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MACROERGONOMICS IN THE STRUCTURE OF THE ISO 45001 OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT SYSTEM

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Purpose: The purpose of this article is to indicate the research and scientific activities of macroergonomics in the structure of the occupational health and safety management system proposed in 2018 by the international standard ISO 45001. The article was created to promote and broadly discuss the topic of macroergonomics in literature studies.
Design/methodology/approach: The theoretical scope of the article includes a literature analysis of the issues of macroergonomics used and standards in the field of occupational health and safety management, with particular emphasis on the ISO 45001 standard. The research methodology consisted in combining the structure of both research teams of the ISO 45001 standard and macroergonomics, which in their implications create a comprehensive project of the work system in organizations.
Findings: The research analyzes used in the article indicated a strong connection between macroergonomics and occupational health and safety management standards. Analyzing the currently applicable ISO 45001 standard, the authors indicated that the elements of macroergonomics are primarily documentation and information media contributing to the creation of comprehensive internal audits and reviews of organizational management.
Research limitations/implications: The macroergonomics research process is as variable as the changes that are introduced to the structure of proposed standards related to occupational health and safety management. Future research on this issue should take into account economic changes that affect the processes of management, transfer and storage of all information media in the organization.
Social implications: Macroergonomics, by understanding the type of connections between sociotechnical and organizational systems that are responsible for designing safe and accessible work management systems. Update management and occupational health systems, which have been created by many standards and legal regulations, are now used in entrepreneurial organizations in normative standards contexts. ISO 4500 offers many alternatives to ensure security. For this purpose, the organization must implement many disclosed procedures that are defined with the achievements of macroergonomics. By collaborating the solution in the structure of the science system, it allows for the creation and results of the work of an entrepreneurial organization, preparation for elements of risk, but also the use of practical and external opportunities.

Originality/value: The article discusses the subject of the third ergonomics research methodology, i.e. macroergonomics, which is often confused with general activities aimed at improving the health and life of employees in the organization through the use of anthropometric data. The study wants to emphasize the importance of studying complex systems of macroergonomics and the multi-object design object (organization) as an inherent component of the external environment, always as a part of a larger whole.
Keywords: macroergonomics, occupational health and safety management system, ISO 45001, work process.
Category of the paper: Literature review.

1. Introduction

The tasks facing the scientific discipline of ergonomics are inextricably linked to the humanistic and applied optimization of human work processes. Ergonomics is shaped by many research disciplines including work physiology, work psychology, occupational medicine, work pedagogy, work sociology, but also anthropology, bionics, work organization, environmental protection and technical sciences. The aim of the multidisciplinary pooling of the knowledge resources of these disciplines is to create a work system based on the principles of ergon (work) and nomos (law, regularity) adapted to the characteristics of the human organism, which functions within the rigid boundaries of its internal environment taking into account the external environment (Tytyk, 2009).

Ergonomics is an applied science that develops in the direction in which changes occur, but also in the direction in which there is a need to design a proper work process or system resulting from legal, technical or organizational changes, which is why it is assumed to be considered on a micro and macro scale. In the literature, one can also find a proposal for its division into three main generations (Jasiak, 2015).

The first generation of ergonomics is the knowledge of man, i.e. the study of anthropometry issues, the study of human perception phenomena but also the design of isolated man-technical object systems. Second-generation ergonomics is the study of human cognitive and decision-making processes and the determination of human-computer interaction indicators. The third generation of ergonomic science is macroergonomics which deals with the study of complex systems.

Macroergonomics deals with multi-objective design, treating the organization as an integral part of the internal and external environment of the work system under analysis. In its solutions, it seeks to achieve the optimum functioning of the entire system, together with a consideration of its efficiency, taking into account the interdependence of all the elements (human, technical, organizational) involved in the work process.

In macroergonomics, the entrepreneurial organization is captured and described in holistic terms, which should be properly examined in terms of complexity, centralization and formalization. It is also based on the principle that one cannot effectively design the components of a work system if one does not first scientifically justify the decisions related to how to control them. This is where the process support of ready-made legal and standardization solutions comes in. One of them is the ISO 45001 international occupational health and safety management standard proposed in 2018. In this standard, a synthesis of all activities related to the scientific concern for human, technical and social well-being that is associated with the conduct of business appears.

In this paper, by analyzing the structure of the ISO 45001 occupational health and safety management system, the authors will identify the specific activities of the hierarchy of macro-ergonomic analyses in supporting the operational decisions of organizations implementing the considered support system.

2. Macroergonomics and participatory ergonomics

Literature sources define macroergonomics as a top-down socio-technical approach to work systems design and the application of overall work system design to the design of the three main interfaces, such as human-work, human-machine and human-software. The authors of this definition identify macroergonomics as a tool for optimizing the design, ergonomically participatory work systems. Participatory ergonomics as a fundamental method of macroergonomics focuses on the involvement of people in planning, controlling and achieving the desired goals related to their work process in an entrepreneurial organization (Pacholski, Jasiak, 2011).

Implementing elements of participatory ergonomics in an entrepreneurial organization means structuring plans and processes in which the work team must pay attention to:

- motivating factors,
- factors influencing the structure of the implementation plan,
- factors influencing the choice of implementation method,
- the environment,
- social, economic and technical legal factors.

Participatory ergonomics within an organization varies according to the formalized requirements, the commitment and the method of implementation, and the analytical tools of macroergonomics allow it to be implemented by an employee. An employee who will help analyses and design it at individual as well as group level. Methods supporting the evaluation and macroergonomic analysis of the work system include:

- field studies and experiments,
- laboratory experiments,
- questionnaire-based organizational review,
- interviews and focus groups.

In macroergonomics, the design of the work system is considered in the context of the socio-technical systems (technology and degree of automation of the organization), the personnel system (degree of professionalism, demographic characteristics, psychosocial aspects of the employees) and the external environment (adaptation of the organization to the environment and monitoring of its critical feedback). Table 1 provides guidance on the main features of macroergonomic design that the designer, the object to be designed, the criteria that must exist and the necessary knowledge that is needed to succeed in the field of the macroergonomic element to be designed.

Table 1.
Features of macroergonomic design

Macroergonomic design	
Person/feature	**Feature element**
Designer	Examines cognitive and decision-making processes. Examines the relationships between system elements. Examines the influence of the external environment.
Subject	A system involving the location of several human-technical object systems in the internal and external environment of an organization.
Criteria	The human factors criterion. Human-technology relationships. The physical and psycho-physical environment of man.
Knowledge	Knowledge of anthropometry. Sociology and psychology. Organization and management of work systems. Technical design and engineering science.

Source: Own elaboration based on Jasiak, 2015.

Once the component features of Table 1 are in place, it is possible to proceed to the design of the chosen system. Macroergonomic work system design consists of ten phases during which specific tasks are carried out to shape production and service (non-production) processes. The research methodology for these processes is a modified socio-technical analytical model focused on:

- a scanning analysis involving the definition of the mission, vision and organizational principles of the internal and external structures of the enterprise and the clarification of the dimensions of the system design,
- analysis of the type and performance of the system related to the definition and clarification of expectations and allocation of system functions,
- technical analysis of the work process, i.e. defining unit operations and the block diagram of the designed system,
- collection of variant data on differences and incompatibilities arising in the enterprise organization (input and output data),

- matrix analysis of key system inconsistencies,
- variant analysis of control consisting of building control tools, defining the grid of roles in the system and specifying the performance evaluations of the objectives,
- organizational design of technical, human resources and organizational subsystem links and functions,
- analysis of the perception of responsibility and training support,
- design of support system and interfaces related to the system linkage of the physical environment,
- implementation, iteration and improvement of the implemented management system (Pacholski, Jasiak, 2011, pp. 9-54).

In the macroergonomic design of a work system, it is important to remember that there are also many variables such as task heterogeneity, importance, autonomy, feedback or identification. These variables have an important influence on the individual design of jobs organized in a specific system. The design approaches of macroergonomics also shape the operational costing methods of design-technology-structural improvement methods of work. Structural macroergonomic analysis thus covers the whole system as it should be shaped to implement positive and effective changes such as maintenance and health and safety management.

3. Occupational health and safety management system

The traditional instrument used to improve the safety and health of workers in an organization is legislation, which has been transformed over the years into systemic developments. A key influence on change was the Framework Directive 89/391/EEC, which recommended measures to improve the safety and health of workers at work. In Poland, the first edition of the PN 18001 standard appeared in 1999, which made it possible to implement occupational health and safety management systems in organizations. It was built on the theory of the classical pursuit of quality improvement, and was based on the philosophy of continuous improvement in line with the Deming Wheel (and this has not changed in any of the systems to this day).

A management system is a set of functions and activities which, by interacting with each other in a compatible way, realize specific goals of entrepreneurial organizations. The Polish Standard PN-N-18001, but also BS 8800 or OHSAS 18001 define the occupational health and safety management system as a composition of organized resources, personnel, procedures and policies guaranteeing the achievement or maintenance of a specific state of the organization. A health and safety management system is part of an organization's overall management system, which includes its organizational structure, planning, responsibilities, procedures,

processes, policies and the resources needed to develop, implement, enforce, review and maintain a health and safety policy. The system is also linked to the topic of management of occupational risks occurring in the direct and indirect work environment of an enterprise organization (Standard PN-N-18001, Standard PN-N-18004).

In 2018, the international standard ISO 45001 was proposed. According to it, an occupational health and safety management system is a system or part of a management system for establishing and implementing an occupational health and safety policy (Standard PN-ISO 45001). The expected results of the implementation of this system are the effective prevention of accidents at work and the minimization of the risk of occupational diseases. According to the system, an enterprising organization is expected to create safe workplaces using all available scientific and technical knowledge.

According to the definition of the ISO 45001 standard, an occupational health and safety management system is a set of interrelated and interacting elements of an organization, necessary to define and achieve policies, objectives and processes. The procedural provisions of the standard indicate that:

- a management system may encompass several areas of activity,
- the elements of a management system include not only the structure of the organization, but also roles, responsibilities, planning and operational activities,
- the scope of the management system does not only cover the whole organization, it can be implemented in specific units or organizational functions.

The normative provision of the ISO 45001 standard indicates that the primary objective of the implementation of the management system is the continuous improvement of elements related to the area of occupational health and safety, the prevention of accidents at work, occupational diseases and the shaping of safe workplaces, and the activities carried out in this system should make it possible:

- compliance with requirements related to applicable national legislation and work organization, including compliance with internal legal requirements and other regulations and policies adopted within the organization,
- integration of health and safety management processes into the organization’s business model,
- achievement of the agreed general and specific objectives set out in the health and safety management framework,
- definition of responsibility and authority for health and safety (assignment of roles and competencies to each member of the organization),
- development and promotion of a safety culture,
- communication, consultation and participation of workers,
- providing the necessary resources,

- implementation of an occupational health and safety policy in line with the overall strategic objectives of the organization,
- the effectiveness of the identification of safety and health risks,
- reducing all risks inside and outside the organization,
- effective use of opportunities,
- continuous critical evaluation of the results achieved,
- as well as monitoring the management system and improving it when necessary (Pawłowska, Pęciłło, 2018).

These elements form, according to the generally accepted definition, the occupational safety and health (OSH) management system is part of the overall management system of the enterprise, which includes: the organizational structure, planning, responsibilities, policies, procedures, processes and resources needed to develop, implement, execute, review and maintain an occupational safety and health policy and thus to manage occupational risks occurring in the working environment in connection with the enterprise's activities (Pacana, 2020). It is widely perceived that an occupational health and safety management system is a tool that facilitates the enterprise to meet the requirements of the applicable legislation and to provide adequate protection for the safety and health of workers (Karczewski, Karczewska, 2012). This system must be standardized.

The legal standards for occupational health and safety management systems are a tool to help improve occupational safety, but for them to really work it is important to have an implementation plan, i.e. a methodology for conceptualizing the areas that need to be designed or transformed in order to provide workers with the required level of protection of health and life against the hazards present in the working environment.

4. System analysis of the ISO 45001 standard - macroergonomics methods

The system analysis of health and safety management described in ISO 45001 is based on the concept of continuous improvement proposed by Deming (PDCA). At the heart of this model (Figure 1) appears the leadership of top management and the participation of employees, who are to be the guarantors of ensuring effectiveness in health and safety management.

By definition, the standard helps an organization achieve the intended results of its occupational health and safety management system, which, in accordance with the organization's occupational health and safety policy, include, among others, continuous improvement of health and safety performance; meeting legal and other requirements and achieving health and safety goals (Standard ISO/PAS 45005:2020).

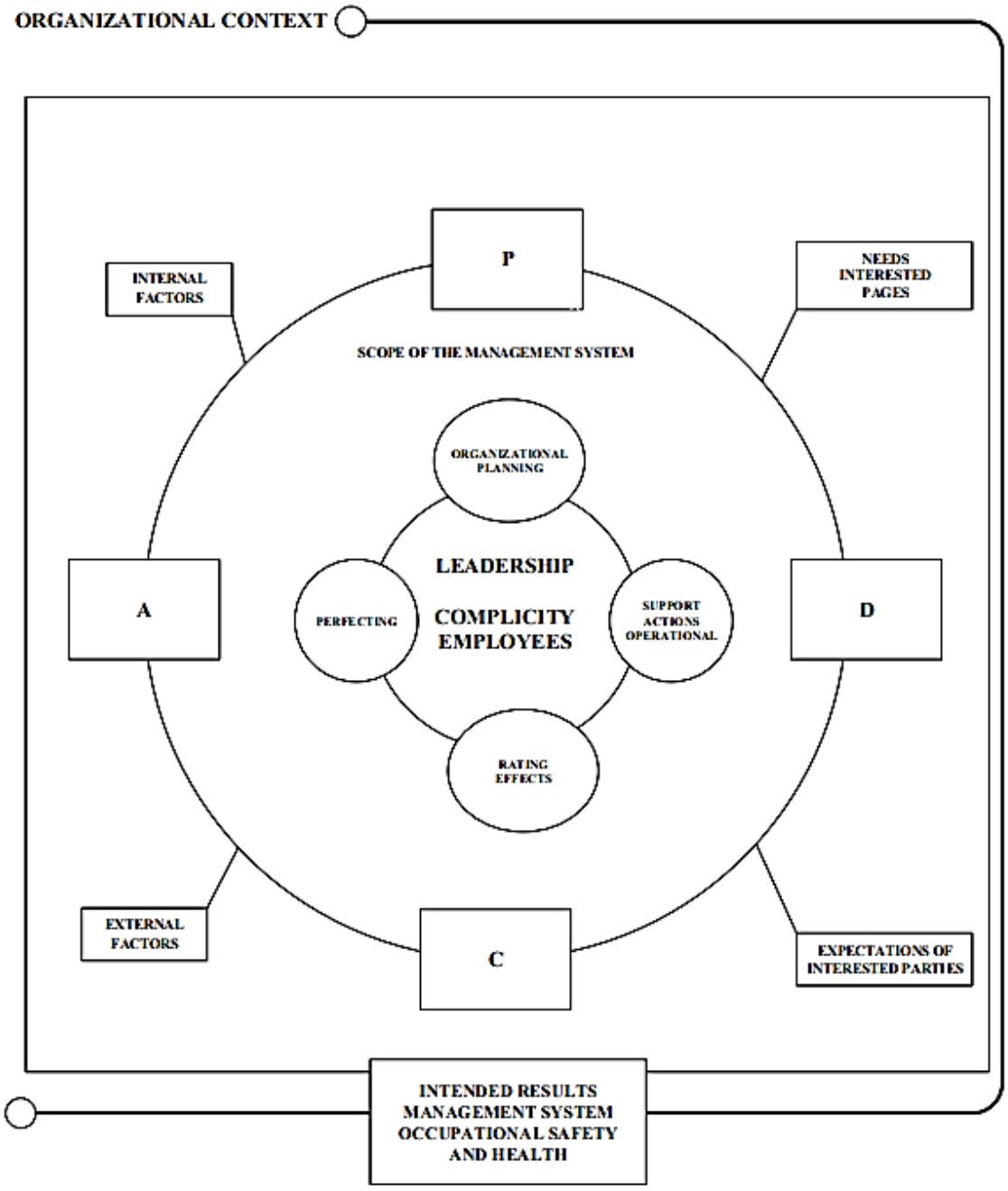

Figure 1. Model of the occupational health and safety management system according to ISO 45001.
Source: own development based on the PN-ISO 45001 standard.

The elements of the health and safety management system model consist primarily of human correlations, i.e. clearly emphasized leadership and participation of workers, who are supported by:

- planned actions that identify risks and opportunities, and set plans and objectives aimed at achieving positive results,
- adequate resources and competences to develop awareness and ensure effective communication on the functioning of the system inside and outside the organization,
- operational planning of activities and supervision of management processes,

– monitoring, analysis and performance measurement, i.e. internal audit and management review,
– improvement planning, non-conformity analysis and corrective action.

The design of the ISO 45001 system and its activities are significantly influenced by the organization's environment or context model, which is based on a process approach or management process. These processes may encompass any sequence of activities carried out in an organization, whether related to production or non-production processes (e.g. services). An example of a management process is provided in Figure 2.

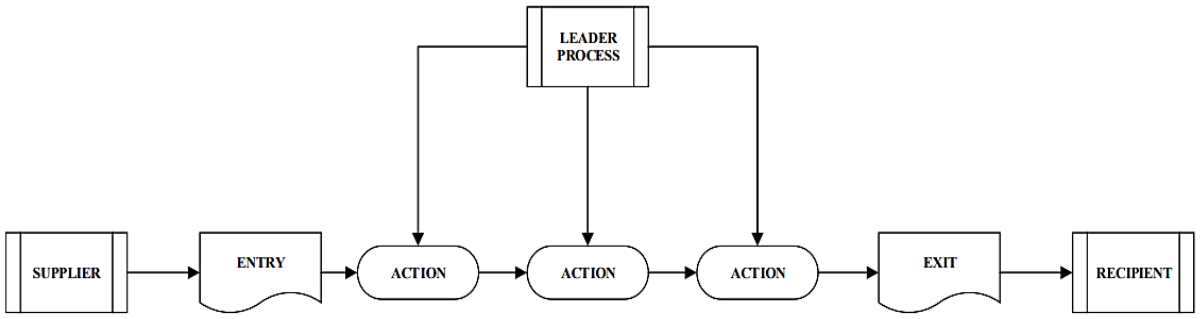

Figure 2. Organizational process according to the ISO 45001 standard.

Source: own development based on the PN-ISO 45001 standard.

The basic organizational process of a system consists of the interaction of input and output data in which people (suppliers, process leaders, customers) participate. The activities realized in it are understood as single activities or sequences of sets of activities, called elementary processes realized by a person or organizational unit. The elementary processes realized in the system combine with each other to form cross-cutting processes, creating tasks in the implementation of which various organizational units participate, which in turn combine with each other to form a network (chain) of processes (Pawłowska, Pęciłło, 2018, p. 14). Among its key processes to ensure the effectiveness of the management of the occupational health and safety system, the ISO 45001 standard lists processes related to:

– system planning,
– consultation and participation of workers,
– elimination of hazards,
– risk reduction within the organization,
– internal and external communication,
– ensuring access to and ongoing updating of legal requirements,
– implementing temporary and permanent changes,
– supervising supplies and services as well as outsourcing,
– preparing an emergency response plan,
– monitoring, measuring, analyzing and evaluating the achieved (planned) results,
– assessment of compliance with legal requirements and related elements,

– reporting and investigation of incidents and non-conformities,
– taking corrective actions.

The documentation of the occupational health and safety management system is also the policy, the objectives, the links of the system and its whole organization in the internal as well as the external structure. And by analyzing the requirements of the occupational health and safety management system as defined in ISO 45001, it can be seen that its main role apart from the human leader-coordinator is information. And here the direct structural links of the management system with macroergonomics will appear. The information contained in a health and safety management system, as in a macroergonomic analysis, must take a researched, documented and comprehensible form.

The simplest, yet documented form of the elements of a health and safety management system are procedures. Procedures describe how individual activities are to be carried out, who is responsible and how they are to be assessed, monitored and corrected (Table 2). The documented procedures of the system must be in line with reality and with the activities or processes carried out in the organization.

Table 2.
Documented procedures as required by ISO 45001

ISO 45001 standard Documents	Internal and external audit of the organization
	Investigation of accidents and incidents
	Corrective and preventive action
	Identification of opportunities
	Hazard identification
	Communication (structure and route of communication)
	Monitoring of measurements and all incidents in the organization
	Supervision of records
	Risk assessment
	Compliance assessment
	Emergency preparedness
	Emergency and non-compliance response
	Operational control
	Training
	Legal requirements
	Internal requirements, records, regulations, procedures
	Cooperation customer, supplier, external companies, etc.

Source: own development based on the requirements of the ISO 45001 standard.

The documentation of the occupational health and safety management system is the policy, the objectives, the linkages of the system and its whole organization in the internal as well as the external structure. The macro-regional linkages of the ISO 45001 standard can also be found in the context of the requirements related to the media of recorded information (Table 3), which are intended to provide evidence of the performance of activities in accordance with the established health and safety management system.

Table 3.
Information media according to ISO 45001

ISO 45001 standard organizational information carriers	Scope of the health and safety management system
	Health and safety objectives and plans
	Incidents or non-conformities, corrective actions and their results
	Information to confirm that processes are running as planned
	Competence of all in the organization
	Methods and criteria for assessing safety and health risks
	Policies in and around the organization
	Emergency response processes and plans
	Audit programmers and results
	Roles, responsibilities and authorities in the OSH management system
	Safety and health risks and opportunities to eliminate or better mitigate them, and processes implemented to mitigate them
	Legal and other requirements
	Results of continuous system improvement
	Results of monitoring
	Results of assessing compliance with legal and other requirements to which the organization has committed itself
	Results of measurement and analysis and evaluation
	Results of management reviews

Source: own development based on the requirements of the ISO 45001 standard.

The documented information is an analytical and research tool for those responsible for the control and supervision of the system. The information produced in the health and safety management system should be easily identifiable, easily reviewable and always validated. In the process of its validation, the enterprise organisation has the task of ensuring that it is available in the designated places (where it is needed), appropriately protected, but also disseminated, updated and, above all, withdrawn (or protected) from use if it becomes outdated at some point.

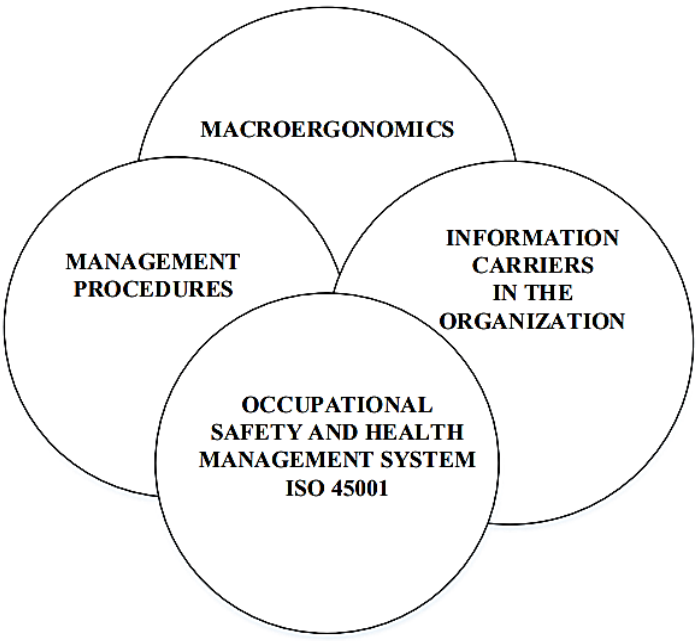

Figure 3. Macroergonomics - ISO 45001.

Source: own development based on the analysis of research on the ISO 45001 standard.

Applying the analytical tools of macroergonomics to the structure of the ISO 45001 occupational health and safety management system (Figure 3) provides the opportunity for agile detection of weak and critical points related to the human-work system interaction that should be subjected to improvement actions. Conducting complex analyses in the system documentation shapes the correct identification of the human work context (in technical and socio-technical terms) in an entrepreneurial organization.

5. Summary

The occupational health and safety management system according to the normative standard ISO 45001 indicates that it is necessary to implement procedures and information carriers that define its improvement functions. Functions that should be continuously monitored, analyzed, developed and reported in the context of:

- the entire organization (and its context),
- actions aimed at eliminating risks,
- activities aimed at exploiting opportunities,
- achievement of objectives and plans,
- human participation and consultation inside and outside the organization (direct and indirect information and communication),
- monitoring, measuring, analyzing and evaluating performance,
- internal audits and management reviews.

The analysis of this data in the context of the macroergonomic tasks of optimizing system work enables appropriate changes to be made for the safety and health of the organization's employees, but also contributes to responding to, correcting and rectifying the effects of root incidents or non-conformities. Analysis of the ISO 45001:2018 standard has proven that macroergonomics in the structure of this system contributes to the procedural identification and implementation of necessary corrective actions, taking into account the applicable hierarchy for the application of risk mitigation measures in line with the continuous improvement of the enterprise organization (Deming cycle PDCA). It also contributes to the creation of criteria for evaluating the system relationships of health and safety management.

Changes in the elements of the standards should be monitored all the time, because with their change the structure of macroergonomics is also transformed. The authors, as part of their research work, decide to follow these transformations in order to further improve the stages of scientific development.

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