

Social Dimension of Sustainable Development – Safety and Ergonomics in Maintenance Activities

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Abstract. The paper considered the issue of the impact of maintenance services for the safety and health of workers. This is undoubtedly an important issue as statistics show that in Europe 10 to 15% of fatal industrial accidents can be traced to maintenance operations. The role of these services in the modern enterprise is increasing, as companies increasingly depend on the proper functioning of its technical systems. In addition, the maintenance process involves not only technical services company employees, but also the employees of other functional areas and external agencies. All this makes, that maintenance in terms of security is a complex issue. Activities of maintenance services are generally associated only with phase of the operation of machinery. In the paper authors consider the effects of enlargement of operations maintenance services for all phases of the life of a technical object, including not only operation but also design, manufacturing and disposal phases. Such approach is able to provide more effective, proactive and preventive health and safety system.

Keywords: Maintenance, maintenance stakeholders, safety culture levels.

1 Introduction

Since the end of the 1980s of the previous century, as a result of the report ‘Our common future’ published by the World Commission on Environment and Development, politics, economy, and science have been dominated by the term ‘sustainable development’ ([1]; [9]). In the report, sustainable development was defined as a process of change in which exploitation of resources, new investments, concentration on technology development, and institutional changes are focused on present and future needs of society. At the macro level a model of economy based on the concept of sustainable development assumes appropriate and conscious forming of the relations between economic growth (economic aspect), commitment to environment (environmental aspect) and quality of life (social aspect). Including sustainable development into business activities of organisations we reach the micro level and may define it as a process in which satisfaction of the organisation’s development needs and improvement of its present become a priority. All at once we assume responsibility for the risk of satisfying the same aspirations in the future.

Despite the fact that sustainable development requires integration of the economic, environmental and social aspects, this paper focuses only on the social dimension and its aspects pertaining to health and safety of employees. Ensuring healthy and safe working conditions in a business organisation is often the first social impact identified by local communities and employees [15]. Both the groups want to be reassured that they work in a place that is safe for people and causes no harm to the environment. Health and safety of all people in a business organisation, no matter employees or visitors, are the basic social requirements of any development [5].

This paper covers issues of employee health and safety from the perspective of maintenance personnel’s activities. The 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 [2]. Hence, it is a fundamental issue. Furthermore, business organisations become more and more dependent upon proper functioning of its technical systems. Consequently, the importance of maintenance personnel will grow.

Technical service personnel are not the only players of the maintenance processes. Other functional area employees and external organisational units also contribute [4]. By contributing to correct operation of plant and equipment they also demand (Fig. 1).

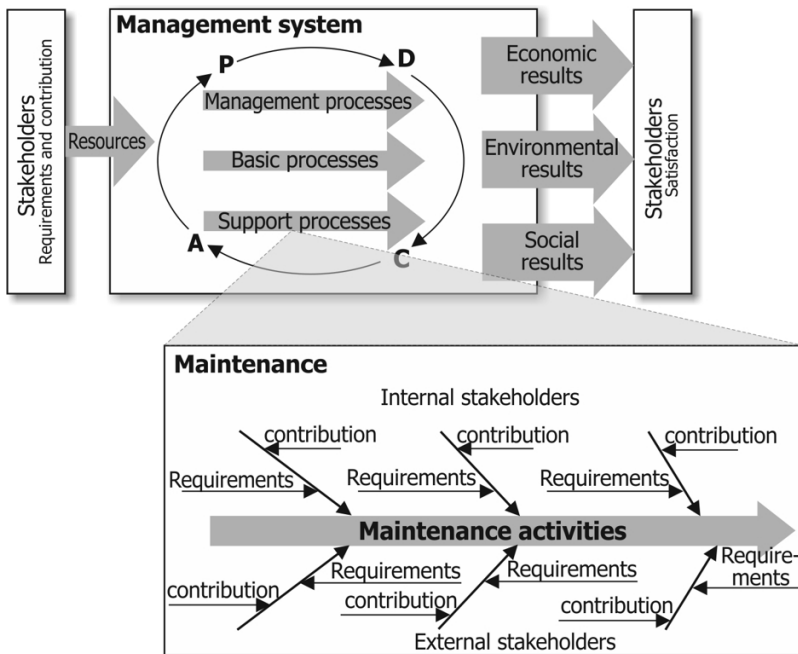


Fig. 1. Internal and external stakeholders involved in maintenance

These requirements refer not only to the economic and environmental aspects but also to the social one, in particular safe and healthy working environment. It should be stressed that maintenance is an essential instrument for preventing hazards in the workplace.

2 Maintenance, Safety and Human Factor in Technical Object's Life Cycle

Maintenance can be defined as the combination of all technical and associated administrative actions intended to retain an item or system in, or restore it to, a state in which it can perform its required function.

Traditionally, the scope of maintenance referred to production processes. It was widely agreed that the main aim of maintenance was the optimization of equipment availability at the lowest feasible cost. However, the shift from production paradigm to sustainable development resulted in a change of the maintenance paradigm towards the product life cycle management; as well as taking into account economic, environmental and social aspects. The maintenance objectives can be summarized under four headings: ensuring system function (availability, efficiency and product quality); ensuring system life (asset management); ensuring safety; ensuring human well-being. The many decisions made during the process of a technical object's design, production and operation directly influence the effect and outcome in the social dimension. Maintenance managers hold all the instruments that allow a business organisation's technical service workers participate in all phases of a machine's life cycle and thus engage them in the implementation of the social dimension of the organization's strategy [6].

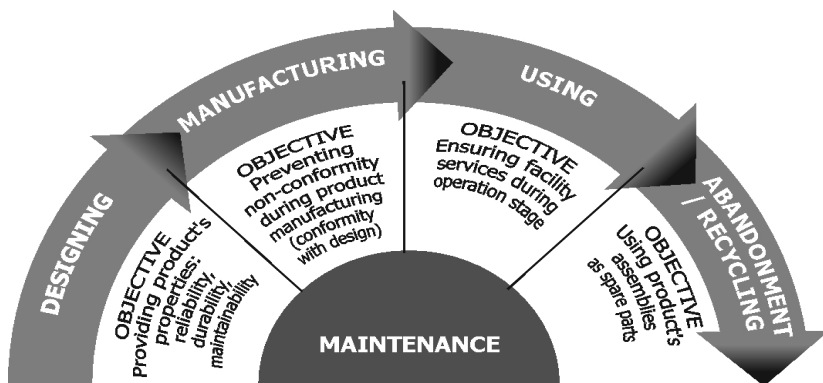


Fig. 2. Maintenance in product's life cycle. Source: [6]

The first stage of a machine's life cycle is the design. At this point technical parameters concerning efficiency are defined. Also here adequate level of reliability and ease of performing maintenance and repair is determined. Thus, the safety of

implemented processes and its participants is ensured. From the point of view of maintenance personnel work safety, it is crucial to minimise the probability of error occurring during maintenance works. Plant and equipment should be designed for maintainability. In engineering, maintainability is defined as ease of maintaining technical objects, e.g. identify defects or their cause, correct defects or their cause, automate fault detection and isolation tasks whenever possible to make future maintenance easier etc. Although the main purpose is to ensure easy and quick performance of service-and-repair tasks, maintainability promotes safety and ergonomics of work. This has an impact on minimizing the human error risk by reducing phases during disassembly and reassembly works. It may also guide employees to take good decisions. Finally, maintainability is linked with cognitive ergonomics. Minimizing the number of components to be replaced, connected, disconnected etc. promotes both effective task execution and reduces cognitive load during the task. Suitable solutions concerning the safety of operational and maintenance activities at this stage of a machine life cycle must be searched in two areas. Firstly, in cooperation between designers and end users, that is engineers and employees forming maintenance personnel of a business organisation. Their suggestions, comments, and initiatives should constitute major input for designing. Secondly, providing machine designers with tools supporting carrying out and documenting of risk assessment at all stages of the machine designing process [3].

The second stage of a machine life cycle is manufacturing. The main task here is to ensure conformity between the requirements included in the design documentation and the actual outcome of the manufacturing process. This conformity is the resultant of materials used in the manufacturing process, knowledge and skills of people as well as machines and equipment applied in production [11]. Their fitness for use has a major impact on the final effect.

Another stage, on which maintenance personnel may have an impact, is the stage of machine operation in a business organization. For safety reasons, at this stage maintenance of infrastructure is focused on ensuring systems, procedures, and training to build operational knowledge, skills, and functional capabilities of systems to prevent, manage, and eliminate risks. From the moment of deciding about the purchase of a new machine one must think about the tasks of maintenance personnel resulting from the mere fact of owning the object. Whether or not the machine works some maintenance activities must be performed. The next stage is designing of the work stand the machine is installed. From the point of view of operator and maintenance-and-repair staff this is a crucial point. As far as the operator and his/her activities are considered in the designing process, the necessity of future service activities is usually neglected. An analysis performed in 2012 in three serious companies with reference to the so called 'Kaizen events' proved that out of 123 improvement activities proposed by maintenance personnel, 14 were linked to work space connected with carrying out of repair works. This situation resulted in non-adherence to rules of conduct and safe performance of work.

Once the technical object is installed and started up, the proper phase of use starts. The machine now performs the functions for which it was designed. From this moment on, the proper use of the equipment's usable resource starts. Apart from the normal wear from use, damages and failures may occur that result from incorrect operation e.g. machine working parameters, work place, etc. [13]. Degradation contributes not only to the reduced capacity of the machine but also has an impact on deterioration of its operational use safety (it may constitute a hazard to operators and other participants of the process). Consequently, it is required to perform regular overhauls, maintenance, and repairs. Such activities provide detailed information on the progress of equipment degradation processes and are the key element in the course of securing health and safety of all participants. It is, therefore, necessary to choose suitable maintenance policy for each piece of the production equipment (Corrective Maintenance - CM, Time Based Maintenance – TBM, Condition Based Maintenance – CBM, Predictive Maintenance - PM, etc.) based on identification and assessment of the risk connected with a machine failure. This enables scheduling of the production equipment service activities in a suitable context (Fig. 3). The main purpose of these activities is to reduce the general risk that may lead to an unexpected failure of equipment [10]. To minimize the total risk, priorities of service actions (overhauls, maintenance) are defined according to quantitative analysis of the risk caused by machine assembly breakdowns. Such an approach enables finding of the right proportions among individual maintenance policies, allowing not only for financial but also environmental and social issues (safety of people).

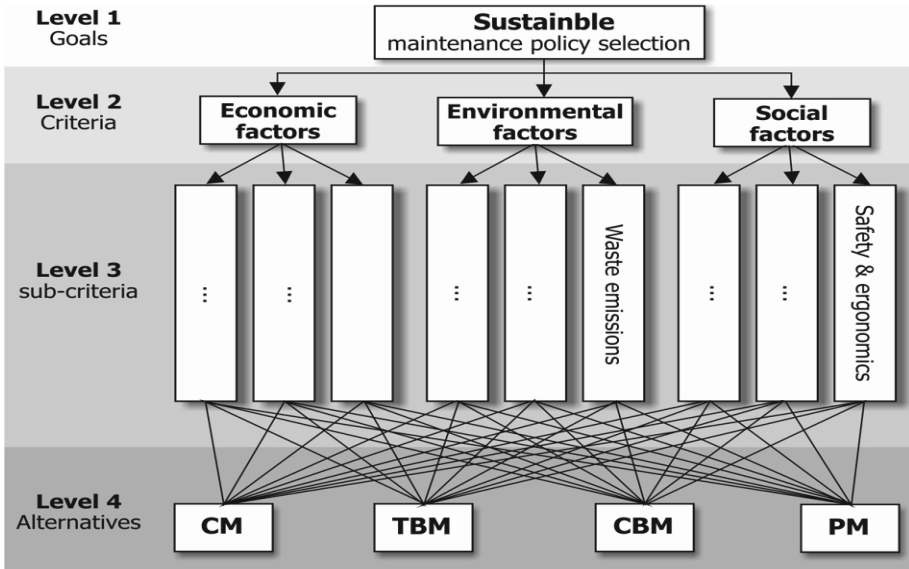


Fig. 3. Maintenance policy selection model

Maintenance is rarely part of the production plan and is mostly considered a waste of time. As a result of such 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. As it results from the survey made by Scroubelos [14] among maintenance personnel the causes of incidents (accidents and near-accidents) are linked to first-line personnel and supervisory personnel (Fig. 4).

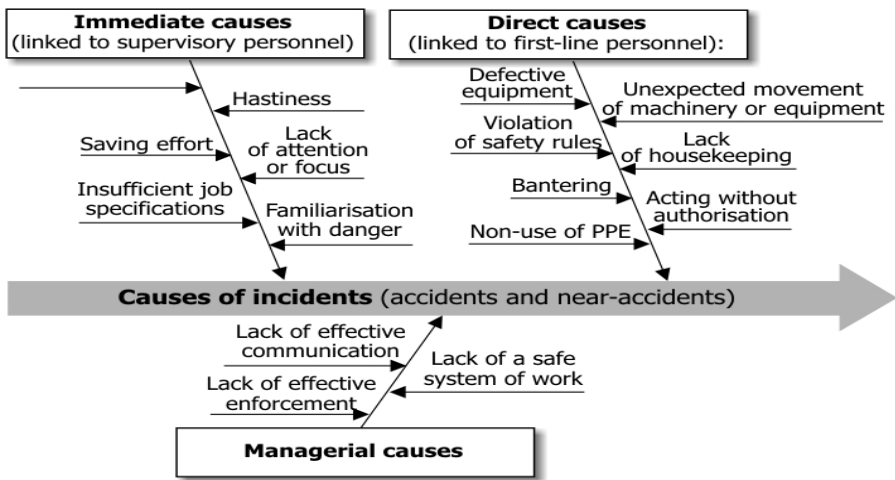


Fig. 4. Causes of incidents among maintenance personnel

After gaining an insight into the causes one may see that they refer to organisational aspects. As practice shows, many actions in the area of safety and ergonomics are taken following occurrence of an incident. In other words, once an error occurs, actions are taken to prevent similar errors in the future (rules of proceeding are developed, training is carried out, protection is implemented). This is the co-called ‘reactive’ safety. Implementation of the sustainable development concept in a business organisation requires proactive actions, i.e. anticipating of the occurrence of adverse incidents. With reference to safety, this means pursuing the goal of ‘zero incidents and unsafe behaviour’ (Fig. 5).

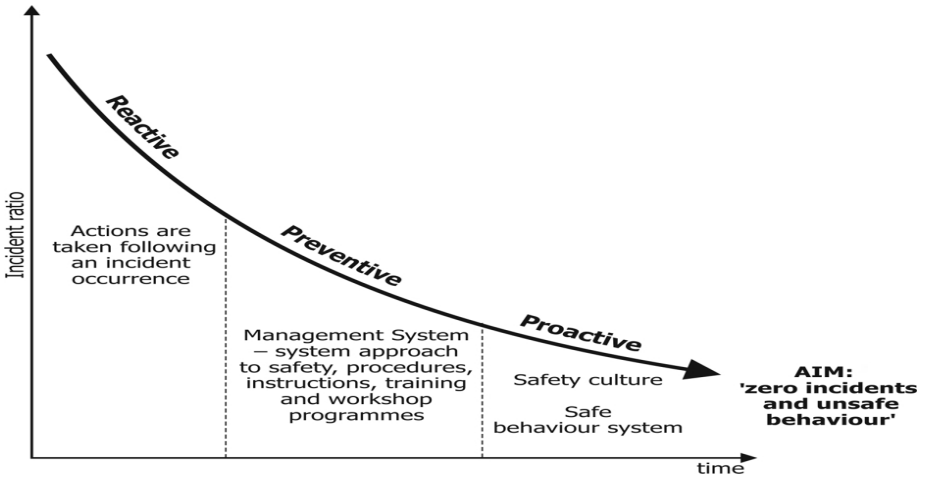


Fig. 5. Evolution of safety culture levels. Source: [7]

Hence, for safety reasons, actions of maintenance managers should be oriented to scheduling of works, supplying resources necessary to perform the works (materials, tools, personal protection equipment, procedures, manuals, etc.), consistent monitoring of adherence to the assumed proceeding methods and results thereof, motivating, conscience building, and ‘good practice’ promotion (Fig. 6).



Fig. 6. Examples of good practices supporting maintenance safety

Implementation of safety procedures and safe working systems must be supported by training, interactive communication between all participants of work processes [12], and activities shaping safe behaviour. Shaping of safe behaviour is connected with a change to perception of risk by employees. The factors that influence the way risks are perceived and actions taken are as follows:

- conception each person has, influences whether or not such person perceives his/her behaviour unsafe or potentially causing injuries. Activities described by low probability of risk occurrence tend to form the conception that employees are safe, while in fact they were just lucky.
- habits that makes employees easily forget about risks attributed to the work or task. It is in the nature of human to adapt to the environment and losing sight of the risk that accompanies our work every day.
- barriers or obstacles that prevent employees from taking precautions and force them to expose to risk, unfit tools, pressure connected with achieving the production target.

For that reason, building a responsible behaviour regarding safety requires shifting from natural instincts, i.e. intuitive perception of risk, to an attitude of team and conscious shaping of the work environment, paying attention to the behaviour of oneself and colleagues (Fig. 7)

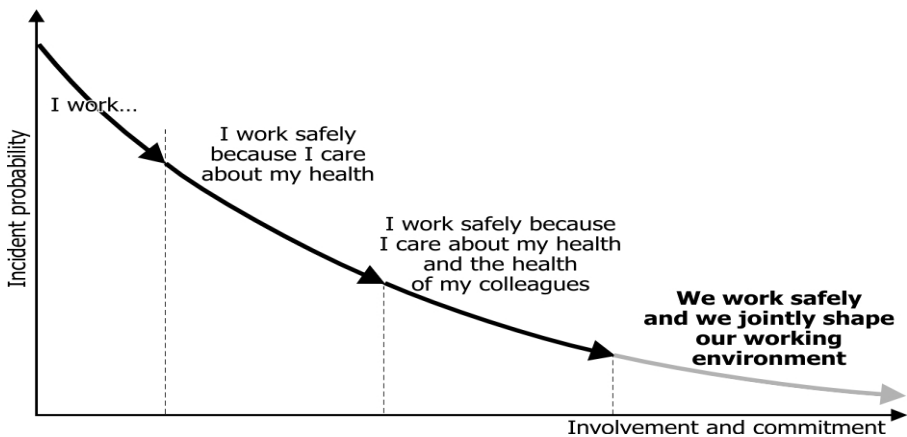


Fig. 7. Model of safety culture expansion among personnel. Source: [8]

3 Conclusion

In recent years, maintenance has been the subject of fundamental change and is now regarded as an essential function within companies. Maintenance is not only necessary to ensure reliability of technical structures or productivity of the company, but regular maintenance has an important role in providing safer and healthier working conditions. Lack of maintenance or inadequate maintenance can cause serious and deadly accidents or health problems. Maintenance is one of the workplace

activities that can affect the health and safety not only of the workers directly involved in it, but of other workers and third parties, if safe work procedures are not followed and work is not performed properly. However, maintenance-related risks continue to receive limited attention and little research has been devoted to the impact of maintenance on the safety of those who work in maintenance and their co-workers. It is essential to take a structured approach to maintenance, seeing it as a process rather than a task. The wider perspective of maintenance refers not only to the service life of technical equipment. Contemporarily, maintenance must be extended to all phases of service life, from design to liquidation. As early as in the phase of designing the basic property of any object, in terms of safety and health of workers performing maintenance and repair tasks, is formed. That is maintainability. When designing machines it is a common trend to minimise the amount and scope of service performed by human. We wish each next generation of a machine to be completely self-operating. However, irrespective of the complex automatics it is equipped with or the amount of work that is performed using wireless technologies, elimination of work performed by human (zero maintenance) in a production company is not possible. There will always be activities that require performance by man. Every effort must be made to lessen the physical and psychological arduousness of such work.

Social sustainability in maintenance activities (similarly to other areas of operation of a business organisation) is realized in concepts such as preventive occupational health and safety, human-centred design of work, empowerment, individual and collective learning, employee participation, and work-life balance.

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