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A HUMAN SAFETY APPROACH TO SAFE MAINTENANCE

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Abstract

The deterioration of the technical condition of plant equipment is a common phenomenon today. This is increasingly contributing to breakdowns and accidents, according to the experience of national and international authorities. Plants that are operating with an inadequate maintenance strategy are nowadays approaching the end of their design life and thus represent an increased risk of accidents. Ageing processes are often accelerated by operators' underestimation of the effects of stresses and strains on equipment and the extent of degradation mechanisms, and consequently by inadequate design and operation of condition monitoring and maintenance procedures. The aim of our work is to investigate domestic and foreign trends in the light of modern maintenance optimization methods and to make related recommendations for optimizing maintenance scheduling for domestic employers.

Keywords: *maintenance, occupational safety, human safety*

1. Introduction

Maintenance has always been present from the very beginning of industrial activity, and the use of technology in the service of installations has always required the reliability of the equipment to perform the exact task for which it was designed.

This fact has always been present since the industrial revolution, but the way we understand maintenance has changed over the years. It can be said that maintenance has been around for four generations. In the first generation, the maintenance organisation only corrected faults, using purely reactive management. Over the years, preventive and predictive maintenance (RCM, TPM, etc.) has progressed and with the implementation of all these, the system has reached proactive work management awareness (Grusenmeyer, 2014). This leads to an interruption-repair routine and the concept of failure analysis is introduced in order to establish corrective actions that will minimize the failure rate in the

future. This fourth generation, starting in the late 1980s, developed this concept of proactivity (González et al., 2015).

2. Human error, engineering reliability

Reliability is present in the maintenance work, in its origin, since the lack of reliability causes failures, and in the implementation itself, since the repair must guarantee the future reliability of the installation. In this sense, it is worth considering reliability as a concept broken down into four elements: (Figure 1).

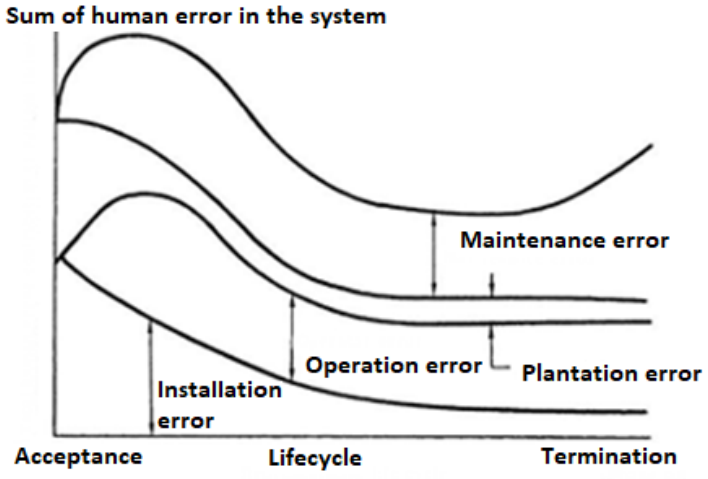

Figure 1. *Distribution of failure types over the maintenance life cycle (Christensen et al., 1980; EU-OSHA 2010)*

Ultimately, human reliability is closely linked to the concept of human error. Norman distinguished between two types of errors: slips and errors (Norman et al., 1980), to which Reason assigned error types (Figure 2) (Reason et al., 1990). An error is an error created by making a wrong decision in the planning stage, while a slip is an error in the execution stage, naturally also due to making a wrong decision. Therefore, slips generate a situation that prevents the proper execution of the activity, while lapses appear as omissions in the planned operations. Slips and lapses are unintentional errors, while mistakes are intentional. In addition, there are errors that Reason has identified as violations corresponding to intentional non-compliance with norms, which by their nature are left out of the engineering analysis of human reliability (Oraez et al., 2019).

All of these processes are part of the engineering part of human reliability and all of them need to be included in an analysis method or model.

There are two main types of maintenance:

- preventive (proactive) maintenance - performed to keep the object of maintenance in working order; this activity is usually planned and scheduled according to the manufacturer's instructions;
- corrective (reactive) maintenance - the restoration of an asset to working order through repair; an unscheduled and unplanned task that usually involves greater hazards and risks than preventive maintenance.

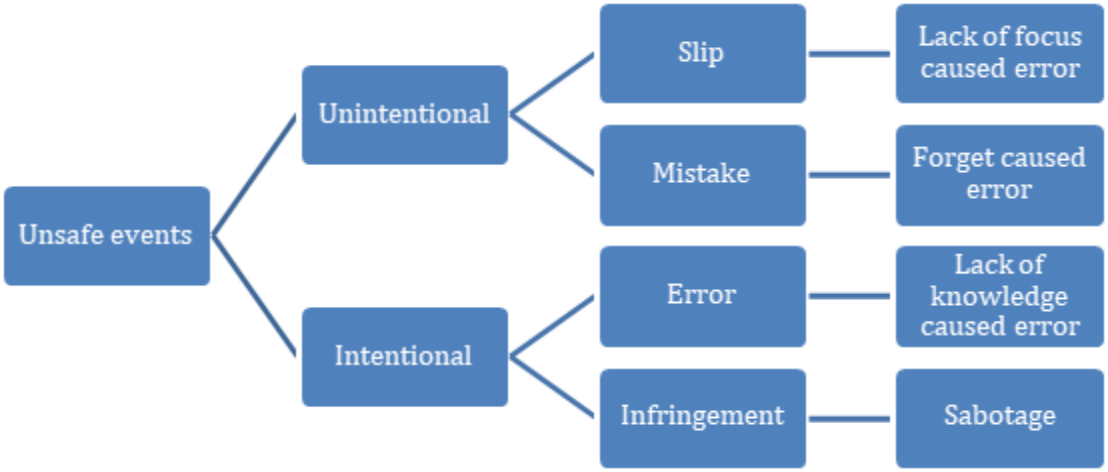

Figure 2. *Categorisation of fault types (Norman et al., 1980; Reason et al., 1990)*

Maintenance is carried out in all sectors and almost all professions - so it is not the exclusive domain of technicians and engineers. Maintenance workers are therefore exposed to a wide variety of hazards, which can be chemical, physical, biological or psychosocial. Workers may be exposed to the following risks:

- the development of musculoskeletal disorders due to working in unusual postures, sometimes in difficult environmental conditions (e.g. cold);
- exposure to asbestos during maintenance of old buildings or industrial installations;
- suffocation in confined spaces;
- exposure to chemicals (e.g. fats, solvents, corrosive substances);
- exposure to biological threats - hepatitis A, legionnaires' disease;
- exposure to dust, including carcinogenic sawdust;
- accidents (all types of accidents, including tripping or falling, or being struck by a flying machine part), etc.

act in accordance with safe working practices and do not carry out the work properly.

Maintenance activities can cause harm to workers and others in three ways:

- an accident/injury can occur during maintenance - for example, a worker repairing the machine can be injured if the machine is accidentally switched on, exposed to hazardous materials or working in an unusual posture;
- poor quality maintenance can cause serious accidents, for example if the wrong part is used for replacement or repair;
- failure to maintain can not only shorten the life of the equipment or building, but can also cause an accident - for example, if there is unrepaired damage to the warehouse floor, it can cause an accident while operating the forklift, injure the operator and damage property.

These unsafe working habits can be the result of poorly trained workers, poor management systems or a lack of the tools and time to carry out maintenance work (Dhillon, 2002).

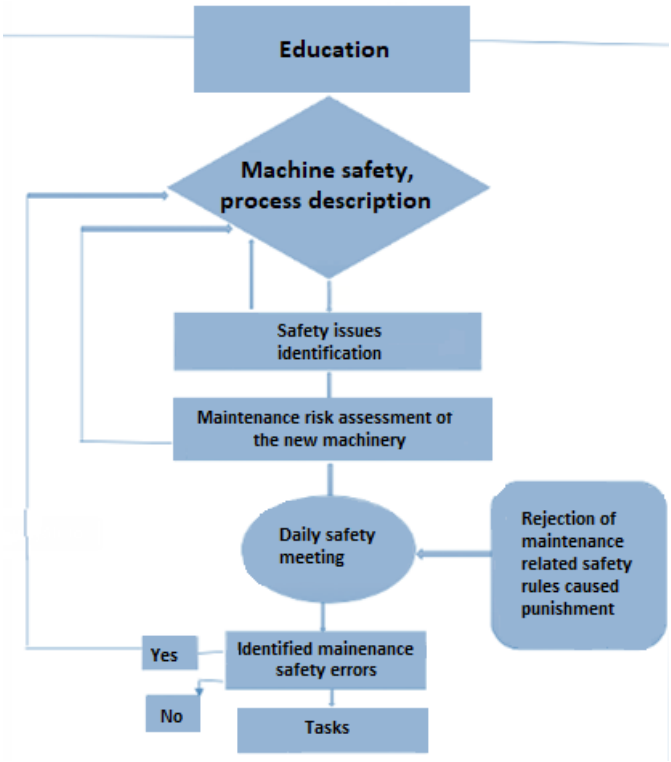

Figure 3. *Maintenance - safety frame (Bupe et al., 2017)*

3. A structured approach

The maintenance process starts at the design and planning stage. It is key to devote sufficient time and resources to maintenance work, ensure the training and competence of maintenance staff, put in place safe systems based on proper risk management and establish effective communication between production and maintenance staff. Guidelines should be followed and records kept. After the completion of maintenance operations, specific checks (inspections and tests) should be carried out to ensure that maintenance has been carried out properly and that the equipment or workplace has been left in a safe condition for continued operation.

The danger of maintenance work is that not all tasks can be carried out in the same way, so there are no regulations for all activities (work instructions, procedures, process descriptions, etc.) and there are also dangerous activities (Grusenmeyer, 2022). The basic principle of the company should be that maintenance activities are not carried out on an ad-hoc basis but in a controlled manner. Risks should be assessed, what hazards are involved and how they can be avoided. The second step could be to introduce task planning and self-monitoring based on documented risk assessment. The next step is to regulate high-risk maintenance tasks individually, followed by a regular review of the individual regulations at a multi-level level.

4. Proposal for the practical operation of the guidelines

Step 1

The maintenance activity should decide whether the task is regular or repetitive. It is necessary to check whether there are already work instructions for this task. If there is not, then the hazard situation should be investigated. If there is a maintenance work instruction, the task should be carried out according to it. In such cases, the instructions, including the necessary permits, must be checked and followed (HR Online, 2020).

Five rules for safe maintenance:

1. Planning;
2. Making the work area safe;
3. Use of appropriate equipment;
4. Working to a plan;
5. Final checks.

Step 2

The next step is to see if you need any permission to perform the task. If a written permit is required, it should be obtained, as it will include a hazard assessment and risk management. The instructions in the permit or procedure should be followed to carry out the task.

Step 3

If no authorisation is required, we will consider whether the task is high risk. For example, the task is considered high risk in the following cases (e.g. a task involving the removal of protective equipment, or a difficult-to-access workstation). If the task is not high risk, the "Start with safety" principle applies, i.e. the task should be carried out in accordance with the hazard elimination or risk reduction measures that have been devised on the basis of the risk assessment. Importantly, this does not need to be documented.

However, if the task is considered high risk, the worksheet must be completed. All risks should be identified and managed (e.g. manual handling of heavy parts, slipping inside the machine, hand and foot injuries) - this is recorded on the notes page of the worksheet, and the immediate supervisor should be informed, and if necessary, additional action should be taken based on the risk management, such as involving more people (HR Online, 2020).

Step 4

A list is used to check that everything has been done. This may reveal, for example, that the protective equipment is missing.

Step 5

Consultation with the line manager.

Step 6

Only then can the maintenance activity be carried out to ensure maximum safety.

Step 7

Once the high-risk task is completed, the worksheet is handed over to the immediate workplace manager, who evaluates it and stores the worksheets. A decision is then taken as to whether specific regulations need to be drawn up, and opportunities for improvement are identified (work equipment, skills, etc.)

Step 8

Regular, multi-level reviews of high-risk tasks (HR Online, 2020).

5. Summary

The uniqueness and complexity of maintenance work requires a specific approach to improve safety performance. Understanding the cause and effect relationships between safety factors becomes essential to implement a more effective safety management strategy.

It is always profitable if there is a high level of risk assessment, maintenance and a high level of attention to occupational safety (Gharib et al., 2021). For example, there are no lost working days due to accidents at work, no extra costs for compensating for absence, and even higher motivation levels among employees.

A well-designed toolkit makes it easy to pass on knowledge to the next generation. It is therefore essential to develop detailed and teachable rules, and to link them to the maintenance task identified as high risk. In addition, workers' knowledge is improved by learning these methods, by structured risk assessment and self-monitoring. This is further enhanced by involving workers in the development process. In addition, the arguments for occupational safety in management decisions are strengthened, and workers' commitment to safety is increased.

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