https://doi.org/10.33271/nvngu/2022-6/104

V. A. Tsopa[1],
orcid.org/0000-0002-4811-3712,
S. I. Cheberiachko[2],
orcid.org/0000-0003-3281-7157,
O. O. Yavorska[*2],
orcid.org/0000-0001-5516-5310,
O. V. Deryugin[2],
orcid.org/0000-0002-2456-7664,
A. A. Aleksieiev[2],
orcid.org/0000-0003-0394-2493

1 – International Institute of Management, Kyiv, Ukraine
2 – Dnipro University of Technology, Dnipro, Ukraine
* Corresponding author e-mail: elenayavorska80@gmail.com

IMPROVEMENT OF THE SAFE WORK SYSTEM

Purpose. To improve the approach to the development of a safe work system, one of the important elements of the occupational health and safety management system (OHSMS) of employees at an enterprise.

Methodology. The research is based on the "Safe Systems of Work", which combines the content of safe procedures, which are determined taking into account the content of the worker's production task when performing production activities, his/her competence in understanding the technological process and characteristics involved technological equipment.

Findings. To reduce occupational diseases and industrial injuries at enterprises, it is proposed to implement the "Safe Systems of Work" (SSW) of "5 steps": "analyse", "summarize", "anticipate", "support", "improve", which will make it possible to identify occupational risks (OR) and justify the feasibility of reducing their impact on the worker during the performance of production activities. For the implementation of each step, a corresponding procedure is provided, which allows ensuring their implementation. It is proposed to carry out the OR evaluation procedure according to the "Tree Trunk Analysis" model, which is a section of the trunk of a tree divided into six parts which characterize the dangerous factors that affect the activity of the employee, the functioning of the technological equipment and the environment. A feature of the proposed approach is the establishment of zones of interaction between the following components of the proposed SSW: the worker and technological equipment, the worker and the environment, as well as the environment and technological equipment, which characterize the specified external and internal factors of influence on the SSW.

Originality. The approach to the organization of SSW to reduce the level of OR during the performance of production activities has been improved based on the improvement of the OR management process, the identification of external and internal dangerous factors that affect the level of OR, the probability of the occurrence of a dangerous event and its degree of severity, taking into account changes, over time, in the conditions of performing professional activities: during stable work, during an emergency situation, during an accident and during martial law.

Practical value. Improved labour protection instructions or maps of safe production processes can be applied at enterprises with the aim of better perception by employees of labour safety requirements and improvement of document flow at the workplace.

Keywords: *safe work system, occupational risk, hazard, accident, hazardous factors*

Introduction. The main task of Occupational Health and Safety Management System (hereinafter OHSMS) of the enterprise is to implement the organizational, sanitary-prophylactic and technical measures to prevent injuries and occupational diseases of workers during the production activities. One of the effective approaches to injury prevention is the implementation of the Safe Systems of Work (hereinafter SSW), which combines a set of carefully selected procedures developed on the basis of the systematic identification of hazards during the performance of production activities by workers, taking into account their competencies and the characteristics of technological equipment [1, 2] . At the same time, its construction is based on two approaches:

- egocentric, focused on the employee;
- ergonomic, focused on production activities [3, 4].

The egocentric approach (or behavioural safety) is the creation of conditions for managing safe behaviour in the workplace by the management of the company. The occurrence of an injury is always the result of the influence of a certain sequence of hazardous factors, so if all accidents are taken as 100 %, then the ratio of the causes of injury will be 88 : 10 : 2, where 88 % are hazardous actions of workers during the performance of professional activities; 10 % is failure of technological equipment; 2 % is influence of natural phenomena [5, 6].

According to the hierarchy of OR control (Fig. 1), with the egocentric approach, the main emphasis is on the use of administrative control measures and the use of personal protective equipment (PPE).

The ergonomic approach is aimed at the development of safe systems, equipment and technologies to avoid incidents in the interaction of people, equipment and the working environment. At the same time, the employee's behaviour is not evaluated as hazardous or unreasonable, but is expressed through the focus of their knowledge, experience and skills, from the point of view of the complex interaction of the "human-equipment-work environment" system. The greater the level of

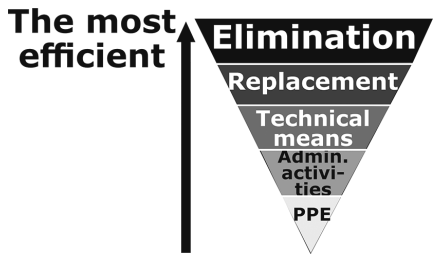

Fig. 1. Hierarchy of PR control [7]

threat during technological processes is, the more necessary better protection systems are, which include both obvious technical solutions (physical barrier, automated shutdowns) and non-obvious ones affecting the human factor: organizational, administrative and regulatory (policy, provisions, instructions, etc.) (Fig. 2). Multi-level protection systems, which allow us to neutralize failures of various origins, have proven to be the best ones.

At workplaces, workers constantly create a changing combination of hidden inconsistencies [7, 8], and technological processes are accompanied by the manifestation of a small number of errors or failures. Individual discrepancies cannot lead to an incident, so they are considered insignificant at the operational management level. It becomes obvious that the management of a complex technical process requires a constant search for a balance between productivity and the creation of conditions to avoid an emergency situation due to the accumulation of failures and errors. In addition, safe procedures with an ergonomic approach should be based on forecasts of changes in hazardous equipment states and its reliability. On the other hand, technological processes can lead to failures, breakdowns, which in most cases are caused by incorrect actions or inactivity of the human operator. Therefore, when developing SBP, there is a need to take into account the change in the psychophysiological characteristics of the human operator over time caused by changes in the production situation.

Literature review. To reduce the level of injuries at enterprises SSW is implemented. It involves the development of appropriate safety and occupational health and safety instructions, the conduct of appropriate training, as well as the provision of constant monitoring of hazards through the assessment of occupational risks (hereinafter referred to as OR), which are the basis for the introduction of various preventive measures. However, in the study [9], the author established that the level of occupational safety depends most on human factors, which are difficult to predict. At the same time, the proposed measures of careful professional selection are a rather dubious approach to reducing the level of injuries, since hazardous actions or inaction also depend on the organizational culture at the enterprise and the social and psychological climate at workplaces. In another work [10], the author recommended creating a system of operational monitoring of employee behaviour; however, as noted in work [11], the conclusions that

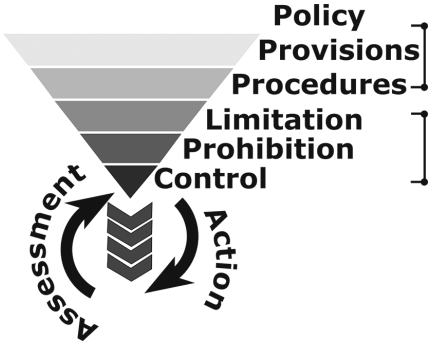

Fig. 2. Multi-level protection system for technological processes [7]

the main cause of incidents is the human factor are quite ambiguous. In the paper [12], the authors, based on a study on the relationships between the causes of accidents and the organization of regulatory and methodological support for production processes, recommend clearly and thoroughly prescribing the procedures that must be performed by employees. Inadequate fulfilment of labour protection requirements (due to the significant number and complexity of procedures) is also indicated in a study conducted at several dozen enterprises in Spain [13, 14]. The researchers note that the greatest confusion among workers occurs with OR assessment due to the lack of a standardized approach. Within the framework of studies [15, 16], the need to ensure objective relationships between the procedures for identification and assessment of OR is indicated. Summarizing recent studies [17, 18], there is a need to develop a clear and objective approach to occupational safety management at the enterprise, which would take into account the change in the technical condition of the equipment and the psychophysiological characteristics of the human operator over time.

Purpose. The purpose of the paper is to improve SSW to reduce the probability of incidents and their consequences for the life and health of workers at workplaces based on OR management, taking into account changes in the conditions of professional activity over time: stable work, emergency situations, accidents and military conditions.

Methods. To improve SSW we will use the generally recognized "5 steps" method [19] ("analyse", "summarize", "predict", "maintain", "improve") to develop procedures based on the OR assessment, which provides:

- assessment of the work task, where the collection and thorough analysis of information about sources of hazard is carried out;
- identification of hazards, calculation of the value of OR from the action of hazardous factors that can affect workers when performing production tasks, including consideration of the psychological aspects of the impact on workers;
- the OR assessment (the product of the degree of probability of the occurrence of the incident and the level of the consequences of the incident);
- establishment of safe work methods planning, where safe work methods are substantiated in cases of existence of even a minor unacceptable level of OR;
- control over the performance of SSW, aimed at ensuring regular monitoring of system performance, training of employees, and their implementation of safety instructions and rules.

In SSW, there are no clear requirements for step-by-step procedures. However, there is a clear form for presenting documented information to employees (Table 1).

In particular, the availability of preparation for the performance of a production task through planning and a safe sequence of its execution is mandatory. Since each type of activity has its own specifics (in particular, in normal, emergency, military conditions or in the event of an accident), there is a need to manage the OR, taking into account the impact of working conditions.

Results. For the development of OHSMS at any enterprise, when creating "SSW maps", it is suggested to take into account various long-term or short-term changes in the production process, which is reflected during the assessment of OR by considering six hazardous factors (hereinafter HF): human, technical, organizational, operational, social and ergonomic (Fig. 3).

This approach, in contrast to the existing ones, allows for a more thorough justification of preventive and protective measures to achieve the planned results in terms of reducing the number of incidents and to carry out continuous improvement of the OHSMS. Also, during the assessment of the OR, it is suggested to take into account the different nature of the works: stable, emergency, in the event of an accident, and during the introduction of martial law.

Table 1

Workplace map template for construction of SSW

Name of the section	What needs to be described
Premises and place of work	The place where the work is done
Work leader/administrator	Enter the full name and position
Date of creation	Specify the date of creation of the map
Auditor	The person who did the inspection
Job description and HF	Description of the work to be performed, with a photo or diagram of the workplace
OR management	Additions to "SSW maps"
The purpose of SSW at this workplace	What needs to be achieved
Tools and equipment to be used	Description of necessary tools and equipment
Preparatory works	Description of steps before starting work
Training	What you need to pay special attention to
Procedures	A list of work instructions that regulate the work being performed
Safety measures	Description of the necessary means of collective protection
	Description of required PPE
Sanitary and household provision	Specify the need for disposal and removal of waste, cleaning the workplace, etc.
Hazard identification, assessment and OR management	Supplement to "SSW map"

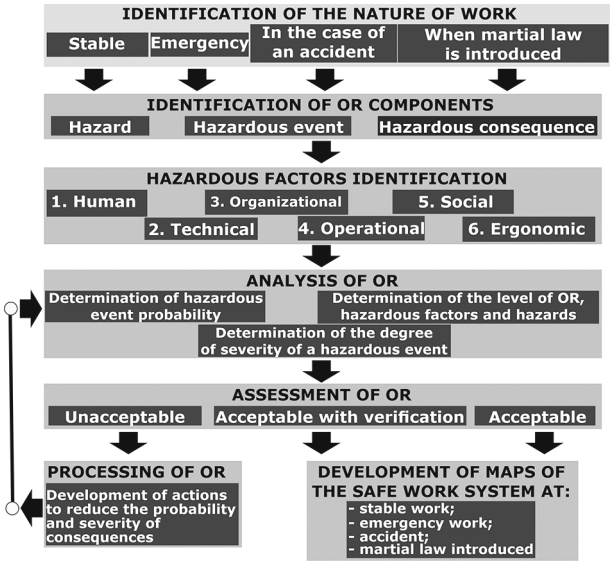

Fig. 3. SSW map development process based on the OR register(s)

As a result, there is a need at the first step of the OR assessment to provide for:

- identification of the nature of the work at the workplace, where it is specified under which condition the OR will be considered;

- identification of OR components, where it is clarified which hazard can lead to which hazardous event and what negative consequences may be caused by its occurrence;

- identification of hazardous external and internal factors at the enterprise that affect the probability of the occurrence of a hazardous event and the severity of its consequences.

It is important to note that external and internal factors are considered for each hazardous condition, as they affect the probability of occurrence of a hazardous event and its degree of severity.

The OR assessment procedure itself in the proposed "SSW map" is conveniently represented by an improved model in the form of a tree trunk section, the principle of which was proposed by Geoff McDonald. The main peculiarity of the presented model (Fig. 4) is the division of the tree trunk into 6 zones in accordance with the types of hazardous factors, and the length of the trunk is divided depending on the nature of the work.

This model provides for the change in each component of the production process over time, under the influence of different HFs, which pass through different types of work along the trunk. This approach makes it possible to establish patterns linking injuries or occupational diseases with the specific HF. In addition, the interaction of production processes makes it possible to assess the level of safety culture, the psychophysiological state of a person, and other components that are necessary for understanding the causes of accidents or incidents. Note that the given states of the production processes component can last for months or years, and then change unexpectedly.

To evaluate OR, a slightly improved process is proposed, which, unlike classical approaches, divides OR into three main types: acceptable, acceptable with verification, unacceptable ones (Table 2).

This approach allows more rational use of the company's financial resources to find and implement preventive and protective measures for OR management.

For each hazard and hazardous event (hereafter HE), you can determine the final OR, taking into account the impact of each external and internal HF, and to assess the probability of occurrence of HF and the degree of severity, you can use an 8-point scale: where 1 means HE does not occur or the consequences are absent, and 8 means HE occurs continuously for a specified period or the severity of the consequences (injury or occupational disease) with a fatal outcome. An example of such OR control, taking into account the HF environment and hazardous actions during the work of the compressor unit driver, is presented in Table 3. More details about the scale for OR assessment can be found in the paper [20].

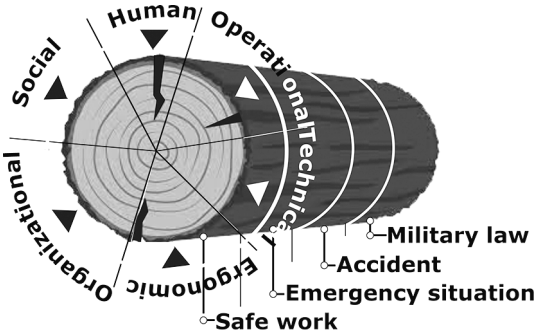

Fig. 4. Model "Section of a tree trunk"

Table 2

OR classification

No.	OR assessment	Score
1	Acceptable OR	from 0 to 130
2	Acceptable with verification OR	from 131 to 260
3	Unacceptable OR	> 260

The novelty of the proposed OR assessment is the determination of the final effect of the combined effect of all negative factors, which allows for a detailed study on the impact of each of them on the probability of HE occurrence and the severity of the consequences. It is this approach that allows you to identify the HF that has the greatest contribution to the final OR and to start developing preventive measures from it. In addition, the proposal to divide the nature of works into four types allows us to identify the most influential HFs in their combined effect. For example, during stable operation, the value of OR is larger than that of a technical negative factor, which is associated with a malfunction of technological equipment, its untimely maintenance, technical inspection, planned repair, replacement of perishable parts, etc., while during emergency operation the human negative factor becomes the major one, while it had a minimal impact during stable work. This is explained by the assumption that all technological processes, as a rule, cope with the task. For the most part, the potential energy of a single discrepancy (error, failure) is not sufficient to form HE conditions. A significant part of failures is blocked at an early stage of

Table 3

Identification of hazards, evaluation and management of OR of a gas pumping unit operator's work (hereinafter GPU) with different nature of work according to the scenario: Hazard: gas release that may occur inside the GPU; HE: explosion, gas poisoning; Negative consequences: death or severe injuries of the operator with the corresponding HF

HF	The primary analysis and determination of the OR level			Assessment of primary OR	Actions to reduce OR level	The final analysis and determination of OR			Final assessment of OR
	Probability of HE occurrence	The degree of severity of the consequences of HE	OR			Probability of HE occurrence	The degree of severity of negative consequences of HE	OR	
1	2	3	4	5	6	7	8	9	10
At stable work (Appendix 1)									
Human: inappropriate psychological state, character and temperament; health condition, low qualification	34	5	170		1. Try to reduce the OR factors that are associated with labour activity. 2. 1 time in 5 years to conduct training in an accredited training centre, conduct briefings on time	2	5	10	
Operational: overloading of the unit, maintenance, control of operating parameters	3	7	21		1. Stop the GPU immediately in the event of a malfunction that threatens the safety of service personnel or may lead to an emergency situation. 2. Forbid leaving working GPUs unattended by service personnel 3. Prohibit the use of additional levers for turning crane steering wheels	2	7	14	
Technical: equipment malfunction, planned repairs	45	7	315		Start the GPU only in good condition, in compliance with the requirements of the instructions, and on the condition that there are no unauthorized persons. 2. Ensure safe conditions during repair work. 3. Prohibit troubleshooting on a working GPU, except for the cases provided for in the operating instructions	3	7	21	
Ergonomic: uncomfortable working posture, monotonous movements, workplace organization	4	5	20		1. Forbid to enter the air filter chambers during the units start-up and operation. 2. Conduct periodic audits of workplace ergonomics and improve it. 3. Establish and adhere to a schedule of work and rest	3	4	12	
Organizational: mode of operation, execution of instructions, provision	4	67	268		1. Scheduled starts, stops, and changes in GPU operation schemes should be carried out during the day. 2. Prepare the GPU for start-up at the Dispatcher's order. 3. Commissioning of the GPU after revision, repair and long-term shutdown should be carried out only according to the approval order. 4. Every shift, check the operating ventilation system by bypassing it. 5. Cameras should always be locked and sealed	3	5	15	
Social: low pay, lack of support	5	4	20		1. Develop positive aspects of work and strengths of employees. 2. Carry out workplace visits in order to identify problematic moments in employees and implement organizational measures to improve them	4	4	16	
Total points:	**814**			Unacceptable	**Total points:**	**88**			Acceptable OR

End of Table 3

1	2	3	4	5	6	7	8	9	10
At emergency work (Appendix 2)									
Human: inappropriate psychological state, character and temperament; health condition, low qualification	8	8	64	Unacceptable	1. Train the work personnel to assess the emergency situation regarding the level of hazard, the nature of the accident, and the degree of threat of its development	4	8	32	Acceptable with verification OR
Operational: overloading of the unit, maintenance, control of operating parameters	7	7	49		1. Provide the GPU with appropriate PPE and a gas analyser in case of an accident.	5	7	35	
Technical: equipment malfunction, planned repairs	5	7	35		1. Ensure availability of spare parts on the GPU to eliminate gaps	4	6	24	
Ergonomic: uncomfortable working posture, monotonous movements, workplace organization	4	4	16		1. Conduct training in accordance with the Plan for Localization and Liquidation of Emergency Situations and Accidents(hereinafter PLLESA)	4	3	12	
Organizational: mode of operation, execution of instructions, provision	7	6	42		1. Develop a scheme of alerts in the event of an emergency. 2. Install systems for alerting employees in the event of an accident. 3. Develop PLLESA; agree it with the bodies of the State Emergency Service	6	6	36	
Social: low pay, lack of support	5	6	30		1. Provide the GPU by means of mergency communication	4	6	24	
Total points:	**236**				**Total points:**	**163**			
At accident (Appendix 3)									
Human: inappropriate psychological state, character and temperament; health condition, low qualification	8	8	64	Unacceptable	1. Provide the GPU by means for medical aid. 2. Train the staff to provide medical aid	6	6	36	Acceptable with verification OR
Operational: overloading of the unit, maintenance, control of operating parameters	7	7	49		1. Provide the equipment with the possibility of emergency shutdown	7	6	42	
Technical: equipment malfunction, planned repairs	7	8	56		1. Ensure clear evacuation routes during repair work	7	7	49	
Ergonomic: uncomfortable working posture, monotonous movements, workplace organization	6	7	42		1. Provide the GPU with medical stretchers	6	6	36	
Organizational: mode of operation, execution of instructions, provision	7	6	42		1. Develop a notification scheme in the event of an accident. 2. Sign a contract for the provision of medical assistance with the nearest medical institution. 3. Provide the GPU by means of recording the circumstances of the accident (for future investigation)	7	5	35	
Social: low pay, lack of support	5	6	30		1. Provide the GPU by means of emergency communication. 2. Always investigate accidents and inform staff about the consequences learned from the incident	4	5	20	
Total points:	**283**				**Total points:**	**218**			
At martial law introduced (Appendix 4)									
Human: inappropriate psychological state, character and temperament; health condition, low qualification	8	8	64	Unacceptable	Provide the GPU with a shelter with long-term food and water supplies.	8	7	56	Acceptable with verification OR
Operational: overloading of the unit, maintenance, control of operating parameters	5	7	35		1. Provide the GPU with the ability to disable external and internal lighting. 2. Provide GPU with appropriate PPE	5	6	30	
Technical: equipment malfunction, planned repairs	5	8	40		1. Ensure the availability of spare parts on the GPU to eliminate gaps	5	7	35	
Ergonomic: uncomfortable working posture, monotonous movements, workplace organization	5	6	30		1. Periodically conduct training on personnel actions in the event of an air raid or an object being seized	5	5	25	
Organizational: mode of operation, execution of instructions, provision	5	6	30		1. Develop a scheme of alerts during martial law. 2. Develop instructions for actions in the event of an alarm signal, chemical or radioactive threat	5	5	25	
Social: low pay, lack of support	6	6	36		1. Provide the GPU by means of emergency communication	6	5	30	
Total points:	**235**				**Total points:**	**201**			

their manifestation by means of protection created for this purpose. At the same time, during emergency work, especially during a state of war, the human factor comes first; any inconsistency can cause an accident, so it is necessary to pay maximum attention to it. From this comes an understanding of the need to select a qualified employee, since technological processes require serious approaches for their safe operation. Also, the influence of the operational factor in an emergency situation, which is associated with unstable work, frequent starts, unstable power grid, unstable compressor power, failures in the control system, etc., increases significantly. In turn, in the event of an accident, the biggest impact, in addition to the human factor, is the technical one, since it is during repairs that the probability of an accident increases.

In the future, the analysis of hazards and the magnitude of production ORs allows establishing technological processes in which it was not possible to reduce the OR value to an acceptable level with the help of protective measures, which requires the appropriate development of the necessary preventive actions for a specific influential HF.

Discussion. The development of the proposed "SSW map", in contrast to the standard one, allows adequate justification of safety measures for different types of work and the development of appropriate recommendations to reduce occupational diseases and injuries. The description of security measures is based exclusively on a detailed assessment of the OR, taking into account various negative factors. The proposed approach allows you to work in advance (application of advanced technologies), which leads to the balancing of the work of the technical system due to the early detection of threats and hazards that can lead to HE. By the way, specialists are constantly faced with the task of achieving the set goals with rational use of resources, economy and reduction of various costs, on the one hand, and on the other hand, ensuring safety based on OR control. It is the specified proposed approach that allows us to ensure its implementation.

The next step is the development of the "SSW map", the basis of which is OR management, with the development of appropriate recommendations for employee actions and the definition of preventive measures (Table 4).

Please note that it is not always possible to completely eliminate the risk by developing collective means or protection measures. In such cases, OR can be reduced by implementing administrative control through various indicators of safe work performance, which are conveniently selected and justified on

Table 4

An example of a "SSW map" for an operator of the GPU

Premises and place of work	Unit of complex gas preparation, compressor workshop
Work leader/administrator	Head of the technological service department
Date of creation	26.06.22
Auditor	Safety Engineer
Job description and HF	Maintenance of GPU being in operation, in reserve, in the stage of start-up and stoppage; auxiliary technological equipment of the compressor shop, which is related to the operation of the GPU and the pressure compressor station (hereinafter PCS) as a whole (air cooling devices (ACD) of oil, high-pressure equipment, shut-off valves, compressors of compressed air, ACD of gas, etc.); operating electrical equipment related to the compressor station and performing planned and preventive repairs of all equipment included in the compressor shop
OR management	Appendix No.1 to the SSW map at the workplace at stable work Appendix No. 2 to the SSW map at the workplace at emergency work Appendix No.3 to the SSW map at the workplace at accident Appendix No.4 to the SSW map at the workplace at martial law introduced
The purpose of SSW at this workplace	Safe maintenance of GPU
Tools and equipment to be used	Locksmith's tools and keys for maintenance of GPU
Preparatory works	1. Wear appropriate PPE. 2. Carry out a bypass of the equipment together with the operator who is handing over the shift, according to the route map. 3. To receive from the operator on shift the information about the condition of the equipment, which must be especially closely monitored to prevent accidents and malfunctions, as well as about the equipment that is under repair or in reserve; 4. Check and accept tools, materials, keys to the premises, change log and other documentation; 5. It is prohibited to accept and hand over the shift during the liquidation of an accident, during switching or operations on starting and stopping equipment without special written permission of the management of the enterprise
Training	Professional training at an accredited training centre for the profession "Compressor unit operator"
Procedures	Job (working) instructions for a compressor unit operator. Occupational health and safety instructions for the operator of technological compressors. Instructions for occupational health and safety during operation of the GPU
Safety measures	Collective means of protection at PCS are fences, gas analysers, and fire extinguishing means: complete fire shield, automatic fire extinguishing means
	Means of individual protection of respiratory organs, hearing, musculoskeletal system (knee pads, elbow pads), overalls, protective helmets, glasses
Sanitary and household provision	Rest room, changing room, shower, toilet, washing machine and dryer, air conditioner, provision of food and drinking water
Hazard identification, assessment and OR management	Supplement to "SSW map" (Table 3)

the basis of the "SSW map". At the same time, the existing recommendations for its development do not contain requirements for risk assessment for different types of work, which does not allow for the provision of appropriate control measures for the activities of employees who witnessed or themselves got into an emergency situation or incident. Also, due to the long-term absence of military actions on the territory of European states, during the risk assessment, possible additional hazards and threats are not taken into account, which can significantly change the situation with the necessary precautionary measures. On the other hand, it is known that the first stage of OR management is the identification of all threats and hazards.

There are different ways to determine the probability of HE occurring. The most accurate is the application of the theory of mathematical statistics; however, this requires sufficiently long-term research and the qualification of specialists. In most cases, the assessment of OR is carried out based on the understanding of technological processes and the availability of experience that allows predicting the development of the event to some extent. However, this is often not enough. This is indicated by the appearance of HEs, which are called "Black Swan". They are caused by some anomalous phenomenon that is quite difficult to predict. Most likely, such events are related to the emergency operation of the equipment, which is difficult to understand and detect, therefore, the introduction of risk analysis according to the nature of the work is an additional opportunity to predict HFs that can lead to the above-mentioned situation. A person always has certain limitations, especially when they do not want to admit them. Errors not recognized in time lead to bitter consequences, because erroneous risk assessment is then used to confirm management decisions and to control it. Therefore, carrying out a risk assessment during certain situations will expand the possibilities of predicting "black swans".

"SSW charts" must provide for all steps necessary to avoid HE caused by any hazard, especially the presence of HF, which increases the probability of its occurrence. For employers, developing SSWs and providing training to ensure they are carried out effectively will not only help prevent accidents, but also assist in accident investigations by providing evidence of measures taken to ensure safe practices.

This approach has certain disadvantages; in particular, critics claim that the implementation of this strategy may under certain circumstances lead to an increase in the bureaucratic OHSMS, which is associated with a significant number of various types of formal procedures, the need to implement strict control over the behaviour of employees and an increase in the training load, for which you need to find extra time outside of your main work shift.

Also, in case of formalization of approaches, a culture of scepticism, cynicism and fear of openness due to fear of fine or reprimand will be formed. At the same time, it is possible to underestimate injury rates and hide violations in order to achieve better indicators and goals. In general, the implementation of the proposed changes requires the introduction of reliable control over the implementation of bureaucratic procedures, the behaviour of workers and possible distortions of real indicators.

Conclusions.

1. SSW was improved to prevent workplace incidents based on complementing the OR management process by identifying external and internal factors in the enterprise that can affect the probability of HE occurrence due to the change in each component of the production process over time, passing through several states: during stable operation, during emergency work, in the event of an accident and when martial law is introduced.

2. The OR evaluation procedure is carried out according to the modified model "Analysis of the trunk of a tree", which is a trunk of a tree, the section of which is divided into six zones that characterize the activity of the employee, the functioning of the production equipment and the influence of the environment.

3. The peculiarity of the approach is the establishment of zones of interaction between the above components: the worker and production equipment, the worker and the environment, as well as the environment and equipment, which characterize the specified external and internal factors.

References.

1. Lis, T., & Nowacki, K. (2019). Modern Trends in Occupational Safety Management. *New Trends in Production Engineering, 2*(2) 126-138. https://doi.org/10.2478/ntpe-2019-0078.

2. Amyotte, P. R., & Lupien, C.S. (2017). Chapter Three - Elements of Process Safety Management. *Methods in Chemical Process Safety, 1*, 87-148. https://doi.org/10.1016/bs.mcps.2017.01.004.

3. Megawati, Arifuddin, R., & Abdurahman, M.A. (2019). Study of Influential Factors in Applying Occupational Health and Safety Management System on Construction Project (Case Study: Vida View Makassar Apartment). *International Journal of Innovative Technology and Exploring Engineering, 8*(4s), 33-37.

4. Rae, A., & Provan, D. (2019). Safety work versus the safety of work. *Safety Science, 111*, 119-127. https://doi.org/10.1016/j.ssci.2018.07.001.

5. Sorensen, G., Dennerlein, J.T., Peters, S.E., Sabbath, E.L., Kelly, E.L., & Wagner, G.R. (2021). The future of research on work, safety, health and wellbeing: A guiding conceptual framework. *Social Science & Medicine, 269*, 113593. https://doi.org/10.1016/j.socscimed.2020.113593.

6. Li, Ch., Tang, T., Chatzimichailidou, M.M., Gyuchan, T.J., & Waterson, P.A. (2019). Hybrid human and organisational analysis method for railway accidents based on STAMP-HFACS and human information processing. *Applied Ergonomics, 79*, 122-142. https://doi.org/10.1016/j.apergo.2018.12.011.

7. *Standard ISO 45001:2018 Occupational health and safety management systems – Requirements with guidance for use* (n.d.). Retrieved from https://www.iso.org/obp/ui/#iso:std:iso:45001:ed-1:v1:en.

8. *Standard ISO 31000 Risk management* (2020). Retrieved from https://www.iso.org/iso-31000-risk-management.html.

9. Karkoszka, T. (2017). Operational monitoring in the technological process in the aspect of occupational risk. *Procedia Manufacturing, 13*, 1463-1469. https://doi.org/10.1016/j.promfg.2017.09.192.

10. Skład, A. (2019). Assessing the impact of processes on the Occupational Safety and Health Management System's effectiveness using the fuzzy cognitive maps approach. *Safety Science, 117*, 71-80. https://doi.org/10.1016/j.ssci.2019.03.021.

11. Tsopa, V., Cheberiachko, S., Yavorska, O., Deryugin, O., & Bas, I. (2022). Increasing the safety of the transport process by minimizing the professional risk of a dump truck driver. *Mining of mineral deposits, 16*(3), 101-108. https://doi.org/10.33271/mining16.03.101.

12. Kruzhilko, O., Volodchenkova, N., Maystrenko, V., Feshchenko, A., & Yeremenko, S. (2021). Mathematical modelling of professional risk at Ukrainian metallurgical industry enterprises. *Journal of Achievements in Materials and Manufacturing Engineering, 108*(1), 35-41. https://doi.org/10.5604/01.3001.0015.4797.

13. Purpura, P.P. (2019). Safety in the Workplace. *Security and Loss Prevention (Seventh Edition)*, 435-455. https://doi.org/10.1016/B978-0-12-811795-8.00014-X.

14. Anaya-Aguilar, R., Suárez-Cebador, M., Rubio-Romero, J.C., & Galindo-Reyes, F. (2018). Delphi assessment of occupational hazards in the wineries of Andalusia, in southern Spain. *Journal of Cleaner Production, 196*, 297-303. https://doi.org/10.1016/j.jclepro.2018.06.008.

15. Çalış, S., & Büyükakıncı, B.Y. (2019). Occupational health and safety management systems applications and a system planning model. *Procedia Computer Science, 158*, 1058-1066. https://doi.org/10.1016/j.procs.2019.09.147.

16. Heras-Saizarbitoria, I., Boiral, O., Arana, G., & Allur, E. (2019). OHSAS 18001 certification and work accidents: Shedding light on the connection. *Journal of Safety Research, 68*, 33-40. https://doi.org/10.1016/j.jsr.2018.11.003.

17. Kalkis, H., & Roja, Z. (2016). Strategic Model for Ergonomics Implementation in Operations Management. *Journal of Ergonomics, 6*(4), 1000173. https://doi.org/10.4172/2165-7556.1000173.

18. Village, J., Greig, M., Salustri, F., Zolfaghari, S., & Neumann, W.P. (2014). An ergonomics action research demonstration: integrating human factors into assembly design processes. *Ergonomics, 57*(10), 1574-1589. https://doi.org/10.1080/00140139.2014.938128.

19. Cheberiachko, S., Yavorska, O., Yavorskyi, A., Naumov, M., & Ikonnikov, M. (2020). Development of safety work system at mining

enterprises. *The Collection of Research Papers of the National Mining University, 61*, 37-50. https://doi.org/10.33271/crpnmu/61.037.
20. Poplin, G.S., Pollack, K.M., Griffin, S., Day-Nash, V., Peate, W.F., Nied, E., Gulotta, J., & Burgess, J.L. (2015). Establishing a proactive safety and health risk management system in the fire service. *BMC Public Health, 15*, 407. https://doi.org/10.1186/s12889-015-1675-8.

Удосконалення системи безпечної праці

В.А. Цопа[1], *С.І. Чеберячко*[2], *О.О. Яворська*[*2], *О.В. Дерюгін*[2], *А.А. Алексєєв*[2]

1 – Міжнародний інститут менеджменту, м. Київ, Україна
2 – Національний технічний університет «Дніпровська політехніка», м. Дніпро, Україна
[*] Автор-кореспондент e-mail: elenayavorska80@gmail.com

Мета. Удосконалення підходу до розробки системи безпечної праці, однієї з важливих елементів системи управління охороною здоров'я й безпеки праці (СУОЗіБП) працівників на підприємстві.

Методика. В основу дослідження покладено «Систему безпечної праці» («Safe Systems Of Work»), яка поєднує в собі зміст безпечних процедур, що визначаються з урахуванням змісту виробничого завдання робітника при здійсненні виробничої діяльності, його компетентності, розуміння технологічного процесу й характеристики задіяного технологічного обладнання.

Результати. Для зменшення професійних захворювань і виробничого травматизму на підприємствах запропоновано впровадити систему «Систему безпечної праці» (СБП) із «5 кроків»: «проаналізуй», «підсумуй», «передбач», «підтримуй», «поліпшуй», що дозволить виявляти професійні ризики (ПР) і обгрунтувати доцільність зменшення їх впливу на робітника під час виконання виробничої діяльності. Для реалізації кожного кроку передбачена відповідна процедура, що дозволяє забезпечити їх виконання. Процедуру з оцінки ПР пропонується проводити за моделлю «Аналіз стовбура дерева», яка представляє собою зріз стовбура дерева, розділеного на шість частин, що характеризують небезпечні чинники, які впливають на діяльність працівника, функціонування технологічного обладнання й навколишнє середовище. Особливістю запропонованого підходу є встановлення зон взаємодії між наведеними компонентами запропонованої СБП: працівником і технологічним обладнанням, працівником і навколишнім середовищем, а також навколишнім середовищем і технологічним обладнанням, що характеризують зазначені зовнішні та внутрішні фактори впливу на СБП.

Наукова новизна. Удосконалено підхід з організації СБП для зниження рівня ПР під час здійснення виробничої діяльності на основі удосконалення процесу управління ПР, ідентифікації зовнішніх і внутрішніх небезпечних чинників, що впливають на рівень ПР, на вірогідність настання небезпечної події та її ступінь тяжкості, з урахуванням зміни в часі умов здійснення професійної діяльності: під час стабільної роботи, під час аварійної ситуації, під час нещасного випадку та під час військового стану.

Практична значимість. Удосконалені інструкції з охорони праці чи карти безпечних виробничих процесів можуть застосовуватися на підприємствах з метою кращого сприйняття працівниками вимог до безпеки праці й покращення документообігу на робочому місці.

Ключові слова: *система безпечної праці, професійний ризик, шкідливість, інцидент, небезпечні фактори*

The manuscript was submitted 02.05.22.