ZESZYTY NAUKOWE POLITECHNIKI POZNAŃSKIEJ
Nr 90 Organizacja i Zarządzanie 2024

Wiktoria CZERNECKA[1], Marea de KONING[2,] Nikodem MIREK[3], Natalia PYTŁOSZ[4], Joanna ANDRZEJEWSKA[5]

THE CONCEPT OF THE MACHINE ACCEPTANCE PROCEDURE IN TERMS OF OCCUPATIONAL SAFETY AND ERGONOMICS

DOI: 10.21008/j.0239-9415.2024.090.11

Machine safety and the participation of health and safety service employees in the process of admitting them for use by employees is an extremely complicated issue, which results from the multitude of legal regulations in this area, but also from the variety of machines provided in production processes. Machines should be assessed for compliance with minimum safety requirements, but it is also important to take into account factors that impact safety (e.g., ergonomics). This article proposes a concept for the machine safety acceptance procedure, emphasizing the role of health and safety service employees in the process. The concept was developed based on legal requirements in this area, also taking into account additional, non-mandatory factors that are crucial for ensuring employee safety and comfort of use. The proposed solution can be used in the work of health and safety services in manufacturing enterprises and integrated into systemic occupational health and safety management in the context of planning and organizing health and safety activities.

Keywords: machines safety, Machinery Directive, machine ergonomics

1. INTRODUCTION

The essence of the work of occupational health and safety (OHS) services today is invariably focused on maintaining the highest safety standards. In the context of machine safety, this involves ensuring that devices and machines operate in accordance

[1] Poznan University of Technology, Faculty of Engineering Management. ORCID: 0000-0003-2060-4488.
[2] Tampere University, Faculty of Engineering and Natural Sciences. ORCID: 0000-0003-0057-4891.
[3] Poznan University of Technology, Faculty of Engineering Management. Student.
[4] Poznan University of Technology, Faculty of Engineering Management. Student.
[5] Poznan University of Technology, Faculty of Engineering Management. Student.

with safety standards and norms while minimizing the risk of hazardous events and employee injuries. These services are responsible for monitoring and assessing potential hazards, implementing preventive procedures, and responding to incidents.

Their activities also include participation in machine examination, testing, and certification, as well as cooperation with other company departments to ensure the highest level of safety (Tiusanen et al., 2020). This is especially important for preventing workplace accidents, the causes of which may lie in improper machine operation or insufficient safety measures. According to the Polish Central Statistical Office, over 10% of workplace accidents in Poland are attributed to such factors (2023). This protection should be assessed at the stage of machine application planning, and detailed verification and approval of the machine for use should take place after official processes of checking safety elements. As modern technologies and innovative machines play a key role in today's world, it should not be forgotten that, along with technological progress, appropriate safety standards should be ensured. It is important to focus on assessing machines for compliance with safety requirements to ensure employee protection and maintain the integrity of production processes.

The continuous development of technology has led to increasingly complex devices and machines, making the procedures and requirements associated with their operation more complicated. Therefore, more and more risk factors need to be taken into account (Lee et al., 2021). Taking into account the above data, the aim of this article was to propose a concept of a machine acceptance procedure in terms of safety, taking into account contextual factors (e.g. ergonomics). This procedure has been developed based on legal requirements and practical experience in occupational health and safety. The implementation of this task is aimed at determining whether it is possible to translate the legal requirements for machine acceptance by health and safety services into a procedure that facilitates taking into account all factors in this respect. The assumption behind using the procedure is its application in preparing occupational health and safety employees to effectively perform professional tasks related to the acceptance of new production machines. It can support employees by equipping them with the required knowledge about the machines, as well as guiding them in preparing appropriate documentation to confirm compliance with both minimum and advanced safety requirements.

2. LITERATURE REVIEW

2.1. Legal requirements for machine safety and ergonomics

Safety in machinery refers to reducing the risk of harm, where harm is defined as physical injury or health damage of people, either directly or indirectly, as a result of property or environmental damage (IEC 61508). In general, machinery safety focuses on minimizing risks related to mechanical failures, accidental contact

with moving parts, or any hazards coming from control system failures (ISO 12100). A key element of this is functional safety – meaning the assurance of safety through the design of safety-related control systems in compliance with ISO 13849 and IEC 61508 standards. With the increasing level of automation in machinery, the Machinery Directive (2006/42/EC) is changing to the Machinery Regulation (2023/1230). A significant amendment in this transition is the inclusion of software in the definition of machinery. This change indicates the growing recognition of software as a main facilitator in the automation of machinery.

With respect to ergonomics, the amendments to the minimum essential health and safety requirements indicate the need for manufacturers to provide a growing emphasis on the operator's well-being, especially in environments with higher levels of automation.

In a highly automated machine, where tasks are independently executed, the human operator acts as a supervisor. This shift requires machine manufacturers to take into account not only human physical ergonomics but also to place greater emphasis on cognitive abilities of managers, whose new role will involve increased cognitive load.

Wickens et al. (2012) illustrate how challenging it is for humans to be placed in a supervisory position. Recognizing this, the Machinery Regulation has amended the section on the minimum essential health and safety requirements for the ergonomic principles. These amendments advocate for avoiding machine-determined work rates and promoting higher-quality human-machine interfaces that are more respectful of the supervisors' cognitive limitations. Additionally, there is an increased focus on operator well-being.

Nevertheless, ergonomics is a key element for ensuring machinery safety, as it specifically considers the physical and cognitive well-being of operators who are in direct contact with machines. It emphasizes designing machinery that respects human physical and cognitive capabilities, reduces fatigue, prevents musculoskeletal disorders, and improves operator efficiency (Butlewski, 2017; Reiman et al., 2021). This includes designing intuitive control interfaces, adjustable components to fit various operator profiles, and features that reduce exposure to noise, vibration, or extreme temperatures.

Aside from adapting machine design to benefit the operator's physical well-being, clear communication between the machine and the operator is essential for safety during operation. This involves (Guzman, Lewis, 2019; Lu et al., 2021):

- visual and auditory signals, indicators, alarms, and displays providing real-time information on the state of the systems;
- HMI (human-machine-interfaces): user-friendly control panels that are clear, accessible, and instructive, providing reliable feedback on the current state of the machine;
- instructions for use: a manual supplied by the manufacturer, detailing operation, maintenance, and safety protocols to ensure that the operator has a thorough understanding of the equipment.

2.2. Machine safety and compliance with legal requirements from the perspective of occupational health and safety services

The specific tasks of an employee of the occupational health and safety services include participating in the commissioning of newly constructed or rebuilt machines or their parts, as well as submitting recommendations to the employer regarding compliance with ergonomic requirements at workstations, including newly created ones (Arikan, Sozen, 2021). These tasks are particularly important during the installation and commissioning of new machines, which often meet the minimum requirements but not necessarily fulfill all the criteria necessary for safe and ergonomic operation. According to ISO 45001 requirements, the employer should minimize risks to employees, including physical hazards. This obligation often rests with the health and safety service, whose task is to advise on providing the best-suited protective measures.

In the context of machinery, these are physical protections (e.g. shields) as well as additional safety measures (e.g. appropriate marking or instructions on how to perform the job correctly). In the process of accepting a new machine and allowing it to be used by employees, the occupational health and safety service has specific responsibilities in the following areas (Górny, 2019; Caputo et al., 2019; Leso et al., 2018):

- assessment of occupational risks associated with working with machinery, taking into account hazards related to work environment parameters and workstation ergonomics;
- verification of machine markings for their visibility and compliance with legal regulations;
- assessing the physical protective elements designed to prevent hazard from affecting employees;
- assessing the correct operation of safety switches;
- assessing health and safety instructions for performing the work and ensuring that all operators are familiar with them;
- ergonomic assessment of the workstation in terms of musculoskeletal strain and overall task load.

Analyzing data presented by various researchers who have examined the involvement of safety specialists in the process of approving machines for operator use reveals some problems. They may result from the need to engage a very large group of specialists to reliably perform the task, as well as from the requirement to provide appropriate resources (especially time). Selected difficulties are described below.

1. A problem with defining the responsibilities of all specialists involved in the machine acceptance process arises from the need to assess technical efficiency, organizational capabilities, and appropriate preparation (such as employee training to perform tasks on the analyzed machine). This may create difficulties in determining at what stage the support of a safety specialist should be provided and what resources are required for effective implementation of their role ort (Lotz et al., 2019).

2. Determining the time resources required for a safety specialist to perform tasks related to the acceptance of a new or modified machine may be difficult. The OHS specialist is responsible for reviewing documentation, analyzing legal regulations, inspecting the machine, and familiarizing themselves with its specifications as well as operational procedures. For this reason, sufficient time should be provided to perform these tasks, but in practice, it is often insufficient due to the urgency to start operations as soon as possible (business goals of the organization) (Bröhl et al., 2016).

3. One of the most important tasks when accepting a new machine is identifying potential hazards for employees, which is also handled by a safety specialist. For this reason, it can only be performed after the machine has been fully installed and its operation has been tested in operational conditions. Therefore, this step should be included in the acceptance procedure and integrated into the schedule for the test run and the full operational launch (Lee et al., 2019).

4. Another important (and at the same time problematic) aspect is taking into account the contextual factors influencing the human-machine-environment system in the case of installing new machines or modifying existing ones. Such a factor may be, for example, workstation ergonomics. It can be pointed out that the costs of implementing ergonomic principles are the highest in the phase of using the machine and lower during the concept or design phase. For this reason, this aspect should be taken into account, and the responsibility for ensuring its proper consideration typically falls to the health and safety specialist or, if available, an ergonomics specialist within the company (Loup-Escande, Loup, 2021; Cardoso et al., 2021).

5. Ensuring appropriate collective and individual protection measures should be planned already at the conception stage of providing a new machine into the process. However, these measures are often established only after a certain period of time of machine operation, exposing employees to accidents and hazardous incidents (Chinniah et al., 2017). For this reason, the acceptance procedure should include the analysis of this aspect before allowing employees to operate the machine.

The above-mentioned tasks require thorough preparation for individuals responsible for advising on assessing a new machine. Therefore, organizations should develop machine acceptance procedures, taking into account the role of each person involved in the process (not only OHS specialists, but also the maintenance, technology, and other relevant departments). From the point of view of an OHS specialist, this procedure should outline the phases of the machine implementation project lifecycle where appropriate steps should be undertaken. It should also detail the necessary resources needed to reliably perform the task.

3. METHODOLOGICAL APPROACH

The aim of the article is to present the concept of a machine acceptance procedure in terms of safety and ergonomics from the perspective of an OHS specialist

(without taking into account the technical adaptation of the machine to the minimum requirements beyond the scope of the OHS department). In order to achieve this objective, the following research questions were adopted:

1. Is it possible to develop a procedure for an OHS specialist in the process of accepting a new or modified machine, considering their limited role in this task?
2. Is it possible to translate the legal requirements for the acceptance of new and modified machines into a scheme of conduct for an OHS specialist participating in this process?
3. Is it possible to take into account contextual factors influencing safety (e.g., ergonomics) into the machine acceptance procedure from the perspective of an OHS specialist the practical execution of this task?

For this purpose, literature on machine safety and ergonomic analyses was reviewed. The result of the literature review was the development of a flowchart presenting the subsequent steps required to assess and approve a new machine for use by employees in production processes. The procedure is intended to facilitate the preparation of OHS service employees by providing a structured procedures in accordance with the established scheme.

4. RESEARCH RESULTS

As a result of the implementation of the goal set in the article, i.e., developing a procedure for the OHS employee during the acceptance of a new machine, figure 1-2 present the proposed implementation concept. The first step in this procedure involves the employee thoroughly reviewing the relevant legal regulations concerning the installed machine. Following this, they should familiarize themselves with the technical documentation of the machine to initially identify potential hazards that that the machine may pose to employees.

An important element of the machine approval process is a visual assessment of the installation to complete the list of hazards resulting from the technical documentation. Risks may also result from the ergonomics of the workstation, making its assessment an important next step in the procedure. For this purpose, it is possible to use many methods of ergonomic assessment (Lowe et al., 2019). Each identified hazard should then be assessed in terms of its potential impact on the health and life of employees (using any selected risk assessment method – allowing each OHS specialist to choose the most appropriate method) (Adem et al., 2020). After this risk assessment, appropriate protective measures should be proposed to ensure employee safety.

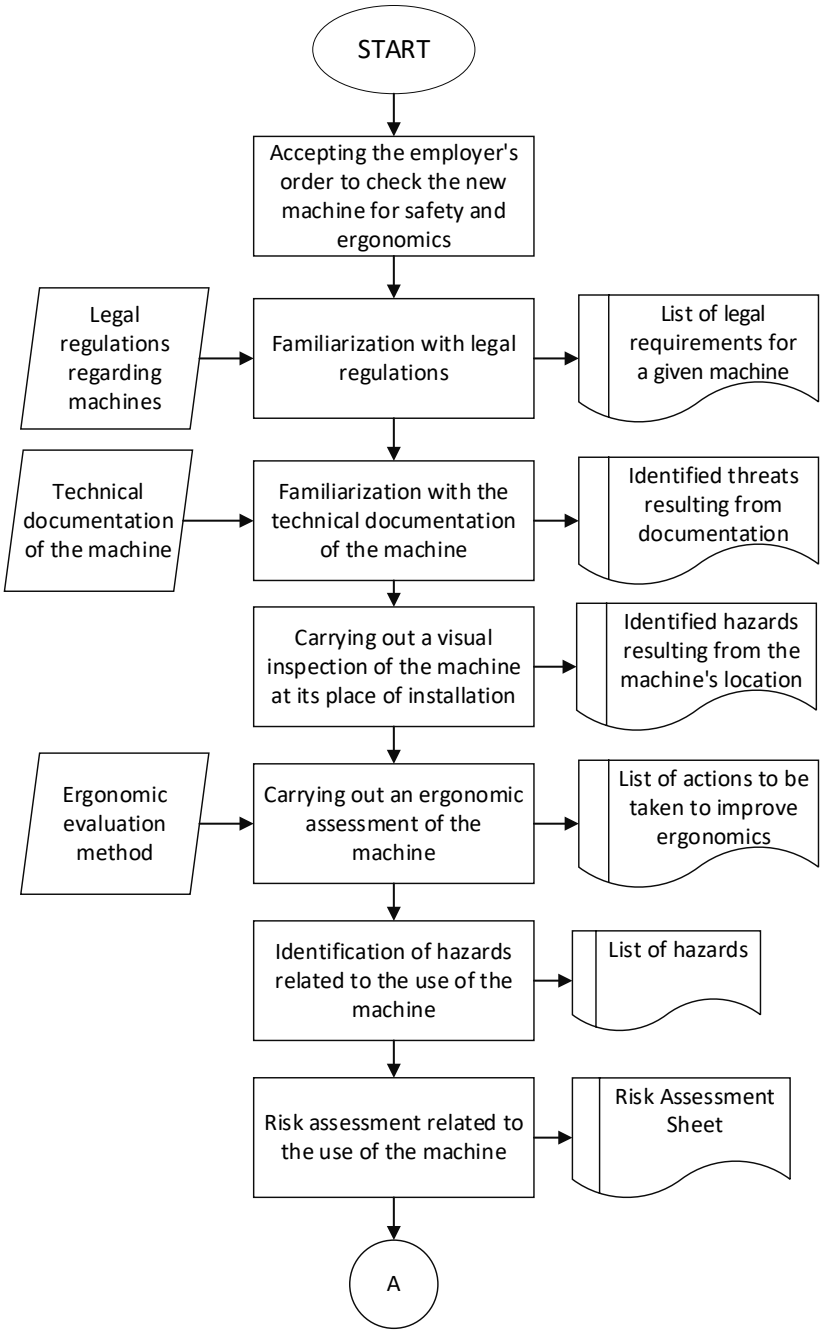

Fig. 1. Procedure for an OHS specialist when accepting a new machine – part 1 (authors' own elaboration)

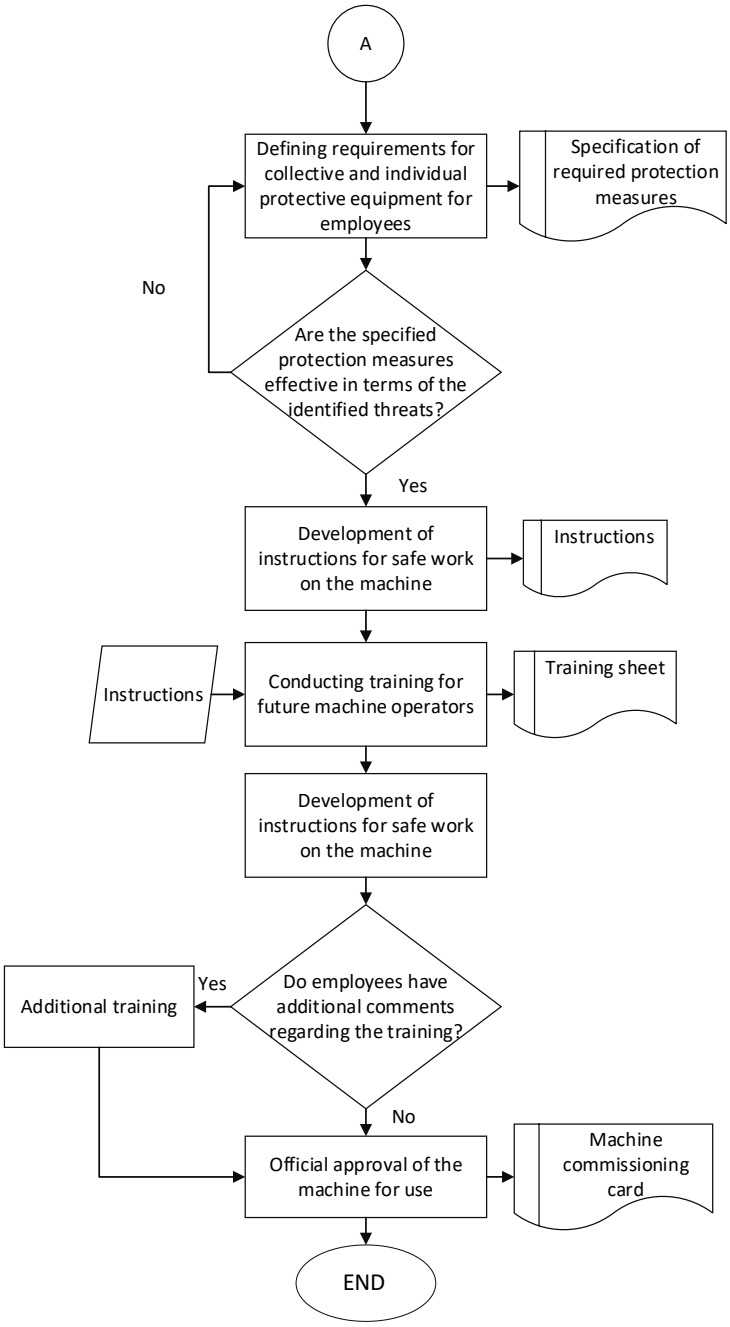

Fig. 2. Procedure for an OHS specialist when accepting a new machine – part 2 (authors' own elaboration)

The final stage in the process of allowing the machine to be used by employees should involve the development of a safety manual, which contains the most important information on potential hazards associated with the machine, as well as a detailed description of the necessary measures to minimize these risks. The manual should be developed by a health and safety employee or, at least, reviewed and approved by them.

After preparing the final version of the manual, employees should be trained based on its content, which should be completed by signing the training card. The final step in authorizing the machine for use should be its official acceptance, accompanied by the preparation of an appropriate card confirming that all the assumed requirements have been met.

It should be noted that the outlined steps of the procedure should be modified depending on the complexity of the installed machine and the time required to perform basic activities related to identifying potential hazards. In some cases, a full implementation of the procedure may not be necessary.

5. CONCLUSIONS

Accepting new machines for use is one of the basic tasks of an OHS employee. Although this process is carried out in almost every company, many organizations lack an official procedure to prepare employees for this task. This may be due to the lack of recognizing for a structured approach, or from performing machine acceptance activities in a superficial way, often due to time constraints.

Limiting the time allocated for machine acceptance (caused, for example, by the urgency to start production) is a highly unfavorable practice. It increases the risk of overlooking critical hazards associated with the machine, which can lead to sever injuries health or even death. For this reason, developing a structured acceptance procedure becomes even more important to ensure the correct performance of this task.

The procedure proposed in this article for occupational health and safety service employees in the process of accepting and approving a new machine for use can help to sort out this issue in many companies where such guidelines have not been developed or are very limited. This procedure outlines the important steps that should be taken to assess important aspects of the machine that may affect employee safety.

A new element to this procedure is undoubtedly assessing the machine ergonomics, which is often done to a very limited extent. However, it is possible to identify potential hazards from an ergonomic perspective (e.g. the need for frequent bending or incorrect positioning of construction elements). Therefore, this factor should also be taken into account in the machine approval procedure.

Answering the research questions, it is possible to determine the tasks of the OHS employee within the acceptance procedure for new and modified machines.

It is worth separating these tasks from the responsibilities of other participants involved in this process. Both basic requirements (minimum legal standards) and contextual factors (ergonomics), OHS employees can be taken into account to ensure proper preparation for the provided consultancy.

It is important to organize the steps of the procedure and assign an appropriate time for completing each task (which should be done individually depending on, for example, the complexity of the machine and the impact of its installation on the change of the work process and the role of the operator).

It is necessary to note the limitations of the proposed procedure, especially in the case of machines with low complexity (where performing all steps may not be necessary). It may also be less applicable in the case where an external OHS employee is responsible for the assessment, as they may have limited time to inspect the machine safety. Nevertheless, even in this case, the employee should follow a structured approach and the proposed procedure can be helpful in this matter. In business practice, this may mean optimizing the time required for machine approval, reducing errors in the process and thus the employees' exposure to risk.

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KONCEPCJA PROCEDURY ODBIOROWEJ MASZYN POD KĄTEM BEZPIECZEŃSTWA I ERGONOMII

Streszczenie

Bezpieczeństwo maszyn i udział pracowników służb BHP w procesie dopuszczenia ich do użytkowania przez pracowników jest zagadnieniem niezwykle skomplikowanym, co wynika z mnogości przepisów prawnych w tym zakresie, ale też z różnorodności maszyn stosowanych w procesach produkcyjnych. Powinny one być sprawdzane pod kątem minimalnych wymagań. Istotne jest również uwzględnienie czynników kontekstowo wpływających na bezpieczeństwo (np. ergonomii). W ramach niniejszego artykułu zaproponowano koncepcję procedury odbioru bezpieczeństwa maszyny z punktu widzenia udziału w tym procesie pracowników służby BHP. Koncepcja została opracowania na podstawie wymagań prawnych w tym zakresie. Uwzględniono także wymagania ponadpodstawowe, istotne z punktu widzenia zapewnienia pracownikowi bezpieczeństwa i wygody użytkowania. Zaproponowane rozwiązanie może mieć zastosowanie w pracy służby BHP w przedsiębiorstwach produkcyjnych, może być wdrożone jako element systemowego zarządzania bezpieczeństwem i higieną pracy w kontekście planowania i organizowania działań BHP.

Słowa kluczowe: bezpieczeństwo maszyn, Dyrektywa maszynowa, ergonomia maszyn