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Optimization of the Occupational Safety Management System at Enterprises Using Potentially Hazardous Technologies

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Abstract. Problem statement. Modern enterprises that use potentially hazardous technologies operate in conditions of increased production risks associated with the operation of complex machinery and equipment, the handling of explosive and flammable substances, and the performance of high-risk work. Traditional occupational health and safety management systems, based mainly on a reactive approach, do not provide adequate effectiveness. This necessitates a transition to a risk-based approach, which involves identifying, assessing and minimising risks at the planning and organisation stage of production processes. Improvements to occupational health and safety management systems should be aimed at preventing occupational injuries and diseases, fostering a culture of safety at work, and creating a sustainable risk management mechanism. The purpose of the article is justification of approaches to optimising occupational health and safety management systems at enterprises that use potentially hazardous technologies, taking into account the principles of risk-based management. Particular attention is paid to the issues of creating safe working conditions during the performance of high-risk work, developing practical mechanisms for reducing production risks and improving the effectiveness of the occupational safety management system. Conclusions. It has been established that when developing occupational health and safety management systems, it is necessary to take into account a set of key components, among which comprehensive and continuous risk and hazard assessment, as well as effective interaction between the components of the 'human-machine' system, both with each other and with the production environment, are of paramount importance. An important element is the organisation of systematic training of personnel and officials in methods of safe work using computer-integrated technologies in combination with automated control of the microclimate parameters of the working environment. Additional attention should be paid to measures for regular medical examinations of employees and monitoring of their physiological condition, as well as minimising risks associated with the technical condition of machines and mechanisms through inspections, certifications and expert assessments. An important aspect is the supervision of racking structures throughout their entire service life and the integration of training materials with data collection terminals and video terminals.



1. Statement of the problem

Almost all modern enterprises use some potentially dangerous technologies or are engaged in work with increased danger. One of the striking examples is industrial and logistics hubs (hereinafter referred to as ILH). As modern warehouse enterprises, they are a key link in ensuring the continuity of supply and storage of products, however, their activities are accompanied by significant production risks. The use of modern warehouse technologies, such as automated transportation systems, lifting equipment, high-rack structures, as well as work with flammable or explosive materials, creates a high level of potential danger for employees. Traditional occupational health and safety management systems, focused mainly on eliminating the consequences of emergencies or accidents, do not meet the requirements of modern conditions for conducting economic activity. This necessitates the implementation of risk-based management approaches that involve preliminary identification of hazards, assessment of the probability and consequences of risks, and development of preventive measures. Thus, it is relevant to substantiate an optimized occupational health and safety management system using the example of industrial and logistics hubs, where safety issues are critical for preserving life, health of personnel, and continuity of production and logistics processes.

1.1 *The purpose of the research*

The purpose of the research is to substantiate approaches to optimizing the occupational safety management system at enterprises that use potentially dangerous technologies, taking into account the principles of risk-based management. Particular attention is paid to the issues of creating safe working conditions during work with increased danger, developing practical mechanisms for reducing production risks, and increasing the efficiency of the occupational safety management system.

2. Research results

In 2018, the Concept of Reforming the Occupational Safety and Health Management System (OSHMS) in Ukraine [10] was adopted, which defines the principles, main directions and tasks of building an occupational safety and health management system in Ukraine based on a risk-based approach, which should ensure the implementation of European Union standards. This Concept was designed to initiate the transition from a reactive OSH management system to a proactive one (hazard prevention). Unfortunately, it remains unimplemented at present.

Baklytskyi I.O. claims that when a person interacts with a machine or environment, a certain system “subject - object” or more precisely “person - technology - environment” arises. This is the system that we will understand in the future as “ergatic” [1].

Bochkovskiy A.P. addressed the problems of uncertainty in the state of the ergatic system in his works [2]. The author focuses on two groups of uncertainty factors (“human” and external factors) that have an impact on the operation of the ergatic system.

A.G. Mnukhin [9], B.B. Kobylanskyi [11], V.B. Hoho [3] consider the production activity of coal mines as an ergatic system.

I. Veshneva [18] and others in their article consider the creation of an ergative model to increase the efficiency of personnel competence formation processes. Such development can potentially be used to increase the efficiency of training personnel of the ILH in safe work methods.

G.I. Zverev and V.V. Menshikh are working on the development of methods for optimizing the selection of functions of an ergatic system. In their work, the scientists focused on the description

of structural and parametric models and functional capabilities of ergatic systems. It is proposed to use weighted hypergraphs as a model [19]. In our opinion, modeling of ergatic systems is important in their development, since it allows us to assess the effectiveness of such systems.

V.G. Zdanovskiy, G.G. Gogitashvili and V.M. Stepanyshyn also justified the need to reform occupational safety management systems of enterprises based on the implementation of European standards and a risk-oriented approach, noting that it is necessary to assess the probability of accidents or breakdowns, as this will reduce the severity of their consequences due to timely implementation of preventive measures to reduce the level of risk [6].

In another article, V.G. Zdanovskiy expresses the opinion that "the starting points for planning the improvement of the OSHM system are statistical data on industrial injuries, although they are not exhaustive due to many objective and subjective reasons, the database of the Social Insurance Fund of Ukraine, as well as statistics and research of the state institution "National Research Institute for Industrial Safety and Occupational Health", other institutions and organizations that study working conditions and their impact on workers" [7].

In their work, Jan Pila and Jaroslav Kozuba [15] investigated the issue of human-aircraft interaction in the context of flight safety, with the aim of determining the level of process safety. A similar approach can also be used in monitoring the safety of logistics processes.

I. Petukhov [14] devoted his works to the issue of using virtual environments in training operators of ergatic systems. A similar approach can be effective in conducting training on labour protection issues.

The issue of interaction of the human-machine interface with electromechanical devices is highlighted in the work of O. Saushev [16]. The emphasis is on mathematical models of joint control of the human-machine system.

Nosov P.S. devoted some articles to the development of means for experimentally detecting the level of attention of workers in the ergatic systems of maritime transport [12].

Separate studies were also conducted to assess the efficiency indicators of the functioning of information ergatic systems [17], which is of direct interest for this work.

As we can see, various aspects of ergatic systems in different sectors of the national economy attract the attention of many researchers, both domestic and foreign. However, there are too few scientific studies that directly concern ergatic occupational safety systems. Moreover, no scientific research has been conducted on ergatic occupational safety systems in industrial-logistics hubs (ILH).

The structure of the OSES and its functional components are created taking into account the tasks assigned to it. The functioning of relevant services, departments and specialists must be ensured at the ILH, and constant work must be carried out to ensure safe and healthy working conditions.

Since the ILH has a large number of personnel, the occupational safety management should be carried out by the deputy head for occupational safety of the enterprise, who has completed appropriate training and testing of knowledge in occupational safety. An occupational safety service (hereinafter referred to as the OSS) or its analogue is created at the enterprise, represented by specialists with appropriate qualifications, headed by a chief.

Regarding the number of this service, it should be noted that, on the one hand, ILH owners have the right to independently determine the number of relevant departments or services, establish staffing numbers, and approve the staff schedule. On the other hand, they must ensure proper working conditions and effective control over compliance with occupational safety regulations and legal requirements. When determining the number of OSS personnel, the ILH

owner or an authorized body must choose personnel calculation methodology that accounts for the working time fund of specialists, the number of employees engaged in high-risk work, and other relevant factors. The effectiveness of the OSS and its ability to perform its assigned functions depend on this choice. The literature contains a calculation method that takes into account all relevant factors [8]. According to this method, the number of OSS is determined depending on the level of hazardous and harmful working conditions:

$$M = 2 + K \times \frac{P_{sr}}{F}, \quad (1)$$

where M is the number of SBPs;

F - effective annual working time fund of a OSS specialist, which is 1820 hours and takes into account the loss of working time due to possible temporary disability, vacation, etc.;

K - a coefficient that takes into account the degree of harmfulness and danger of working conditions.

$$K = 1 + \frac{(P_{sh} + P_{pn})}{P_{sr}} \quad (2)$$

where P_{sr} is the average number of personnel of the ILH, of which P_{sh} are exposed to hazardous substances in work and P_{pn} are engaged in work with increased danger.

According to formulas (1) and (2), it is possible to calculate the number of OSS for an ILH with a staff of, for example, 1500 people (of which 200 people perform work with increased danger):

$$K = 1 + \frac{200}{1500} = 1,133.$$

$$M = 2 + 1,133 \times \frac{1500}{1820} = 2,93$$

As we can see from the calculation, it follows that for the functioning of the relevant OSS of such an ILH, at least three specialists are required, and this is without taking into account specialists involved in ensuring fire, technogenic safety, civil protection, etc. The OSS carries out its activities in accordance with the annual work plan, schedules for checking the state of occupational safety in all structural units. Once a year, the OSS provides CEO with an annual report in the field of occupational safety, which should present a comprehensive assessment of the state of occupational safety at the enterprise.

By order of the head of the ILH, responsible persons (heads of services, departments, etc.) for the state of occupational safety in all structural units are appointed. A special commission should be formed from representatives of the OSS, competent specialists from other departments in order to fully and regularly assess risks and hazards at each workplace, all members of the commission undergo appropriate training in risk assessment methods. OSS employees record the results of such an assessment, develop and create an optimal system of training for personnel and officials, monitor the status, collect and analyze data on the functioning of the OSES, and together with the heads of structural units develop measures to improve the efficiency of the OSES.

In addition, heads of structural divisions are assigned the function of direct control over the safe work of subordinate personnel, organization of briefings, and responsibility for the safe operation of loading and unloading equipment and racking structures.

The ILH should have a technical control department, the tasks of which will include conducting technical inspections, expert examinations of machines and equipment, releasing vehicles for flights, ensuring repairs and proper technical condition of equipment.

The medical service deals with the issues of conducting medical examinations and surveys, monitoring the physiological condition of employees, and providing qualified medical care for all ILH personnel.

Also, the personnel services of the enterprise should be involved in creating healthy and safe conditions, at least in terms of organizing training, improving the qualifications of personnel, conducting psychological assessments of personnel before hiring. The personnel service, together with other departments, organizes the development of job and work instructions for all positions of managers and specialists. Job and work instructions specify occupational health and safety responsibilities [5].

All personnel involved in the operation of forklifts or other high-risk equipment undergo briefings, training and knowledge testing on occupational safety issues. For each department that operates forklifts, responsible persons from among the engineering and technical personnel for the proper technical condition and safe performance of work with forklifts should be appointed. An exemplary functional diagram of the OSES is shown in Figure 1.

When analyzing the state of occupational safety at an industrial plant, a large number of prerequisites should be taken into account, some of which are random in nature. They can be determined by the conditions of the working environment, the technical condition of the equipment used, the human factor, etc.

The approach to developing an occupational safety system requires a rational approach, clear interaction of engineering and technical personnel, heads of structural units, occupational safety services, and also important is the interaction between various co-owners of the ILH, if any, and regulatory authorities. An important function of any management system is the analysis and forecasting of indicators of the effectiveness of its functioning. In this regard, the question arises of how to form an OSES that would comprehensively consider the issues of occupational safety of industrial and logistics hubs and provide an opportunity to respond in a timely manner both to changes in the conditions of the technological process or working conditions, and to the causes of accidents, occupational diseases or breakdowns.

The ergatic system of occupational safety should be based on a comprehensive assessment and constant monitoring of production factors that may have an impact on the personnel of the ILH, including both internal (psycho-emotional state, lifestyle, physiological characteristics, level of fatigue, etc.) and external (noise, lighting, technical condition of mechanisms, materials used in work) [4]. The impact of the human-machine complex (for example, the work of a driver of loading and unloading equipment) on the surrounding working environment and possible risks for other personnel should also be considered separately.

Many employees of the ILH perform a number of works with increased danger or professional selection, in particular, operate motor vehicles, technological vehicles, perform loading and unloading operations using machines and mechanisms. It is also possible for work to be performed by persons under the age of 21. All these elements must be taken into account when developing the OSES, as they carry a potential danger not only for themselves, but also for the personnel around them.

An important component of the OSES of the ILH is the training of personnel and officials in safe methods and techniques for performing work. Improving competence requires the search for completely new approaches, the development of OSES in such a way that it ensures the prevention

of risks in the workplace, the search and justification of necessary preventive measures. One of the cornerstones of effective training should be automated systems for monitoring and accounting of training, which allow not only to reduce the time spent on training, but also to simplify the process of their implementation. In this case, additional risks that arise when employees use computers should also be taken into account.

For the training and professional development of officials, software packages with methodological guidelines should be developed to assist heads of structural units in properly organizing and conducting occupational safety briefings, providing an understanding of the enterprise's occupational safety management system, organizing medical examinations, ensuring the inspection and maintenance of equipment, and conducting hazard monitoring at the workplaces of subordinate employees. Such software packages should include examples of filling out logbooks, address key issues related to safe work practices, and contain answers to the most common questions that arise among heads of structural units when implementing occupational safety measures.

In warehouses, temperature, noise, air velocity, and humidity should be monitored using appropriate sensors, guided by the relevant regulatory requirements for the working environment. In those premises where, in accordance with the requirements, the internal air temperature is not regulated and heating is not provided, it is also necessary to monitor the parameters of the working environment. When conducting monitoring, it is worth paying attention to air conditioning systems, if such are provided for by the requirements of cargo storage technology, if the specified parameters of the production environment in them cannot be provided by general exchange ventilation. In air-conditioned premises, air or air-heat curtains are usually also provided near external doors or gates, which creates additional difficulties when assessing the air velocity in the room. In those places of the ILH where harmful substances can be released into the air, the concentrations of these substances should be regularly monitored and recorded.

An extremely important aspect is the medical examination of personnel. Special attention should be paid to vehicle drivers and workers servicing machines and mechanisms before the start of a work shift or departure on a flight. For drivers, mandatory procedures include blood pressure measurement, a detailed external check, and a breath alcohol test [13]. All medical examination data must be available in real time in an automated system. Employees of the occupational safety service, as well as maintenance personnel (such as mechanics), must have access to this data to prevent individuals in improper condition from being admitted to work.

Another component of creating safe working conditions for the personnel of the ILH is ensuring the proper technical condition of machines, mechanisms and equipment. Regular technical inspection, monitoring of the condition of the equipment allows minimizing risks from the side of the machine. Such information should also be recorded and be available for analysis. Responsible employees should enter information on periodic technical inspections, expert examinations into the database, and information on the shift release of vehicles for the trip should be collected and processed.

Attention should be paid to the supervision of racking structures, which are usually present in large quantities at ILHs. Supervision should begin from the moment of their installation by a specialized organization and continue throughout the entire period of operation. All information obtained as a result of monitoring should be documented electronically and be available for analysis.

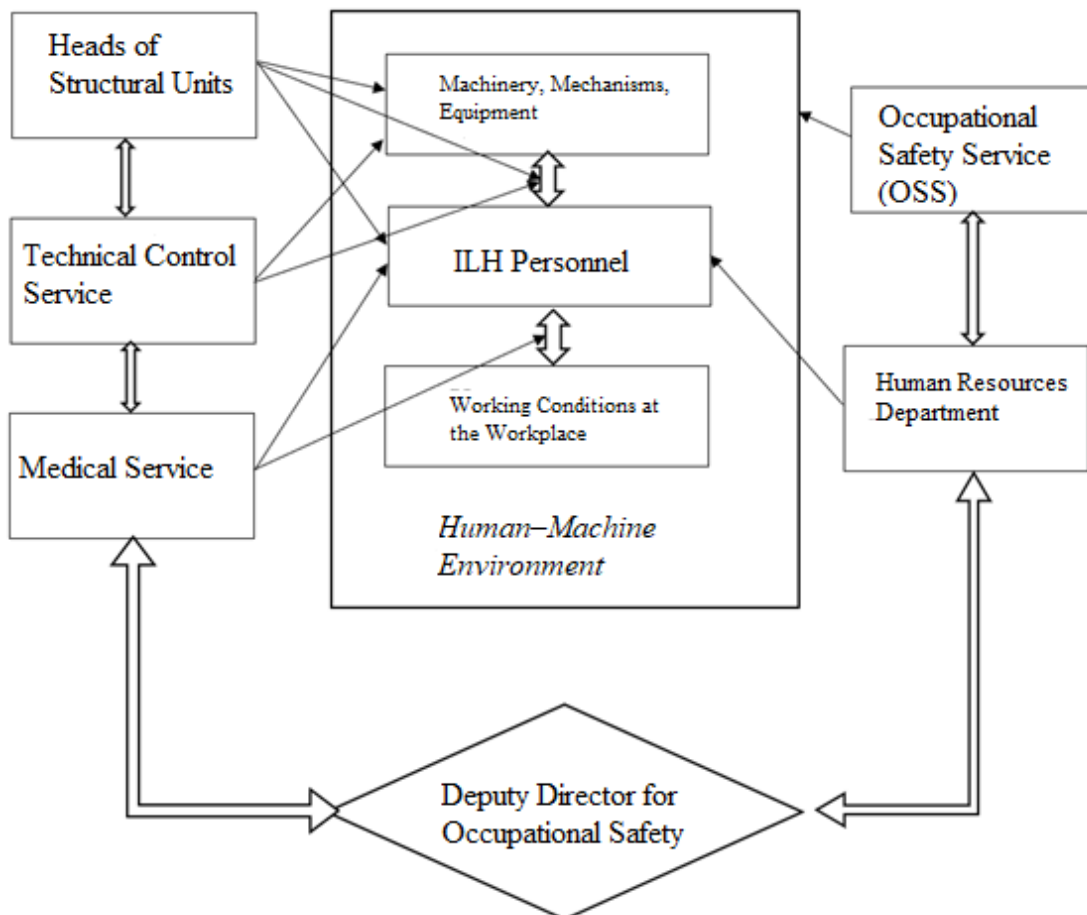


Figure 1. Functional diagram of the OSES and the interaction of its structural components

In the case of the use of data collection terminals by the ILH personnel or the installation of video terminals on the territory, it is effective to integrate occupational safety instructions with them. The employee always has the necessary requirements for the safe conduct of work “at hand”, which allows for additional stimulation of employees to personally realize the importance of their own safety, approaching an independent level of safety culture (people's thinking: I do this because personal safety is important to me).

3. Conclusions

Summarizing the above, it can be stated that the development of an Occupational Safety Management System (OSMS) requires consideration of several key components, including:

- continuous and comprehensive assessment of workplace risks and hazards;
- effective interaction between elements of the “human-machine” system, as well as with external production environment factors;
- an efficient training system for personnel and officials on safe work practices involving computer-integrated technologies;
- automated control of workplace microclimate parameters;
- conducting medical examinations, monitoring the physiological condition of employees;
- minimization of risks associated with the technical condition of machinery and equipment through regular inspections, assessments, and expert evaluations;
- supervision of rack structures throughout their entire service life;
- integration of training materials with data collection terminals and video terminals;

- collection and analysis of statistical data at all stages of OSES operation, in order to develop occupational safety measures and monitor the system effectiveness.

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