optimal time between two shut-downs is steadily increasing. In Finland it used to be commonplace that continuously operated process plants were stopped for Christmas and Mid-summer holidays and maintenance work was carried out during these breaks. Nowadays plants might run for 18 months or more without being shut down. This, in turn, means the personnel at these plants have fewer opportunities to become experts in planning and executing shut-downs. This trend led the Technical Research Centre of Finland (VTT) and its partners to carry out a research project to compile information on how risks for chemical accidents during shut-downs should be handled by companies representing the Finnish process industry.



By courtesy of Oy Metsä-Botnia Ab

Until now, research on shut-downs has mainly been focusing on risks caused by the contractors. The aim of the study led by VTT was to investigate whether the safety management systems of the production companies would ensure the safety of the contractor workers during shut-downs. The study was restricted to risks caused by process chemicals.

Risks caused by process chemicals during shut-downs

In most cases, process chemicals are also present at the site during shut-downs and often parts of the process plant are still in operation during the shut-down. Even if all processes are stopped, chemicals are still stored in tanks and warehouses. Sometimes temporary storage solutions are used. One example of this is to use safety basins for the storage of liquids. Even when chemicals are stored in their normal places, there is an increased risk of accidents. This may be because of prolonged storage times, absence of cooling media, closed safety systems or the allocation of staff for other tasks.

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

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

As a consequence, persons carrying out shut-down work are at risk of:

- exposure to process chemicals;
- exposure to dangerously high or low temperatures and pressures (hot and cold surfaces and substances);
- involvement in a situation where there is not enough oxygen in the air or too much of a hazardous substance;
- being affected by explosions or fires or the consequences of these (for example throw-outs or cave-ins).

Safety management

According to the EU Seveso Directive, safety management systems (including the management of change procedures and training of staff) are mandatory for installations storing hazardous chemicals over certain quantities.

In Finland, contractors entering process plants to carry out work during a shut-down are systematically introduced to their tasks and to the safety risks involved. The training of the plants' own staff is less systematic. None of the studied companies held records of who had been trained in the tasks they were given prior to, and during, a shut-down. However, more experienced workers had a fairly good grasp of the main tasks needed in order to ensure a safe shut-down period. In other words, our study showed that safety during shut-downs did not rely on the safety management system of the operating company, but merely on the experience of the responsible persons at the various departments.

Interestingly, the companies studied did not consider shut-downs to constitute a change that needed to be covered by the management of change procedures. Neither could we find any indications in the open literature that such procedures cover shut-downs in industry in other parts of Europe either. In reality, however, the situation at a plant during a shut-down is completely different from a normal day: processes are stopped, equipment is emptied and opened, the number of people at the site is much higher than normal and many safety systems are not fully functional. In addition, the situation during a shut-down is very dynamic. As Joel Levitt (Springfield Resources) once put it: 'Be vigilant because once the action starts the fog of battle settles over the shut-down. Hazards are being opened every hour. Situations change, what was safe is safe no longer. Vigilance, along with good solid job plans, is your best defence.'

The project team also noticed that risk analyses were carried out together with the contractors and their subcontractors. These risk analyses focused on risks caused by the contractors and often failed to cover risks caused by the process plant itself. Neither did we find any indication, in our study or in the open literature, that the contractors would have demanded a risk analysis, or a safety audit, to be carried out in order to identify hazards caused by the environment in which the shut-down work was to be done.

Bringing the processes to a controlled halt and leaving the process plant in a safe state are two crucial tasks of the plant operators prior to the shut-down. The following tasks are examples of duties related to chemicals and various utilities (for example nitrogen and steam) that must be taken care of when a process plant is prepared for a shut-down.

- A plan must be drawn up stating what to do with the process chemicals that will remain at the plant during the shut-down.
- A plan must be prepared to make sure the part of the installation that is shut down is safe during start-up, normal operation and/or shut-down of other parts of the installation.

- A sufficient amount of portable gas meters must be checked and calibrated.
- Providers of gases, other chemicals and utilities should be informed in advance about the shut-down in order to avoid unnecessary deliveries during the shut-down.
- Other users of on-line gases, chemicals and utilities must be consulted before the distribution is stopped.
- Management must ensure that the persons in charge of making the plant safe have the necessary skills to carry out their tasks.
- Process equipment, pipes, valves, pumps, and other machinery must be emptied and cleaned in a safe and reliable way.
- Pipelines containing compressed air, inert gases, water or steam must be depressurised and flushed if not used during the shut-down.
- Equipment and even entire plants containing chemicals or utilities must be reliably isolated from those sections still working during the shut-down.
- The success of the isolation must be verified, for instance by measuring the concentration of the chemical in question.
- A procedure must be in place to assess when a piece of equipment is cold enough, clean enough and ventilated enough to be worked on by the contractor.

Seisokki.vtt.fi

In order to highlight the issue of hazards caused by process chemicals, the VTT-led research project produced a guidebook in Finnish, which is available on the Internet (<http://seisokki.vtt.fi>). After an introductory section, shut-downs in the process industries are described, as are the various chemical hazards that might constitute a risk to the maintenance workers. Section 3 of the guidebook deals with the management of change in general, and with shut-downs as a demanding change situation in particular.

Section 4 of the guidebook describes how to manage chemical hazards: identification of the hazards, making the plant safe, work permit procedures, safety audits and plans, training, work instructions, dissemination of information, and crisis management.

Section 5 introduces a new hazard analysis method and a safety audit method customised for turnarounds. Also, some older methods that might be useful during plant turnarounds are briefly described. Finally, Section 6 of the guidebook focuses on internal emergency plans for process plants.

The website (<http://seisokki.vtt.fi>) also has information on tools developed during the Finnish research project. This includes a set of work permits. The first is a general work permit, the second is for hot work and the third is for work in confined spaces. There is also a fourth permit for work in areas with potentially explosive atmospheres (ATEX zones). During shut-downs these EX-marked zones are especially problematic from a safety management perspective. Despite the EX sign, some of these zones are not hazardous during the shut-down, and maintenance work is typically allowed without any special arrangements. However, the explosion hazard still remains in some of

the marked zones. The danger is that the latter ones are also considered to be non-hazardous and are worked in without taking the necessary precautions.

The web pages include four sets of safety checklists for internal audits carried out by the plant manager, the production manager, the maintenance manager and the safety manager, respectively. These sets consist in three to five checklists. The first set consists of questions that are generic and thus not related to any particular turnaround. This set should lead to improvements in the safety management system of the company. The other sets should be used at different stages of each turnaround process. If all checklists are used, those in charge of different aspects of a shut-down should get a fairly good idea of how chemical safety is handled at both the planning stage and the execution stage of a shut-down.

A new safety analysis method is also described in detail on the website (<http://seisokki.vtt.fi>). Templates of the forms to be filled in during the hazard analysis are given too. The method relies on a list of chemicals, their presumed location and amount during various times of a shut-down. Based on this knowledge, those in charge of the various departments, or of writing work permits, can assess whether one or more of these chemicals could have consequences for the maintenance workers, should they be released.

The website has four brief checklists outlining the most central safety-related questions to be asked during a shut-down. These checklists are in pocket-sized card form. One of these cards is to be filled in by those granting work permits; another is to cover the needs of the person carrying out the shut-down work. The third card is for members of the safety organisation and the last one is aimed at the plant's fire chief.

A thesis from the Emergency Services College, which deals with external emergency plans developed by Finland's fire brigades to deal with shut-down situations at major hazardous chemical installations (top tier Seveso-sites), is also available.

Finally, there are links to published papers and presentations covering various aspects of the research project.

Further development

The developers of the Seisokki tools briefly described above currently lack the funds to translate the guidebook and the tools into other languages, or to develop the tools further. However, the results of the study may be used by any organisation without charge. All comments and suggestions for improvements are welcome.

The Finnish research team did not study contractors' safety management systems, but our understanding is that, as a general rule, whenever there is a difference in the way safety is managed between the customer and the contractor, the former's safety management system is applied, even when the contractor's safety management system is more stringent than that of the customer. It was unclear to our research team how the contractors and the subcontractors fulfilled their legal obligation to be aware of, and minimise, the occupational risks that their employees are facing during shut-downs, and indeed during any kind of work carried out at various customers' sites. These aspects of occupational safety during shut-downs should, in our opinion, be investigated, as there is a risk that an optimal safety level will not be reached if the contractors aren't active in fulfilling their share (as employers) of the total safety management at plant shut-downs.

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7. Occupational risk prevention in a context of subcontracted maintenance

Use of subcontracting for maintenance operations has grown considerably in recent decades. Naturally, this applies to large process industries such as oil refining, chemicals and steel that wish to refocus on their core trades. It also applies to smaller industrial structures and to tertiary structures, an example being the use of external firms for doing maintenance in office buildings. Today, some would claim to have detected a return to having certain strategic functions such as instrumentation insourced, but the use of external firms for maintenance work (or for other tasks such as cleaning, caretaking, security and corporate catering) is firmly anchored in the way production is organised. Indeed, the re-insourcing trend is denied by others who, on the contrary, are predicting an ever-increasing growth in the use of subcontracting.

In terms of occupational risk prevention, such an organisational choice is not neutral. Although risk assessment remains the starting point for any occupational safety and health policy, the context is not the same when maintenance is always done in-house as when the work is done by external firms. This applies both from a regulatory point of view, since a specific legislation described in more detail below exists in France, and also as it relates to production: the workers from the external firm are not directly subordinate to the client's maintenance department, because the company manager of the external firm retains all his or her prerogatives.

A prevention plan, which is mandatory under all circumstances, must be established in writing when more than 400 hours per year of work is entrusted to an external firm, or when the work is deemed to be risky (as can be seen in a list published by the government). The aim is to organise, under the responsibility of the client company's manager, the prevention of risks related to interference between the various maintenance firms and the client as regards staff, equipment, or processes. The plan is based on a joint risk assessment. It is desirable for the occupational physician and the institutions representing the staff to be involved in the assessment. The assessment is more effective if the documents supplied early on by the client firm, during the consultation or bidding process for selecting the external firms, give precise indications to make implementation of the occupational risk prevention policy possible. The firm who wins the contract will thus have all the technical and financial elements, enabling it to work under healthy and safe conditions. However, continuous adaptation is necessary during the course of the work: the prevention plan should therefore be adaptable.

The prevention plan should also include working facilities for external firms, such as dedicated rooms or areas, cloakroom/ changing room facilities, toilet and washroom facilities. It should include information and possibly training which is specific to the structure of the site, such as details about access and utilities, alarm and evacuation procedures, a site plan and information about the particular risks of the site. Cooperation between the occupational safety and health structures of the various firms, in particular the occupational physician, may also be organised when necessary. For instance exposure (atmospheric or biological) may be monitored by the client firm, who is more used to managing any pollutants present on its site. Although company managers retain their respective prerogatives, it is also their duty to alert each other of any malfunctions observed in the other's system that might entail risks for some or all of the workers.

This legislative requirement has been applied for almost 20 years. It has clarified relations between the client and service providers and enabled significant progress to be made. It has also shown its limitations in certain situations. For instance, the regulations stipulate that the prevention plan should adapt continuously to adopt the working method and prevention measures that are most appropriate for each operation. In that respect, a document established at the time of the initial joint



Péter Temesvári, EU-OSHA photo competition 2009

inspection of the facilities, after the contract has been awarded, is insufficient. However, through a well-conducted overall risk assessment, it can be a valuable 'base' on which to build the risk prevention policy. Naturally, facilities and working techniques can change, and what applies at any given time will not apply in exactly the same way one week or six months later. The 'base' prevention plan should be updated to remain as finely tuned to the realities on the ground as possible, through a further risk assessment when authorisation for the external firm to perform a precise operation is given by a client firm's manager. That second assessment is not intended to replace the first. Its main objective is to check that no new element in the configuration of the work to be done might affect the cogency of the initial prevention measures. The idea is to check the relevance of the measures decided at the time that scenarios were being built, based on operation of the facilities and on the coactivity-related alterations that might be induced by maintenance.

The additional workload from such updating of the initial assessment before the maintenance operation is carried out can be significant. Hence certain trade unions point out that in some process industries, in particular during periods in which a lot of maintenance operations are carried out, the line management of the client does not have enough time to make all of the necessary checks on top of its own work.

The development of quality policies, in particular through safety management systems, has also had a strong influence on occupational risk prevention. Refocusing everyone's attention on occupational risk prevention, by making it a requirement to establish working procedures and precise modes of operation, has enabled firms to tighten up on, and to be more effective in, designing, performing, and monitoring the work that is ordered. This formalisation in writing facilitates exchanges and improves return on experience. One aspect of this quality policy does, however, appear less favourable: the setting up of quantitative performance indicators for occupational safety and health. This is because those indicators are often very strongly influenced by the various occupational accident rates. It is clearly in the interest of external firms to obtain the best possible scores for those indicators, and a doctoring of the figures has been observed in some cases. Mediocre scores can mean that the contract is lost or not renewed. Some external firms can therefore be tempted to conceal certain occupational accidents, and give workers who have suffered accidents 'lighter' or administrative positions if they cannot do their usual job, or pay them to stay at home until they recover. In this case, the client might not be aware of some accidents. Such practices are naturally contrary to the transparency and traceability principles on which the quality policies of the client firms are based. Worse still, they can mislead the client about the safety of its own facilities and call into question the effectiveness of its occupational risk prevention policies.

It is thus important for the clients, in order for them to continue to be in control of their facilities, to make sure that they are aware of any incidents that occur. It is the clients who should coordinate establishment of the prevention plans, and should thus have flawless knowledge of their own production

equipment. It is also important for the clients to maintain all the skills corresponding to the trades that they no longer performs directly, so as to reinforce that control. Such skills preservation must not be taken as a foregone conclusion. This is caused by the staffing levels of the client often decreasing in recent years. The practical knowledge of the facilities might have become poorer as generations of workers have retired, and the design office capacities, in particular, might have been reduced.

However, it is unanimously accepted that external firms are increasingly professional and technically skilled, in particular in the maintenance sector. Some of them have reached sizes greater than the sizes of the client firms, even though their geographical subdivision into local branches means that they might still operate like small businesses. Their practical and everyday knowledge of the facilities they maintain can make them partners of choice for clients who need to make alterations to the facilities, or to design new ones. They have often developed their own design offices to work on this type of project. Such work in partnership is very important: maintainability (like cleanability) of production equipment remains an essential prerequisite for setting up an occupational risk prevention policy that is consequential. The more the facilities are designed to accommodate their future maintenance, the simpler it is to establish the 'base' prevention plan and its update tuned in as finely as possible to the maintenance operation.

This concept of partnership and dialogue between client and external firms is important: they should cooperate and organise occupational risk prevention together. This does not diminish the responsibility for organisation that the regulations place with the client firm. Consequently, the Occupational Risk Prevention Department of the French Occupational Health and Pension Insurance Fund (CARSAT) of Normandy has established training courses devoted to risk assessment carried out jointly between the client firm and external firms. These training courses take place on the client's site. Based on everyday work situations of trainees, they aim to have common references adopted and to consider the work (and risk prevention) from an angle involving all the partners. In particular, the courses aim to give back visibility to maintenance operations and to show that they are an integral part of production.

The issue of exposure to chemical pollutants is also very important for maintenance workers. Their trade often means working during start-up, shut-down, or disrupted operating phases giving rise to potential exposure. Their work often requires them to remove or dismantle collective protective equipment, or else such equipment is not effective for the type of work they do. In addition to the potential pollution emitted by the facilities on which they are working, maintenance workers can themselves generate pollutants: for instance with welding fumes, or the degreasing of parts. It is often difficult and sometimes impossible to design specific collective protective equipment for such maintenance work. If, as a last resort, the use of personal protective equipment proves to be the only solution, choosing such equipment requires careful thought. Work rates should, in particular, be adapted to accommodate the discomfort or hin-

drance caused by wearing such equipment. For instance it is impossible to work as efficiently with a breathing mask on as without one. It should be clear in everyone's mind that if such discomfort or hindrance is not felt, the equipment is not being worn effectively and the worker then has a false impression of safety.

Assessment of such exposure often requires a measurement programme that is specific compared with that required for production staff, for example. Thus, as explained above, both pollutants and exposure conditions (in particular during start-up or shut-down phases, or during incidents) can be different.

Despite the various problems mentioned here, the use of external firms for maintenance in industrial environments takes place in a context in which a genuine culture of environmental and occupational risk prevention exists. Reception and

management structures organise the work of external firms. Conversely for maintenance in the tertiary sector, and in particular in office buildings, the context is much less favourable, even though the hazards are potentially fewer. Some studies do, however, show that the accident rate of tertiary maintenance staff is high and that it is often due to poor knowledge of the sites and of the associated risks. Few buildings have occupational risk prevention services and prevention plans are rarely drafted. In other words risk assessment is often only performed by the external firm, without that firm having the context data that should be supplied by the client. The files for facilitating subsequent work on the buildings are often not filled in properly, and the plans are rarely updated, and indeed they are too rarely supplied. Raising awareness in prime contractors of their obligations, and raising awareness in external firms of what they should be able to obtain from the prime contractors, are clearly avenues for improvement in making this type of maintenance work safer.

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8. Measures to improve cooperation between operators and maintenance staff

Introduction

Maintenance work is potentially dangerous. During maintenance tasks such as inspection, repair and overhaul systems may have to be opened, safety devices switched off and work needs to be done in hazardous areas. These are the main reasons why accidents happen during maintenance. For instance in Germany maintenance is associated with the second highest rate of fatal accidents at work (see Figure 1):

Complex nature of maintenance processes

Most companies have separate machine operators and maintenance staff. In addition, maintenance of buildings and in manufacturing industry is different from maintenance in process industry. In the building and the manufacturing industries the units to be maintained are or can be isolated from other processes, so maintenance staff do not necessarily need much information about the plant system and rarely come into contact with the machine operators.

However, in the process industry maintenance is frequently carried out while the plant is still in operation and has to be

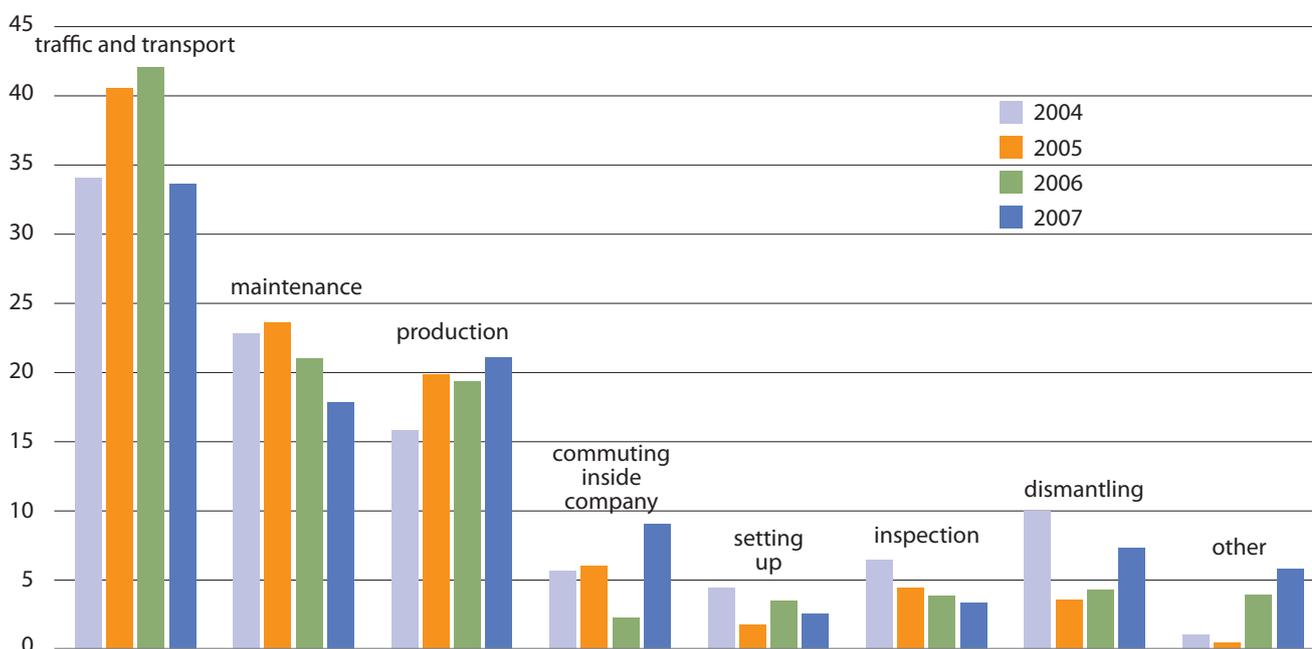
carefully planned in order to protect staff from hazards. Such hazards are, for example, dismantled safety devices or opened installations of the running plant. Cooperation between machine operators and maintenance staff is therefore essential for occupational safety and health, and bad communication can cause serious and even fatal accidents as the following examples show.

- One maintenance worker died while repairing a stirrer in a reactor, because an operator switched on the stirrer.
- Several employees were injured when an external maintenance worker opened a compressor under pressure.
- A maintenance worker was burnt by a hot substance while cutting a tube.

The accidents were caused by inadequate communication and coordination, so that there was insufficient information on:

- the presence of maintenance staff or other workers;
- general safety measures or regulations;
- safety devices and technology;
- the task and working area;
- the preparation of the plant for the maintenance work and permission to start the maintenance work;

Figure 1: Percentage of fatal occupational accidents 2004–07 by activity. Reference: BAuA database



- hazards related to the plant or to the hazardous substances present.

Accidents are not usually caused by maintenance workers not knowing how to do their job, but by lack of information on safety rules.

Most companies have safety rules for all staff and special procedures for maintenance tasks based on risk assessments. Large companies sometimes publish their general safety rules (http://www.vattenfall.co.uk/en/file/Code_of_Conduct_8459986.pdf), so maintenance companies can inspect the procedures before they take on a job.

Practical suggestions to improve cooperation between the staff and maintenance workers are given below.

Cooperation between operators and external maintenance staff

Usually, safety policies are laid down by the client. In most of the companies, occupational safety and health management is integrated in the maintenance strategy. The procurement policy of the company lays down the foundation for good conditions of safety at work. Essential issues are (Examples according to Ground et al., 2008; IET, 2009):

- time management,
- process and coordination of maintenance work,
- ergonomic work conditions.

The next step is choosing a maintenance contractor. Ideally, client and maintenance service provider should work together to align safety and health policies and to manage safety and health during maintenance in an efficient way, for example, through:

- setting up joint workshops on plant safety working conditions during maintenance,
- having on-site inspections of safe work processes and safety measures,
- introducing training to discuss general and specific safety rules.

The client's staff must know when maintenance is due to start and what time maintenance workers will arrive. A risk assessment needs to be carried out and preventive measures need to be developed. Maintenance workers must be informed about the results of the risk assessment and the preventive measures. Duties and responsibilities must be clearly defined and understood by all concerned in the process (see Figure 2). The duties, responsibilities, safety precautions and measures should be documented in work permits and counter-signed by safety representatives to confirm their completion. For corrections, additions or other variations, an additional risk assessment should be made by the person responsible for the approval process.

If unexpected incidents take place, the work must be stopped and a risk assessment made with the operators.

Afterwards, operators should check that the maintenance has been carried out correctly and test the plant. They should also ensure that nobody is in a hazardous area before the plant is restarted.

Companies with long-term maintenance contracts should monitor the work regularly with the help of the contractor, and improve the procedures where possible, particularly after incidents, near-misses and difficulties (See Figure 3). A root-cause-analysis (RCA) can be helpful to find out why errors have happened without attaching personal blame. This can expose organisational weaknesses and problems in the cooperation between the client and contractor during maintenance work, so practical solutions can be introduced.

Figure 2: Process of maintenance

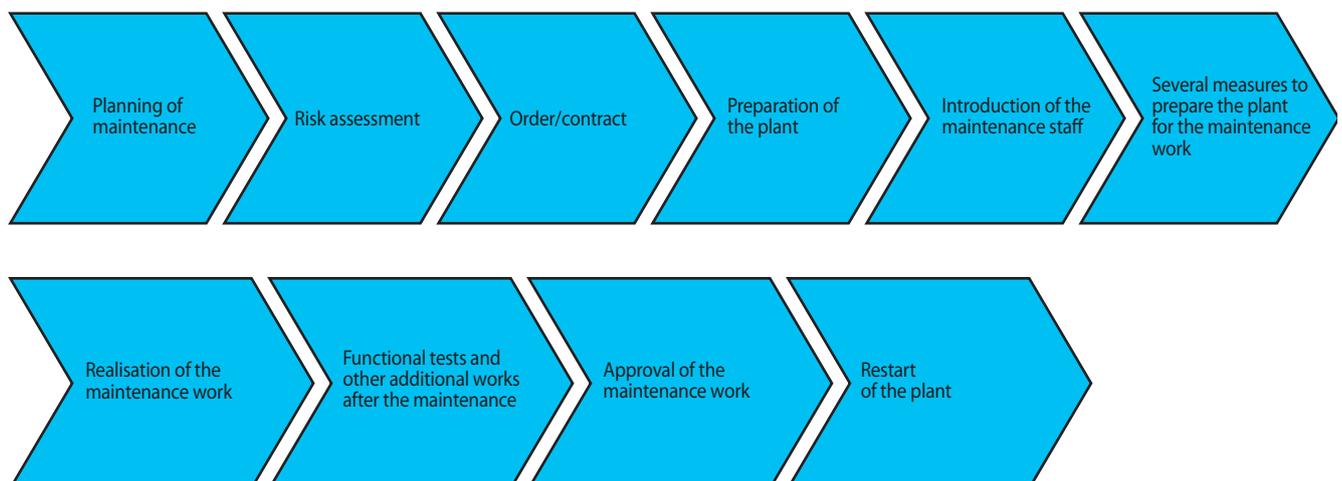
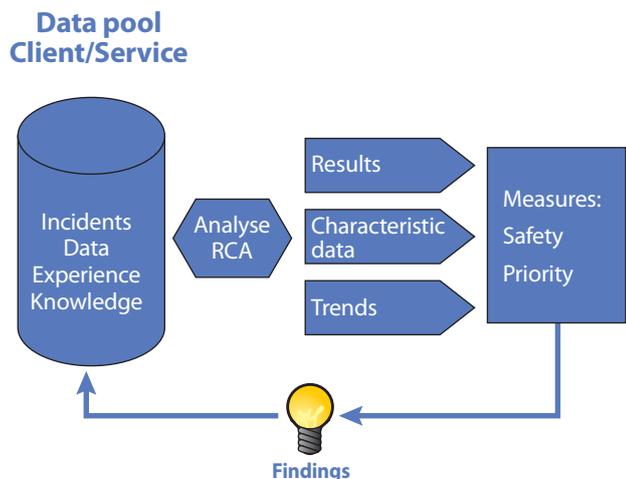


Figure 3: Improvement of maintenance process



Responsibilities

To ensure good cooperation and adequate communication between the client's staff/operators on the one hand and maintenance staff on the other hand, it is necessary to clearly define roles and responsibilities and assign the persons in charge (TRBS, 2010):

- the coordinator, if multiple maintenance tasks take place in one area;
- a person to oversee cooperation between operators and the maintenance staff;
- a supervisor for hazardous maintenance works;
- a contact person of the maintenance service provider.

The coordinator must make sure work can continue safely in areas where maintenance is not being carried out, and must deal with problems if they occur. The client's staff should be informed of all plans for maintenance and warned of hazardous areas. They should be told of any additional measures and procedures in case of incidents, such as emergency plans. If a critical situation occurs the coordinator must halt all work immediately.

The person overseeing cooperation between the client's staff and the contractor's workers must ensure safe working conditions for everybody. The overseer is also the contact for the maintenance contractor, and should provide feedback once the work has been completed.

The supervisor must develop measures for all hazardous maintenance work and control their implementation, taking ultimate responsibility for the safe execution of the maintenance work.

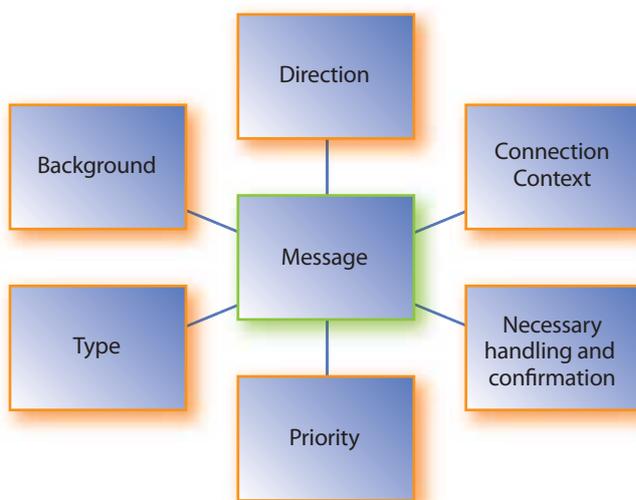
Those coordinating, overseeing or supervising work should be involved in discussions about how to implement safety rules and maintain sufficient work flow while taking into account time pressure and costs.

Preventive measures: management, technical support, human behaviour, training

Before work starts, maintenance contractors should undergo an induction, familiarising them with general safety rules and specific safety measures. New situations and unscheduled work must be discussed with coordinators, overseers and supervisors and an additional risk assessment has to be carried out. Sometimes it is best to suggest potential scenarios before work starts.

Workplace management, supervisors and staff should agree procedures for potential emergency situations in advance so they can be mobilised quickly if necessary, and maintenance staff should be informed of the procedures and trained. Verbal instructions during emergencies should be clear and concise. The first few words are vital and should include information on 'who, where, what, why, when' context. Video monitoring techniques within the workplace can help localise disturbances and detect the context of the breakdown.

Figure 4: Content of a message



Verbal messages can be disturbed by:

- bad reception,
- complex and unstructured expression,
- incorrect, too much irrelevant or not enough information,
- language differences.

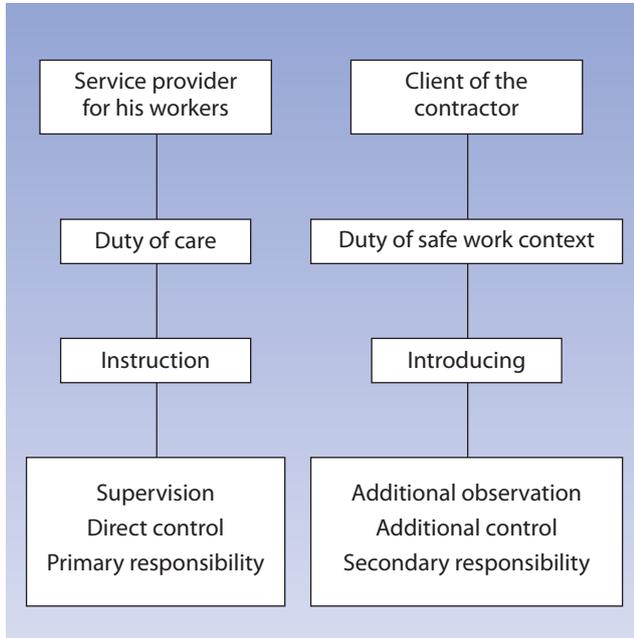
Operators and maintenance staff should be trained to deal with emergency situations, to be able to interpret critical situations and communicate adequately.

Messages can also be written and should follow agreed formats, with procedures in place to help the messenger. In modern installations the messages can be given via bus systems in a written form.

External contractors may not know the plant and work environment in detail. They may have different safety procedures

and use different safety terminology. This can complicate their communication with the client's staff and supervisors.

Figure 5: Employer's duty while employing contractors



Conclusion

Clearly formulated and structured communication is essential to coordinate work between the client's staff and the external maintenance service provider.

Modern technology can be used to transmit information quickly and clearly and to identify problems.

All stakeholders must be included in all safety communications. Meetings, joint training, etc. can help to improve the cooperation.

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9. Audiovisual Catalogue of Critical Situations: a powerful training tool

Developed within the framework of the Spanish pulp and paper industry's sectoral programme of occupational health and safety, Spain

In 2005, the Spanish paper industry launched a sectoral programme of occupational health and safety, under which a range of projects have been and continue to be developed, most notably the Audiovisual Catalogue of Critical Situations and Preventive Measures in the Pulp and Paper Industry, a powerful learning tool that provides the novelty of an audiovisual format plus the additional benefit of having been filmed at actual plants in the sector.



The audiovisual catalogue focuses on the operations considered as the most hazardous in the sector, such as working in confined spaces, working at heights, provision of maintenance and cleaning equipment, hot work and working with chemicals, most of which are performed by maintenance personnel. Proper coordination between maintenance and production staff is also considered a fundamental factor in this type of work.

Many mills in the sector (especially during the annual maintenance shut-down) hire specialised outside firms to carry out some of these jobs, so subcontractors are also targeted to receive these new audiovisual training materials. The question in hand is, basically, to ensure strict adherence to working procedures and to provide for equal levels of safety regardless of whether the workers are the company's own employees or outsourced.

Spanish pulp and paper industry's sectoral programme of occupational health and safety

The programme is sponsored by the Spanish Association of Pulp and Paper Manufacturers (ASPAPPEL) and the trade unions FIA-UGT and FSC-CCOO, and has just reached its fifth anniversary. It began with the 2005 Diagnosis of the Status of Occupational Health and Safety (H&S) in the sector, which is now

being reviewed in a project called HSE Diagnosis +5. The initial diagnosis revealed a number of areas for improvement, such as defining roles and responsibilities, preventive planning, safety inspections, training tailored to each job, the system of work permits, the adaptation of machinery to current legislation (RD 1215/97), and more. To cover these needs, a series of projects have been launched, such as the Model Guidelines for H&S Management Systems, the Manual for Improving Safety in Paper Machinery and the Audiovisual Catalogue of Critical Situations. These were launched with support and funding from the Foundation for the Prevention of Occupational Hazards, or the Manual of Observation of Safe Behaviour, funded by the Industrial Observatory of Paper Sector of the Ministry of Industry.

The Model Guidelines for H&S Management Systems provides companies in the sector with clear guidance on how to address prevention management and what tools to use to boost a stronger prevention philosophy in daily life at the mills, with the aim of increasing control over the hazards involved in the business. To implement the guide, which is constantly updated, a number of technical assistance programmes for companies have been developed.



The Manual for Improving Safety in Paper Machinery provides the industry with a wide range of solutions to address the problems of adapting its machinery to the provisions of Royal Decree 1215/97 (implementation of Council Directive 89/655/EEC of 30 November 1989 and Council Directive 95/63/EC of 5 December 1995). This represents a benchmark in the sector

based on the consensus of technical experts from the industry, manufacturers of papermaking machinery and specialist consultants who all participated in the project.



The Audiovisual Catalogue of Critical Situations is an innovative training tool specifically designed for the sector.

The Manual of Observation of Safe Behaviour seeks to create a true culture of safety, putting the focus on safe behaviour to encourage and create consolidated awareness about prevention.

Audiovisual catalogue: safety depicted in images taken from a standard working environment

This audiovisual catalogue is perhaps the most ambitious and complex project ever taken on by the Spanish paper industry's health and safety programme. It focuses on operations with the highest risks in the paper industry and on situations where the most serious accidents occur. These particularly hazardous operations are grouped into five areas: working at heights, working in confined spaces, allocation of equipment for maintenance and cleaning work, working with chemicals and hot work.

The catalogue is not limited to providing a repertoire of especially hazardous situations but also describes in detail the preventive measures to be taken in each case to avoid accidents and illness associated with such risky operations.

They say a picture is worth more than a thousand words. This was the thinking behind the choice of the visual format, given the power of audio-visual tools for catching and holding the audience's attention. The catalogue also includes the procedures to determine the method for issuing work permits for such operations, as well as training videos on the subject.

As the instrument that ensures proper implementation of the preventive measures required to complete any specific operation in hand, each procedure covers anything to do with work permits: their purpose and scope, description, administration and compliance, and there is even a template.

This template work permit can be downloaded and printed to be adapted to each company's corporate image. For its part, the training video uses imagery to define what this type of operation means, to specify which people are involved, to explain the details of the work procedure and the contents of the relevant work permit.

It therefore represents highly customised material to teach workers how to behave and act in a number of critical situations that may arise in mills and working environments similar to their own, thereby enhancing learning and awareness.

The goal is to make this material available to the sector for use as part of the health and safety training given to workers involved in such operations.

Catalogue stages of development

The training materials were developed in six stages, which involved information gathering, visits to mills, development of commonly agreed procedures and scripts, discussion groups to elicit the views of workers targeted for the material, film shooting and post-production, and finally communication workshops.

1. Information gathering from companies: companies were asked to provide information on the work procedures or standards in place at their mills relating to critical operations, to develop procedures that could be agreed upon across the sector and which formed the basis for the scripts.
2. Visits to mills: visits were organised to five representative mills or plants in the industry to spot-check the work procedures implemented for the chosen operations. Interviews were held with experts and group discussions with workers involved in those operations. The plants visited were Holmen Paper Madrid, Smurfit Kappa Nervión, Papertech, Europac Alcolea and Gomá-Camps. At the first four, interviews were held with engineers, while at the last mill, a panel discussion was set up with workers attended by SCA, Matías Gomá Tomás and Newark Catalana, as well as Gomá-Camps.
3. Development of commonly agreed procedures and scripts for the video recording: the draft procedures and script were written using the data collected from companies in the course of the visits to the mills, and were subsequently analysed and validated by both the project work group and the Steering Committee formed by ASPAPEL, FIA-UGT and FSC-CCOO and the Spanish Paper Institute.
4. Discussion group: once the scripts had been written and prior to the film shootings made at the mills, a second discussion group was set up to hear the views of employees about the materials developed so far.
5. Recording and post-production: the visual training materials were shot at a number of mills in the sector.

6. Communication workshops: the final product was presented at four separate workshops in different cities (Madrid, Bilbao, Barcelona and Valencia).

Development control and monitoring of the audiovisual catalogue: flexible and participatory structure

To ensure suitable monitoring throughout the project, the Steering Committee and the working group met regularly, and regular control meetings were also held with the consulting firm commissioned for the project.

- Steering Committee: made up of representatives from the employers association ASPAPEL, the trade unions FSC-CCOO and FIA-UGT, and the Spanish Paper Institute (IPE), it reviewed and validated all documents generated, it participated in visits to mills and monitored the overall progress of the project.
- Work group: formed by 20 technicians, experts in HSE and training, the group was commissioned to review and validate the draft procedures and the scripts used as the basis of the recording.
- Follow-up meetings with the project consultants: the IPE as the executive entity held regular follow-up meetings with the expert consultants hired to provide support for project implementation.

This gave the project a widely participatory structure which was the key to its success, enabling consensus throughout the process to design a tool that meets the real needs of business, enhanced by the numerous contributions from technicians and workers in general.

The difficulty in achieving consensus among experts from different mills lies in the fact that in Spain there are 95 pulp and papermaking mills with very different characteristics, including 10 mills with more than 300 workers and 47 plants with fewer than 100 employees.

	Number of plants	% of total
More than 300 employees	10	11
Between 200 and 300 employees	12	13
Between 100 and 200 employees	26	17
Less than 100 employees	47	49

Communication workshops: to boost implementation of the audiovisual catalogue in business companies

The Audiovisual Catalogue of Critical Situations and Preventive Measures in the Pulp and Paper Industry was presented at the third edition of the sector's Health and Safety Con-

ferences, which were held in Madrid, Bilbao, Barcelona and Valencia.

These sessions were attended by important figures in the field of H&S, such as Javier Esteban Vallejo, Director General of Labour at the Community of Madrid; Concepción Pascual, Director of the Spanish Institute for Safety, Hygiene at Work (INSHT); Francisco Marqués, Technical Sub-Director INSHT; Pedro Montero, Managing Director of the Foundation for the Prevention of Occupational Hazards; Alejo Fraile, Director of the National Centre for the Verification of Machinery; Jordi Martínez i Navarro, Director of the Occupational Health, Safety and Labour Conditions at the Government of Catalonia; Joan Guasch, Director of the National Centre for Work Conditions; and Román Ceballos, Director General of Labour, Cooperatives and Social Economy at the Government of Valencia.

The sessions were also attended by the promoters of the project on behalf of the trade unions: Joaquina Rodríguez, Secretary General of the Pulp and Paper, Graphics and Photography Sector at FSC-CCOO; Francisco Ligeró, Secretary of Occupational Health and Environment at FIA-UGT; José Luis Rodríguez, in charge of Occupational Health in the Pulp and Paper Sector at FSC-CCOO; Manuel Fernández Balanza of the General Secretariat for the Pulp and Paper, Graphics and Photography sector at FSC-CCOO; and Maria Luisa Cano, Occupational Health at FIA-UGT.

ASPAPPEL was represented in various workshops by its President, Florentino Nespereira, and the Director General, Carlos Reinoso. Iñaki Ugarte, Managing Director of the Basque Country Paper Cluster Association, also attended the conference held in Bilbao.

The presentation of the catalogue was made by Ines Chacón, who was at the time Project Manager of HSE at the IPE.

The sector's health and safety sectoral programme: collaboration and participation

The objectives of the sector's programme for the prevention of occupational hazards have been set out on the basis of the needs identified throughout the sector, so that the various projects undertaken have provided businesses with genuine work and consultation tools developed with their own active participation.

The technical forum, which was organised as part of the programme, and in which 75 technicians in the prevention of occupational hazards from 40 companies in the sector participate, has become the most important channel for sharing information, resources and experiences in this matter.

The Spanish paper industry's sectoral programme for the prevention of occupational hazards has been developed with the participation of sector employers, ASPAPEL, major trade unions — FIA-UGT and FSC-CCOO — and the Spanish Paper Institute. Given their inherent interest, several of the projects have also received

support and funding from the Foundation for the Prevention of Occupational Hazards, as for example this audiovisual catalogue.

Such participation and collaboration by all stakeholders is a fundamental principle of the Spanish paper industry's programme and is in the spirit of the recently launched European Social Dialogue between the Confederation of European Paper Industries (CEPI) and the European Mine, Chemical and Energy Workers' Federation (EMCEF), which consider the prevention of occupational hazards as one of the main issues to be tackled in joint collaboration. Furthermore, ASPAPEL's participation in the CEPI work group on safety and health allows for experience and information on best occupational health and safety practices to be shared among the European paper industry.



Communications, a priority of the programme

Fully aware of the importance of communications in a programme such as this, which is intended to be distributed as widely across the sector as possible, several activities have been

carried out over the past few years. These include a newsletter, of which 14 issues have been published to date, communications workshops and the implementation of free downloading facilities from the ASPAPEL website (<http://www.aspapel.es>) of sector-related documents developed within the programme.

The communications workshops, attended to by more than 300 people at each of the three editions held to date, have been instrumental in providing publicity for the various projects.

Since 2005, a newsletter providing updated reports on various activities within the framework of sectoral occupational health and safety has been published and distributed as well as being made available free of charge from the ASPAPEL website.

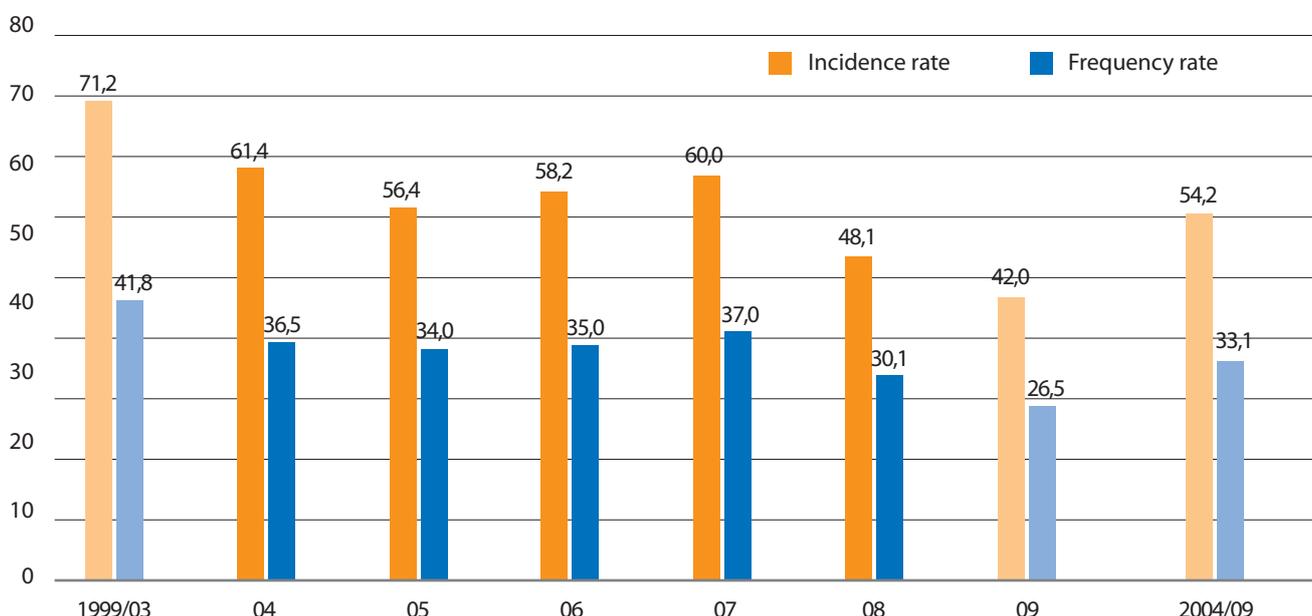
A programme for the future and for success

In the past five years the Spanish paper industry has developed a full series of projects which, like its Audiovisual Catalogue of Critical Situations, have led to significant progress being made in the control of the risks and hazards to which workers are exposed.

The projects carried out in the last five years have had a lot to do with the improvement in accident frequency rates in the sector, which went down from 36.5 in 2004 to 26.5 in 2009, while incidence rates dropped from 61.4 in 2004 to 42 in 2009. This accounts for an average reduction of 24 % in incidence rates and 21 % in accident frequency in the period 2004–09, compared to 1999–2003.

The participation and collaboration of different stakeholders at all levels is essential for boosting the implementation of preventive measures and achieving true reductions in accident rates in the sector.

Highlights of the main achievements of the programme are: the development of sectoral benchmark criteria; the significant



involvement of enterprises; the cooperation between businessmen, unions and workers; and the important work carried out to distribute and communicate the end-results.

The target now is to consolidate and build on these achievements of the Spanish paper industry in the next few years. That is the reason for the Health and Safety Diagnosis +5, which gives a new perspective for the future.

Such positive results are an incentive to continue working in new ways, in line with the needs identified in the Health and Safety Diagnosis +5. Some of the new projects to be developed in coming years are: the publication of a sector's simplified guide to occupational health and safety for small- and medium-sized enterprises, the creation of specific health and

safety benchmark scorecards and the development of behaviour guidelines in the sector to cover the systematic coordination of all different types of external contractors. Other new projects include the continued development of educational materials at a sector-wide level in line with the audiovisual catalogue, the publication of an analytical guide to hazardous jobs with concrete examples from the paper industry, and the drafting of a handbook with action guidelines for tasks, operations and activities in the paper industry that may require the presence of preventive action.

These new projects will enable the sector to further its excellent performance in reducing accident rates in recent years and to continue striving towards improved working conditions.

J.C. Blaise,

National Research and Safety Institute (INRS), France

10. Integrating maintenance into design: the machinery directive sets goals

Abstract

Safety during the production-related modes of operation of work equipment is relatively well addressed by the regulatory and normative guidelines. Work equipment manufacturers have been applying these guidelines since they emerged more than two decades ago. However, adjustment modes and maintenance-related modes are poorly integrated because they are relatively disregarded from the standpoint of safety. Accidents are therefore more likely in jobs other than production work. Two analyses of accidents and a study on formalising the maintenance process show the multi-causality of such accidents; equipment design is one of these causes. Regulatory requirements exist, as do standard specifications. However, it is necessary to get back to basics with these regulations to help designers take them on board.

The criticality of maintenance stems from various causes

Whereas a great deal of research has been done on ‘production’ work in firms, there has been little focus on maintenance activities. Yet, on analysing a number of studies, it appears that maintenance work is subject to a high accident rate. More generally, it has been observed that the risks related to work equipment tends to be shifted from the use equipment onto maintenance operations. While operating automatically, the equipment generally does not require any direct intervention from an operator. However, when, for any reason, there is a malfunction, the equipment often needs to be operated in degraded mode (semi-automatic or manual mode) with an operator being present or indeed when it fails completely, and then maintenance intervention becomes necessary. Furthermore, the increasing complexity of industrial machinery is changing the nature of maintenance: it is undergoing a radical transformation, with the equipment to be maintained becoming increasingly complex (for example mechatronics, where maintenance is needed for both the mechanical and electronic components). Finally, whereas traditionally, maintenance was performed by an independent and centralised department, or a unit with specialist operators, it is nowadays organised differently and takes many different forms. These include subcontracting, transfer of servicing tasks to users, geographically organised maintenance, more versatile (less specialised) maintenance operators, and other options. These organisational choices are not always without any consequences for safety.

We might also question the emphasis of the prevention measures. Although the repair stage might appear to be the most hazardous phase, is it right for us to focus all the safety measures on it? Could it be that the problem is to be found at an earlier stage, at the preparation phase, for instance? Whilst the preparation phase exposes the operator to almost no major risk, an inadequate preparation can be a decisive risk factor for the maintenance worker when maintenance work is being done on the equipment!

Isolation and energy dissipation: is it the only solution?

Similarly, and even further upstream, the characteristics of the equipment to be maintained are a decisive factor in performing the intervention or the maintenance work. A distinction can be made between intrinsic characteristics related to design, (for example the maintainability of the equipment), and the operating characteristics (for example whether the equipment is running during the maintenance). An analysis of 93 maintenance accident report cards from the EPICEA database reveals that 76 % of the accidents studied were caused by interventions on continuously operating machinery, or while machinery was being restarted (automatically or manually). Could those accidents have been avoided if the machinery had been deprived of its energy sources, in other words isolated from the power source? Would such isolation be possible? Certain types of intervention (for example diagnostics, testing and adjustment) need to be performed while the power is connected. Very often, isolation and energy dissipation is presented as the only solution. Yet this can lead to major constraints. Furthermore the level of safety that can be achieved relies on strict compliance with procedures. Machinery manufacturers’ instructions handbooks recommend isolation and energy dissipation for every maintenance intervention, without taking into account the real intervention conditions and the needs for such intervention. Usually this procedure is not applied because it is considered complex or costly to implement. In particular this is either because of the ratio of intervention time to isolation and energy dissipation time, or simply because the intervention requires the energy supply to be kept on. However, if provisions for a specific mode with associated safety measures were made at the machinery design stage, those safety measures would be simpler and perhaps more effective to implement than shutting off the energy sources. This is particularly true when such a shut-off is not applied, or is improperly applied.



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The essential requirements of the directive

In all cases, the aim, as defined by Directive 2006/42/EC is to secure a safe working zone for any intervention by the operator. It is thus incumbent upon the designer to make provision for safety measures for all of the operating modes of a piece of equipment. However, the technical solutions appropriate for such intervention are not necessarily self-evident for the designer, who might be tempted to shift the burden of safety onto organisational measures. In its Annex I, the ‘machinery’ directive defines the essential health and safety requirements relating to the design and construction of machinery. The requirements relating to maintenance are given a dedicated paragraph, but they are also to be found at various places in the text. We refer to the main ones below.

Paragraph 1.6 states that ‘Adjustment and maintenance points must be located outside danger zones. It must be possible to carry out adjustment, maintenance, repair, cleaning and servicing operations while machinery is at a standstill.’ If that is not possible ‘for technical reasons... measures must be taken to ensure that these operations can be carried out safely (see section 1.2.5)’. The cross-reference corresponds to the requirements related to selecting control or operating modes. It transpires that the cross-reference concerns, to a large extent, the concept of maintenance. The old directive (Directive 98/37/EC) stipulated that ‘for certain operations, the machinery must be able to operate with its protective devices neutralised’ and listed a set of conditions to be complied with. The new directive adds that ‘If these conditions cannot be fulfilled simultaneously, the control or operating mode selector must activate other protective measures designed and constructed to ensure a safe intervention zone’. From a ‘practical’ point of view, this represents progress because certain types of intervention can be performed only with the protective devices disabled, while the machinery is operating normally, without complying with the entire set of conditions listed by the text. However, the compensatory provisions translate, in certain standards, into implementation of organisational measures whereby safety relies solely on the training of the operator. Thus, a ‘hasty’ interpretation of this requirement paves the way to ‘bare

minimum’ measures, whereas the text requires other protective measures to be activated. To mitigate this, the National Research and Safety Institute (INRS) is currently conducting a study for proposing technical measures making it possible to satisfy this requirement.

Then, paragraph 1.6.2, relating to access to operating positions and servicing points, stipulates that: ‘Machinery must be designed and constructed in such a way as to allow access in safety to all areas where intervention is necessary during operation, adjustment and maintenance of the machinery.’ Naturally this requirement consists in providing a means of access, in order to make the operating positions safe from risks of falls. The ergonomic aspect of operating positions remains a crucial point in the working conditions of maintenance operators and needs to be reinforced. It should, however, be pointed out that making operating positions and servicing points safe applies to all risks, be they mechanical, physical, electrical, or anything else.

In paragraph 1.6.3, the directive addresses ‘Isolation of energy sources’ which is necessary for isolation and energy dissipation. Such measures are essential, but, as explained above, isolation and energy dissipation are not the only answer when it comes to intervention for maintenance.

Finally, in paragraph 1.7 relating to information to be provided, it is specified that the instruction handbook should indicate the types and frequencies of inspections and maintenance required for safety reasons. It should also, where appropriate, indicate the parts subject to wear and the criteria for replacement. This information is very important for future users so that they can define their operating modes and maintenance schedules.

Naturally, these requirements remain very general. Applying them is not always easy and they necessitate a non-negligible amount of thinking from the designer.

Conclusion

Safety for production-related modes is relatively well addressed by normative and regulatory guidelines. During the 20 years or more for which such guidelines have existed and have been evolving, work equipment manufacturers have been applying them. However, the other modes of operation, such as the degraded modes and the various states of machinery shut-down are relatively unstudied from the standpoint of their safety. They are neither defined nor characterised by manufacturers, whose objective is to build a machine that ‘produces’. The same applies to users who essentially see their equipment as means of production. The ‘non-productive’ modes lack prestige, and yet maintenance operations remain necessary. In addition to it being impossible to guarantee that machinery will not suffer degradation or indeed failure, machinery also simply needs to be serviced.

The ‘machinery’ directive sets goals for making equipment maintenance operations safe. But the major difficulty lies in how future needs for intervention on work equipment can

be taken into account at the design stage. In order to facilitate such identification, it is necessary to encourage dialogue between designers and future users through the drafting of specifications, or to seek feedback on experience from such users when it is available.

Another difficulty relates to making measures taken for one mode compatible with another mode. Hazards can differ depending on the mode of intervention; for the same hazard,

the protective means can also differ depending on the mode. Finally, one means of protection for one operating mode can be a source of harm or damage in another mode. Optimising the prevention solutions is therefore not easy and it is by risk analysis that we can organise prevention measures hierarchically and, if it is still necessary, we can prevent certain interventions from taking place unless the machinery is isolated from its energy sources, by using isolation and energy dissipation procedures.

Jean-Luc Clément,
STIB, Belgium

11. A maintenance site designed for safety

Summary

A considerable amount of planning and consideration of all aspects of the work organisation, equipment, work environment and staff has led to a design for a metro depot which guarantees maximum staff safety and welfare.

Introduction

The Brussels public transport company STIB designed its Jacques Brel maintenance site for trams and buses aiming to guarantee maximum safety for the maintenance staff. It is equipped with modern technologies and features that enable maintenance work to be performed in safe conditions. The concept of safe maintenance encompasses the safety and well-being of passengers and drivers, as well as maintenance workers.

The J. Brel site of STIB at Anderlecht covers 6 hectares with 1.5 hectares reserved for the metro depot. This contains an underground workshop, a depot and the equivalent of 3 km of railways.

J. Brel metro depot was opened in 2007. It was planned using the experience of Delta's depot, the first underground repository built in the 1970s. The J. Brel depot can accommodate 100 vehicles and has about 70 employees on day and night shifts. There are 48 people responsible for preventive and corrective maintenance, diagnosis of problems and reported damage to subway cars. Another 18 technicians are specifically assigned



By courtesy of STIB-Belgium

to projects, movement of vehicles in the depot and team management.

In order to guarantee maximum safety and welfare at work for employees the buildings' design, choice of work equipment including the latest technologies, work processes, plus organisational and individual training was discussed before the site was built.

Building design

The major risks identified within depots (warehouse) are the electrical hazards (900 V presence), the risk of accidents when using work equipment, the risk from moving vehicles and the risk of falling from high platforms.

Thanks to the 30 years of experience in Belgium's first underground depot DELTA, located in Auderghem, lessons were learned and used to develop safe and healthy facilities.

In the new depot, openings and outlets on the roof but also on the side of buildings substantially improve lighting by providing natural light, ventilation, fresh air exchange and heat and smoke extraction.

Various components of the depot have been designed to ensure safety:

- Platforms are protected by removable railings and the platform's floors are at the vehicle's height (no stairs and no gaps between the platform and the train).
- The reference level is the pits. Thanks to sufficient height and good lighting employees can move safely under the vehicle do inspections very fast.
- Connecting corridors, an underground corridor and metal walkways allow rapid movement of staff without any risk because these areas are entirely isolated from those where 900 V is present.

Equipment

Equipment and machinery were chosen to ensure maximum safety, particularly electrical safety. Here are some examples.

- Dust extraction from chests: a completely isolated pit was designed for this purpose. Workers clean the dust chests under the vehicle by blowing compressed air. They wear protective masques with supplied air. The dust is then sucked by a powerful suction system at the bottom of the pit. In

this way, workers and the rest of the workshop are protected from the dust.

- The car wash: the area for this automatic operation is closed off and away from electric power points.
- The lifting: a special system of lifting columns was developed, and to avoid accidents the raising or lowering of vehicles requires two operators on both sides of the vehicle. Their control units work in unison and, to lift a vehicle, it is necessary that the two workers operate at the same time their control units;
- The lathe: this is for re-profiling wheels. It is placed on a particular and isolated track and the equipment and power supply automatically cuts out when an employee enters the pit.
- Windscreen replacement: special equipment allows quick, easy and ergonomic handling and replacement of the vehicle's front windscreens.
- Command and control centre: a dispatch system tracks the movement of all trains and can control much of the depot's power supply and monitor emergency and dead-man reset buttons (see below).
- Electrically hazardous areas are separated from access corridors or gateways through interlocks: when these gateways are unlocked, the voltage is automatically cut off and areas with 900 V power supply are marked by a light system. Finally, the high voltage supply for moving trains is completely separate from the power needed in the workshop.

Working procedures

Apart from the safety instructions for each workstation, there are also general work procedures.

- The red disc rule is a lock off procedure: only the employee who placed the red disc on the equipment can remove it and reactivate it.
- Emergency calls and dead-man reset buttons: call buttons for emergencies and dead-man reset buttons are distributed throughout the depot. They need to be activated every five minutes by employees who are working alone in the workshop. All alarms are connected to the depot's control centre.

This can quickly send help if an emergency call is activated or if an employee does not activate the dead-man reset button in the time allowed.

- Procedure to access 900 V area: the entire workshop and depot are considered a 900 V area. Access procedure involves mandatory training for all staff on site, who must also pass a test. A badge is needed to access the depot, and this is time-limited.
- Visitors and subcontractors are routinely recorded.

Training

The staff's recruitment is not only based on technical skills but also on behaviour. Prospective employees must demonstrate a strong attention to safety-related issues. In addition to the 900 V access training, they are accompanied on their first day by the safety engineer or his assistant for an in-depth workshop visit when all on-site risks and procedures to avoid accidents are pointed out.

Technical training and driving training is on-going, through the BU metro's training centres. This is certified ISO 9000. Each employee has an estimated 80 hours of training every year.

The members of staff are required to be versatile, so they can rotate between different stations. This prevents over-familiarisation with tasks and a disregard for safety.

Conclusion

Since the site opening, three years ago, 16 minor accidents were notified on the J. Brel subway's site. These have only been superficial injuries caused by falling or slipping on wet surfaces at the car-wash or by the mishandling of tools. Each of these accidents has been analysed and preventive or corrective measures have been implemented to avoid recurrence.

For STIB, safe maintenance procedures guarantee the safety and welfare of passengers and workers.

W. Vancauwenberghe,

Belgian Maintenance Association VZW, BEMAS, Belgium

12. On the way to safe maintenance

During 2010–11, the European Agency for Safety and Health at Work (EU-OSHA) is running a European Campaign on Safe Maintenance. In Belgium the Federal Public Service Employment, Labour and Social Dialogue (FPS ELSD), EU-OSHA Focal Point, is leading the way. In this framework PreBes, BEMAS, Arcop, Agoria, and Febelsafe have collaborated to set up a Belgian campaign project with the goal of reducing maintenance-related safety accidents by 10 % in two years to, in the long term, ultimately reach zero accidents.

In order to achieve this goal, they must map out the current maintenance accident figures in Belgium. A survey is currently underway. More on the results of the pilot phase can be found below.

What is maintenance?

Maintenance is a wide range of activities, aiming at keeping machines, buildings, traffic infrastructure, computer programmes, even nature, in an acceptable condition. Maintenance is necessary in the home and at work. Maintenance is required, for example, on entire production installations at chemical companies or nuclear power plants, on railways and trains and in office buildings. German studies show approximately 10 % of the gross national product is spent on maintenance. In industry, depending on the sector, 3 to 5 % of the company turnover is spent on maintenance.

Competent people are needed for all these maintenance tasks. The Belgian Maintenance Association (BEMAS) estimates that 65 000 employees in Belgian industry are maintenance workers. This safety campaign is therefore directed at a very substantial target group.

Contrary to what many may think, maintenance entails much more than just repairing breakdowns. These days, maintenance aims to continuously improve the reliability of the machinery. In particular, maintenance aims toward a high availability of machines and optimising maintenance expenses.

We differentiate between four important types of maintenance.

- Reactive or failure maintenance: repairing disruptions technical problems are solved so the machine functions correctly again.
- Periodical maintenance: certain tasks carried out at a prescribed frequency or after a particular amount of working hours.
- Predictive maintenance: maintenance interventions after an inspection to see whether or not certain maintenance works

need to be carried out. Periodical and predictive maintenance together form preventive maintenance.

- Proactive maintenance: improvements to permanently prevent certain disruptions, for example adapting the design, selecting other materials and components.

Impact of maintenance on safety

Everyone agrees that the condition of an installation has an important impact on the risk of incidents. Unfortunately, maintenance only hits the headlines when something goes wrong. A recent example is the catastrophe at BP's drilling platform Deepwater Horizon in the Gulf of Mexico on 20 April 2010. Eleven technicians died in the accident. Several months before the catastrophe, an audit showed that 390 important maintenance tasks had not been carried out. Also, a large number of critical systems did not function correctly or did not function at all at the time of the explosion. This is said to be the case with, among others, the blow-out preventer (BOP), which normally prevents oil from the oil field leaking out in case of problems.

Poor maintenance can thus have very serious consequences for man and the environment as well as for a company. Just take a look at the prices for shares in the BP oil company. Unfortunately, this is not an isolated incident and serious accidents can also occur even closer to home. A recent study in the Netherlands shows that 12 % of 420 respondents are concerned about the technical condition of their company's equipment. Of the technical managers of capital-intensive companies, 7.6 % estimate the chance of a serious incident occurring is realistic. There is no reason to think the situation in Belgium is any better.

Safety figures in maintenance

The safety organisations PreBes, BEMAS, Arcop, Agoria, and Febelsafe are conducting research into the Belgian safety figures regarding maintenance employees. We would like to use this to create a basis for possible improvement projects. Below, we discuss the results of the pilot phase, based on the answers provided by 81 production companies with a combined total of 44 724 employees and 4 024 maintenance technicians. The table below shows the average annual figures for 2008 and 2009. In the sample group, the province of Antwerp (33 %) and the companies with more than 500 employees (66 %) are over-represented. This means that we see very good safety figures because a great deal of Antwerp's chemical companies, which traditionally have very good safety results, took part in the survey. Table 1 shows the accident figures.

Table 1: Accident figures

Number of fatal industrial accidents annually	7.5
Number of fatal industrial accidents with maintenance technicians	6
Number of accidents resulting in disability annually	611
Number of accidents resulting in disability with maintenance technicians	127
Number of days of disability annually	5 576
Number of days of disability with maintenance technicians	2 089

Of course, it only really becomes interesting when we translate these figures into the degree of frequency and actual degree of severity. A degree of frequency means the number of accidents per million exposure hours. The actual degree of severity is the number of calendar days lost per thousand exposure hours. The average degree of frequency among all Belgian economic activities is 24.66. The average degree of severity is 0.59. The results of these calculations can be found in Table 2.

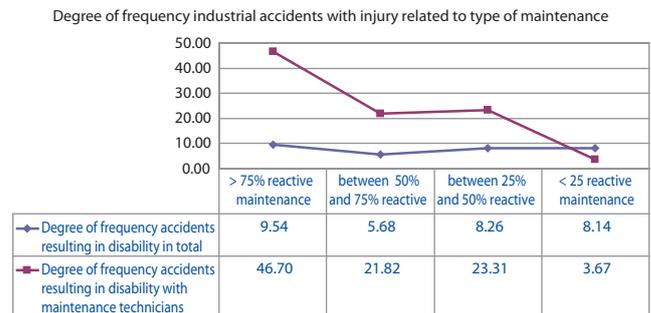
Table 2: Degree of frequency and actual degree of severity

Degree of frequency of fatal industrial accidents for all employees	0.10
Degree of frequency of fatal industrial accidents with maintenance technicians	0.86
Degree of frequency of accidents resulting in disability for all employees	7.94
Degree of frequency of accidents resulting in disability with maintenance technicians	18.15
Actual degree of severity for all employees	0.13
Actual degree of severity for maintenance technicians	0.28

What is striking is how low the figures are for the degree of frequency and the degree of severity for all employees in the sample group in relation to the national average. As mentioned earlier, this is the result of the relatively high number of chemical companies that took part in the survey. Therefore, the figures discussed further are those of good to very good performers. Table 2 also shows that the risk to maintenance technicians of having an accident resulting in disability is double that of the average employee of the company. In addition, the accidents are twice as severe.

Figure 1 shows the degree of frequency for accidents with disability according to company size. It appears that employees of a small company run a much higher risk of having an accident than the employees of a large to very large company. This confirms the results of other studies, which indicate small- and medium-size

Figure 1: Degree of frequency industrial accidents with injury related to type of maintenance



enterprises (SMEs) as a risk group. What is also striking is the very high degree of frequency of accidents resulting in disability for maintenance technicians in SMEs, namely 83.94. This means that annually in an SME, one technician in seven will have an accident resulting in a disability and that every technician will have six accidents during a 35-year career. Compared with a colleague working for a large company with more than 1 000 employees, the risk of having an accident is eight times higher.

Type of maintenance determines the number of accidents

In the survey, we also enquire about the type of maintenance commonly carried out in the companies. These results are shown in Figure 2.

Figure 2: Degree of frequency accidents with injury related to number of employees



When we look at the global accident figures of the companies, we see there is no connection between the type of maintenance and the degree of accident frequency. However, when we look at the degree of frequency for maintenance technicians we see a very high correlation. In companies with more than 75 % reactive maintenance, the maintenance technician faces a degree of frequency of 46, an accident risk five times higher than the average accident figures indicate.

However, when it is mainly preventive maintenance being carried out in the company (less than 25 % reactive) the same

technician's risk of having an accident is only half as high. In other words, if you work for a company with mainly disruption maintenance (unfortunately, this is often still the case in companies), then you have a 12 times higher risk of an accident than a technician working in a company where mainly preventive maintenance occurs. This is in fact quite logical, as reactive maintenance is by definition unprepared and often has a short deadline. This inevitably leads to dangerous situations.

An important conclusion we can already draw from this is that if we want to decrease the number of maintenance accidents we must focus on switching from reactive to preventive maintenance. This will not only please maintenance staff and safety supervisors, but financial directors as well. A great many studies have shown that a scheduled maintenance task is much cheaper than an unscheduled maintenance job.

Figure 3: Degree of severity of accidents

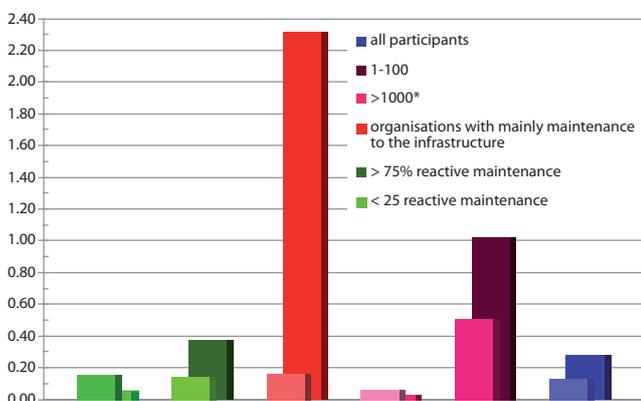


Figure 3 shows a repetition of the same correlations in the degree of severity. A peak is the degree of severity of accidents with maintenance technicians in organisations where maintenance is mainly required for the infrastructure. With an actual degree of severity of 2.32, this type of maintenance belongs in the high-risk industry table. This sector includes the extraction of minerals (degree of severity 2.02) and the wood industry (degree of severity 2.39). Every infrastructure maintenance technician is absent an average of 3.5 days per year as the result of an industrial accident.

Conclusion

The first results of the survey indicate that there are certainly increased risks for maintenance technicians in the area of safety. The safety results of the large companies are proof that there is room for improvement. The fact that these large companies carry out scheduled maintenance undoubtedly plays an important role. Those who actively wish to decrease the number of accidents among the technicians in their organisation must chiefly aim to reduce disruption maintenance. In addition, those who invest in the reliability of the machinery via a proactive maintenance programme not only reduce the risk of serious incidents, but they also reduce the number of maintenance interventions necessary. Result: even fewer accidents.

In short: safety and maintenance = allies in the fight! More on BEMAS at <http://www.bemas.org>

Ludwig Grubauer,
Maintenance Society (MFA), Austria

13. MFA survey on the topic: employment safety for maintenance workers in Austria



How safe is your job?

This recent survey initiated by the Maintenance and Facility Management Society of Austria (MFA) provides interesting data regarding safety in Austrian companies, especially in the area of maintenance. The online survey was launched in Austria during the European Campaign 2010–11 on safe maintenance.

A joint questionnaire was put together through the Association for Job Safety (VAS), the Public Accident Insurance Institution (AUVA) and the technical safety centre Andritz Hydro.

Between July and September more than 2 200 Austrian companies, and particularly small- and medium-size enterprises (SMEs), were contacted by e-mail and asked to participate in the online survey. This request was supported by a professional article in the magazine *Sichere Arbeit* (Work Safety). Almost 300 businesses took part in this survey and answered the 30 questions related to job safety in their business as a whole, maintenance tasks for job supervisors and other entrusted personnel.

Alarming results

The results of the survey were finally brought to light and then discussed intensely during a special event for the Federal Ministry of Labour, Social and Consumer Protection (BMASK) in Vienna, on 14 October.

According to information presented by the European Federation of National Maintenance Societies (EFNMS), 25 % of all job-related accidents are associated with maintenance work. The MFA is taking on the responsibility for collating current data for the Austrian companies in order to initiate specific programmes and bring about targeted measures.

Guidelines for the future

The advantages of structured safety management with clear responsibilities, systematic analysis of near-accidents, as well as removing weak spots and enforcing regular use of personal protection equipment (PPE), are becoming increasingly evident.

The spread of usage of PPE in conjunction with eye protection is certainly a favourable development. Of those asked, 98 % used hand and eye protection during maintenance work. The optimisation potential here is also apparent. Almost half of those interviewed admitted not using respiratory protection, and close to a third (31 %) used no head gear.

Increased planning in maintenance clearly indicates positive results in work safety. As well as improving performance, job safety is enhanced through the increased use of planning tools and the involvement of maintenance service providers in risk management early in the procurement stage.

The survey showed that 84 % of those responsible for maintenance are involved in the procurement of new plant so that technical safety requirements for future repairs are taken into account. Nevertheless, this means that one in six plants is purchased without considering maintenance safety.

Workers participation and information

Workers need to be assigned active roles in risk management (identifying hazards and risks, establishing measures, testing for effectiveness). In this way, a sense of conscious scrutiny can be established concerning risks and hazards in the workplace.

Often, the significance of workers information and training is taken too lightly. About 40 % of those surveyed answered no to the question: 'Are the employees informed systematically about new legal reforms?' Almost 14 % admitted that the employees have not been made aware of the results of risk assessment and of the preventive measures. This is not just small businesses. Approximately 80 % of these companies employ more than 100 employees, and they also hire their own safety specialists.

The results of the survey are not representative of all Austrian businesses, but they shed a different light on everyday conditions. Nevertheless, the survey is the first element that should — in the framework of the European Campaign —



result in lasting improvements to provide worker safety in the area of maintenance.

The MFA — maintenance and facility management society of Austria

The goal of this non-profit organisation is an international practice-oriented exchange of knowledge between business and science in the area of maintenance, facility management and technical service.

The MFA sees itself as an information and communications platform that offers their members a wide assortment of special services. The association is the official Austrian representative in the European Federation of National Maintenance Societies (EFNMS) (<http://www.efnms.org>).

The MFA supports their members by exchanging experiences and building upon (mutual) knowledge in maintenance and facility management. MFA members profit from numerous cooperation and special conditions (for example rebates on professional seminars), best practice events, negotiation activities, and other benefits.

All information concerning MFA is available at <http://www.mf-austria.at>

You can obtain the presentation of the survey results, in addition to photographic material that is available for free use, in the listing MFA-PressInfo at <http://www.mf-austria.at>

You may obtain details and information about the survey results and additional specific measures (office@mf-austria.at or at <http://www.mf-austria.at>). For any questions please contact the survey coordinator DI Ludwig Grubauer (umfrage@mf-austria.at).

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14. Guidelines for inspecting the physical condition of industrial safety helmets

Introduction

These days many workplaces involve risks associated with mechanical hazards, for instance mining, energy production, construction, forestry, warehouse management or communications. The risk of head injuries is significant. Data published by the Central Statistical Office (2009) and the National Labour Inspectorate (2008) concerning work-related accidents indicate that most head injuries are caused by falling objects, impact against sharp and hard objects and crushing by moving large objects.

Injuries range from skin abrasions to damage to the skull, the brain or the cervical vertebrae. In extreme cases, these injuries may lead to lasting disability or even death.

It is not always possible to eliminate mechanical hazards by using collective protective measures, such as engineering or administrative controls. In many cases, personal protective equipment in the form of industrial safety helmets is the only possible way of protecting workers from head injuries (EN 397:1995).

Helmets must have appropriate protective qualities and fulfil their purpose properly. This is ensured through:

- structure and materials;
- type testing and certification, performed by a notified body to conform with Council Directive 89/686/EEC (implemented by the directive of the Minister of the Economy, dated 21 December 2005 on the basic requirements for personal protection equipment) (see References below);
- the manufacturer's quality control.

During the period of use, inspection of the physical condition of the helmets and maintaining their protective capacity mainly rests on the employers who have supplied their employees with such equipment. In order for this supervision to be effective, monitoring must be performed on two levels:

- directly before each use (performed by the user after appropriate training);
- periodically (performed once a year, for example, by a competent person who has been especially trained within the workplace, or an authorised service directly by the manufacturer).

The user's inspection is especially important as it allows spotting damage that causes loss of protective parameters. Inspecting a safety helmet requires the user to have relevant knowledge. Basic information is in the user's instructions manuals, which are included with the helmets. However, descriptions of potential damage are very general in these manuals and do not cover specific examples. This means the person performing the inspection is not able to evaluate if a change is significant or not. To solve this problem the Central Institute for Labour Protection-National Research Institute produced guidelines in 2008 within the National Programme on Improvement of Safety and Working Conditions (see References below). Its main goal is to help workers to inspect their personal protective equipment, including industrial protective helmets. This article presents selected information prepared as part of this task.

Evaluation of the physical condition of industrial safety helmets

Periodic evaluation of the physical condition of safety helmets should begin with checking whether the manufacturer's guarantee has not expired. The inspection should be performed on the basis of the manufacturing date stamped on the shell and entered in the user's manual supplied by the manufacturer. If the time indicated by the manufacturer has passed, the helmet should be withdrawn from use regardless of its appearance.

Checking the shells of safety helmets

Checking the physical condition of the safety helmet shell is very important in evaluating its suitability for use. The shell is the exterior part of the helmet. Its fundamental task is to cushion the impact of a dangerous object, by reducing its force and spreading its effects to the helmet's harness. The shell shields the user's head from the dangerous object. Helmet shells are produced from different types of plastics, for example polyethylene, ABS plastic and polyester glass fibre laminates. These degenerate over time, especially when exposed to sunlight (Baszczyński, et al., Mewes, 1998). One of the main effects of the ageing of plastics is its increasing brittleness. This may occur in safety helmets in the form of quiet crackle, noise audible when light pressure is applied. In order to check for this, a helmet should be taken in both hands (see Picture 1) and squeezed lightly.

Picture 1: Checking for crackle noise in the helmet shell



The crackle noise of helmet shells may indicate degeneration of the shell material and the creation of micro-fractures, which indicates the loss of the helmet's protectiveness.

Clearly visible shell damage also indicates a helmet has lost its protectiveness. The most important kinds of such damages include:

- surface cracks and cracks across the entire thickness of the shell;
- deformations which can be identified visually;
- local fading and discolouring of extensive areas (over 10 %);
- deep abrasions of extensive areas (over 10 %);
- chip-offs from the shell materials in extensive areas (over 10 %) or ones which result in sharp edges;
- chips or dents to helmet edges which result in sharp edges.

Examples of damage which would require a helmet to be withdrawn from use are illustrated in Pictures 2 to 6.

Picture 2: Fractures of the shell



Checking the helmet harness

The harness is an internal part of the helmet, connected to the shell with special attachments. It is usually a strip moulded with low-pressure polyethylene injection, or it is made of textile strips. The purpose of the frame, which rests on the user's head, is to absorb the impact energy on the shell and to spread the impact over the largest possible area.

Picture 3: Deformation of the shell



Picture 4: Faded areas of the shell



Picture 5: Shell chipped over an extensive area



Picture 6: Ragged edges of the shell



The main aim of checking the physical condition of the helmet harness is to ensure that it is connected to the shell. That is why the helmet shell must be held with one hand, while the

fist of the other presses onto the frame (see Picture 7). During such an inspection, it is important to check that neither the shell nor the strips are separated from the harness. Otherwise, the helmet must be withdrawn from use.

Picture 7: Checking the helmet harness



The physical condition of the harness and its connection with the helmet harness indicate other changes that the user can easily see. The most significant is damage to the harness fastenings or the connectors located on the shell (see Pictures 8 and 9)

Picture 8: Damage to harness fastenings securing the frame



Picture 9: Damage to harness fastenings



Equally dangerous to the user is damage to the harness strips. Examples of such damage, in the form of cuts and tears of the seams, are shown on Picture 10.

As a result of damage sustained during a significant impact to the helmet, such as a falling object, the helmet shell may come into contact with the user's head, thereby transferring most of the impact's force to it.

Picture 10: Damages to the harness strips



Inspecting the headband

The headband encompasses the user's head from the forehead around to the base of the scull. This, combined with the harness, makes the helmet stable on the user's head. The headband has two adjustable elements:

- the depth of position within the shell (an appropriate height of the helmet from the user's head);
- the length (the adjustment of the helmet to the circumference of the user's head).

Inspecting the physical condition of the headband should start with checking its fastening to the helmet shell. To do this the headband should be grabbed with one hand and the edge of the helmet with the other. Then the movements shown in Picture 11 should be performed to check that the headband does not separate from the shell of the helmet and that none of the straps adjusting the height are damaged. If there are any such defects, the helmet has to be withdrawn from use.

Picture 11: Checking the fastening of the headband to the helmet shell



Next, check that the length of the headband does not change in an uncontrolled manner. To do this, take the headband with one hand, as shown, so that the adjustable element can be tightened and stretched (see Picture 12) and to make sure the

movement does not cause changes in the length of the headband. If this is so, the helmet should not be used.

Picture 12: Checking the stability of the headband setting



Chin strap

The chin strap is an additional piece of equipment for industrial safety helmets. It ensures that when workers move their heads the helmets do not fall off. To be effective the strap's fastening points to the shell (or the harness) must not be damaged, and the length adjustment should allow for loosening the strap when necessary. To check the physical condition of the strap, hold it between fingers and thumb and pull to make sure it does not change its position and to check that the mounting points hold their ends (see Picture 13).

Picture 13: Inspecting the chin strap



During the inspection, it is important to watch out for mechanical damage to the strap itself, as well as the plastic elements with which it interacts. Examples of such damage are presented in Picture 14.

Picture 14: Damage to the elements of the chin strap



Elements of the helmet coming in contact with the user's head

When inspecting the physical condition of the safety helmet, the elements coming into direct contact with the user's scalp and hair should be checked for contamination and cleanliness. This includes: the frame, the main strap with the sweat-absorbing pad and the chin strap (see Picture 15). If these are dirty or contaminated they may cause skin irritations or even sickness.

Picture 15: Heavy contamination of the safety helmets' frame and sweat pad



Contaminated or dirty helmets must be cleaned in accordance with the manufacturer's recommendations. Alternatively, contaminated elements should be replaced with new ones.

Summary

Industrial safety helmets can perform their functions only when their physical condition is good. The described inspection methods and examples of damage are for information purposes; they should be used only in combination with the instructions provided by the manufacturer.

The physical condition of the helmets should be visually inspected every time they are used, while manual checks (the crackle noise test of the shell, harness connections of the headband with the shell, the settings of the headband and chin strap) should be performed depending on the intensity and conditions of use. This should take place at least once a year.

In addition, regardless of the physical condition checks, safety helmets that have been subjected to a severe impact should be withdrawn from use whether damage is visible or not.

More information on these issues in Polish language is available in CIOP-PIB websites, including information on inspecting the condition of the following personal protective equipment:

- industrial protective helmets,
- equipment protecting against falls from a height,
- eye and face protection equipment,
- protective clothing,
- protective gloves,
- protective footwear,
- respiratory protective equipment.

This information will be in the form of files that can be downloaded and printed or played back in the form of a presentation. They are for users of personal protective equipment; for employees of occupational health, hygiene and safety departments monitoring the use of these materials in work places; and to manufacturers who should use the materials when preparing instructions on servicing their products.

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