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HAZARD MAPPING AS A FUNDAMENTAL ELEMENT OF OSH MANAGEMENT SYSTEMS CURRENTLY USED IN THE MINING SECTOR

Purpose. Development of approaches to modernize the occupational health and safety management system in a mining company based on the introduction of a risk-based approach, which reduces the likelihood of incidents and improves the quality of working conditions of personnel.

Methodology. In this study, it is advisable to use a matrix method based on score estimates of working conditions for each identified hazard. To prepare the professional risk assessment map, the register of violations (incidents) over the past 10 years was carefully analyzed on the cross-section, the opinion of employees directly related to the implementation of technological operations was taken into account, third-party experts were also involved, thanks to which it was possible to structure the information obtained during the study.

Findings. The main result is a map of professional risk assessment for a dragline driver compiled based on real data related to incidents, consisting of 90 dangerous situations, on the basis of which the main causes of injuries at a real mining enterprise were identified, as well as measures to improve working conditions were proposed.

Originality. The authors proposed a specific type of maps for assessing the professional risks of employees, which allows considering the general situation of exposure to harmful and hazardous production factors on employees with the possibility of classifying: sources of danger; negative events with the reasons for their manifestation; risk management measures; assessing the severity and likelihood of such events. The specificity is that risk assessment should be carried out for all major open-pit coal operations. The proposed approach makes it possible to identify problem areas for each operation and to focus on specific tasks, with responsible actors. In this way, management has some recommendations to improve the quality of working conditions. Risk assessment maps are an intermediate element in the calculation of the safety index (Elmeri Index). In this way, it is possible to obtain a final opinion not only on safety in the performance of specific technological operations, but also on safety at the enterprise as a whole. Such information is relevant for insurance companies in connection with the application of tariff coefficients for obtaining services, which include comprehensive enterprise protection programs, which is an integral part for mining companies.

Practical value. Early identification and elimination of situations that can adversely affect the health of an employee of the enterprise allows controlling the risk arising in the process of professional labor activity.

Keywords: *mining enterprises, OSH management, occupational risk map, scoring method, risk matrix*

Introduction. It is common knowledge that open-pit mining prevails over underground mining, being used in extracting more than 80 per cent of all mineral resources mined in the world.

Professional risk assessment has long been proven in the gas, oil and gas industry, but in the coal industry, prior to the Federal Environmental, Technological and Nuclear Surveillance Order No. 520 of 30 November 2017 "Model Regulation on Unified Industrial Safety and Labour Safety Management System for Coal Mining Organizations", it was not necessary for this procedure. With the introduction of this document, the occupational safety management system should include occupational risk management as one of the basic occupational safety procedures.

Therefore, the practice of occupational risk management in the coal industry in Russia is not as widespread as in foreign countries such as the United States or Poland, where this procedure has been applied for a long time and in many industries. With the emergence of specific regulatory instruments in the Russian sector, it has become necessary to assess risks, while demonstrating the interest of researchers in developing this area, as evidenced by the number of articles in Russian practice since the publication of such documents.

At the same time, the rate of mineral extraction at quarries and open-pit mine on the territory of Russia continues to increase steadily. Emerging complexities associated with mining and geological conditions and technologies lead to an increase in the level of exposure to hazards at work. Therefore, it is necessary to continuously improve systems designed to protect workers from dangers.

Due to its complexity, the existing internal audit system leads to incorrect or insufficient recommendations for protecting employees from exposure to professional risk factors.

To date, the main or frequent causes of accidents and incidents have already been eliminated. However, various professional risk factors continue to affect employees.

Literature review. The problem of incorrect orientation of measures used to protect employees from the manifestation of occupational risk factors, due to the complexity of the existing organization and the functioning of the internal audit of labor protection conditions, is important for mining companies. Articles written by such authors as Kuletsky V. N., Tskhadaya N. D., Rudakov M. L., Kazanin O. I., Sidorenko A. A., Kuletsky K. V., Zhunda S. V., Nikulin A. N., Ikonnikov D. A. and many others, testify to the diversity of information on the topic and only confirm its relevance.

The paper [1] analyzes the current state and promising opportunities for the development of the coal mining industry in Russia, citing data on the largest man-made disasters at Russian coal mines. The main reason for the accident rate, according to the authors, is the discrepancy between engineering and technological solutions to modern mining and geological and mining engineering conditions of work. Despite the fact that enterprises use modern high-performance equipment that increases the safety of mining operations, without a proper approach to the analysis of mining and geological features, it is impossible to achieve absolute safety, but, thanks to a high-quality and timely solution of emerging problems, it is possible to minimize the risk of negative manifestations. The task must be managed by qualified specialists, the quality of knowledge of which must be constantly maintained [2].

The authors in the paper [3] argue that each type of professional activity is accompanied by the presence of harmful and (or) hazardous production factors that have a more or less negative impact on the employee. The authors propose for each occupation involved in hazardous conditions to assess

the degree of negative impact using calculation methods, for example, the method of scoring or the method of Fine and Kinney. The results of applying such techniques are quite close, which indicates the possibility of using such methods in assessing professional risks. The approach to identifying specific violations of mining requirements or non-compliance with sanitary and hygienic standards allows identifying where there are gaps in the OSH management system. The authors also argue that the use of such practices will allow the enterprise to reduce costs, thanks to the timeliness of measures taken to prevent risk reduction.

The same approach is described in the article by General Director of the Tugnuisky Open-Pit Mine [4], dedicated to the organization of the safety of production processes of a coal mine. The aim of the study was to develop a sound approach to the management of production processes that arise during the operation of a coal mine. The authors talk about the need to comply with the current policy of modern conditions of mining, characterized by an increase in technical risks. It is proposed to introduce an integrated approach aimed at reducing such risks, thereby increasing occupational safety by improving the quality of labor processes. The authors pay special attention to the safety of workers, considering that the cost of a negative event in the coal industry in Russia is extremely high in the socio-economic aspect. In this connection, they note that the early identification and elimination of situations that can lead to an accident will allow one to control the risk of injury in labor processes. The authors state the need to create a system for monitoring the state of labor processes and hazardous production situations. According to the authors, the presence of such a system makes it possible to establish effective interaction between the heads of all services that ensure occupational safety. Improving the quality of the work process is a key task in the system of ensuring safety and efficiency in production. Based on the above, an integrated approach is proposed, consisting of several stages.

Nowadays, emphasis should be placed on multi-faceted and multilevel work with personnel. So, for example, the paper [5] talks about the need to include the position of a specialist in human factors (ergonomics) in the staffing tables of mining companies. The main functions of this specialist will be to bring information about working conditions and the state of industrial safety to the employees of the enterprise, as well as to facilitate decision-making on the standardization of new equipment, staff training and investigation of the causes and consequences of accidents.

Indeed, statistics show that the main cause of accidents is the human factor, but it is worth noting that the key aspect of human error is the lack of control over the situation, which the authors of the study also say, arguing about the urgent task of labor protection, which is to ensure transparent remote control over employees and prevention of the influence of the human factor on labor productivity. An effective solution will ensure continuous monitoring of compliance with the mandatory requirements prescribed by the enterprise.

The similar study [6] proposes the introduction of the concept of "Zero accidents" in the coal industry. The zero accidents approach assumes that, in the prolonged nature, the possibility of preventing accidents is foreseen. In accordance with this, the development of modern OSH management systems created at enterprises should be aimed at preventing accidents and incidents. The author emphasizes that due to the relative "youth" of this concept in Russia, there is a significant deficit of regulatory documents on this topic, therefore, the results of benchmarking studies are taken as a basis.

The reports on the activities of the Federal Service for Environmental, Technological and Nuclear Supervision over the past 10–15 years clearly show that there is no clearly pronounced trend towards a decrease in injuries, with its worst manifestation as a fatal outcome (Fig. 1).

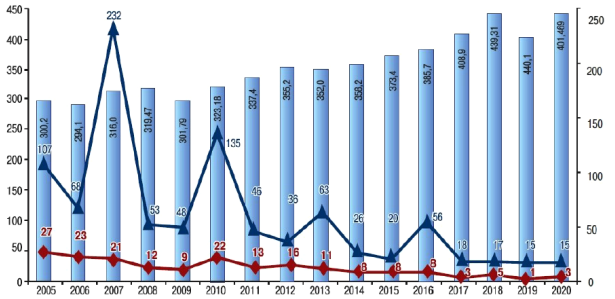

Fig. 1. Dynamics of changes in coal production volumes, fatal injuries and accidents in 2005–2020 [1]:

Blue column – coal production, millions of tons; red curve – the total number of the major industrial accidents; blue curve – the number of occupational fatalities, persons

The peaks in the death of workers that occur every three years indicate the discrepancy between safety measures aimed at protecting against the manifestation of occupational risks, the modern level of complexity of technologies in mining and hard conditions for the development of deposits.

We have analyzed available information on fatal injuries in mining industry and signed main causes of accidents by their shares (Fig. 2).

This distribution of causes of fatal incidents in Fig. 2 is due to the fact that the measures taken to protect employees from the manifestation of risk factors are either insufficient or incorrectly oriented, due to the complexity of the work of internal audit.

This problem is significant in risk assessment, since the difficulty of understanding what needs to be done, and even more so how, leads to incompetent work, and, as a result, to the adoption of incorrect or insufficient recommendations for improving the working environment that can reduce the likelihood of accidents in production.

Occupational risk maps as the basis for modern occupational safety management systems. ***Implementing a systematic approach.*** It is proposed to use a Unified Industrial Safety and Labor Protection Management System (hereinafter as UISS), moving from the used OHSAS 18001:2007 "Occupational Safety and Health Management Systems. Requirements" to the International standard ISO 45001:2018 "Occupational health and safety management systems. Requirements and recommendations for use".

Fig. 3 shows the structure of the UISS with its main sections.

Practical application of professional risk assessment cards. Modernization of the labor protection management system based on the use of professional risk assessment cards helps to consider the general situation of exposure to harmful and hazardous production factors, with the possibility of classifying: sources of danger; negative events, with the reasons for their

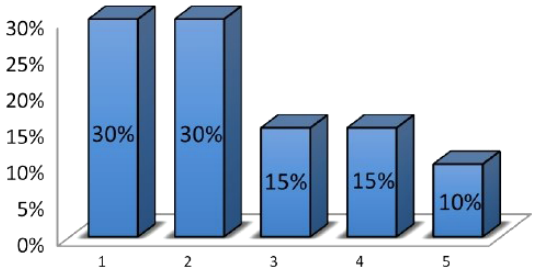

Fig. 2. Causes of fatal injuries:

1 – ineffectiveness of production control; 2 – improper organization of production work; 3 – violations of production discipline; 4 – violations of the technology of production work; 5 – low level of knowledge of safety requirements

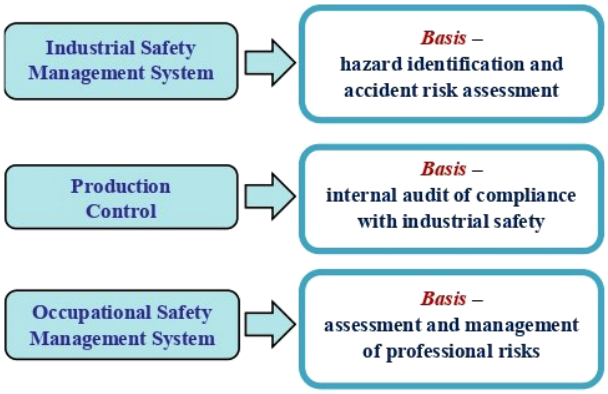

Fig. 3. The UISS structure

manifestation; risk management measures; assessing the severity and likelihood of such events [7].

Early identification and elimination of the occurrence of situations that can adversely affect the health of the employee of the enterprise, allows one to control the risk arising in the process of professional work.

The procedure for managing professional risks. Occupational safety management system based on the implementation of an occupational risk management system will allow:

- improving the quality of labor processes, thanks to which the growth of safety and production efficiency is ensured;
- ensuring the implementation of consistent and continuous measures to prevent occupational injuries and diseases of workers;
- implementing a systematic continuous improvement of the UISS and the adoption of effective and efficient decisions in the labor protection policy at a mining enterprise;
- informing employees about the working conditions and labor protection at workplaces, about the risk of damage to health, the guarantees provided to them, the compensations they are entitled to and personal protective equipment.

The main stages of professional risk management. The main stages of the professional risk management procedure include:

1. Revealing (identification) of hazards.
2. Assessment of the levels of professional risks.
3. Planning of measures to manage professional risks.
4. Assessment of the possibility of eliminating risks.
5. Implementation of measures to eliminate or reduce the levels of professional risks.

Revealing (identification) of hazards. Hazard identification is a procedure for detecting (identifying and recognizing) and describing hazards.

The purpose of hazard identification is to identify sources of danger, the actual hazards themselves, hazardous conditions and hazardous events that create and (or) increase the occupational risk for workers.

Identification must be carried out for all possible situations that arise when performing technological operations:

- regular mode of performing technological operations;
- an abnormal mode of performing technological operations, characterized by the appearance of other hazards that do not arise during the normal mode;
- emergency mode of performing technological operations (taking into account the conditions of an evolving accident (emergency), into which an emergency mode passes, at all stages of localization and elimination of the consequences of the accident).

Assessment of the professional risk levels. Risk assessment (professional risk assessment) is the process of assessing risks caused by exposure to hazards at work to determine their impact on the safety and health of workers.

Below is an assessment of professional risks for the conditions of the Russian mine. Dragline brand ESh 40/85 was chosen as a sample of equipment, which performs re-laying of waste rocks into the internal mined-out space of the section.

The following types of work will be typical for the selected equipment for standard, abnormal and emergency modes (Fig. 4):

Let us consider several examples of hazards for all modes of technological operations (Figs. 5–7).

Let us consider several main types (groups) of hazards with their characteristic sources (Fig. 8).

Methods. ***Analysis of methods.*** Risk assessment can be divided into direct and indirect methods (Fig. 9). The choice of one method or another is based on the availability and nature of the information available on the basis of which the assessment will be made.

It is known that direct methods can be divided into qualitative and quantitative ones. The use of a direct quantitative assessment in this work is impossible, due to the lack of information on the frequency of cases of damage to the health of workers (accidents) and their severity at the risk assessment facility. Therefore, a rational option would be to use a direct qualitative (matrix) method based on scoring the working

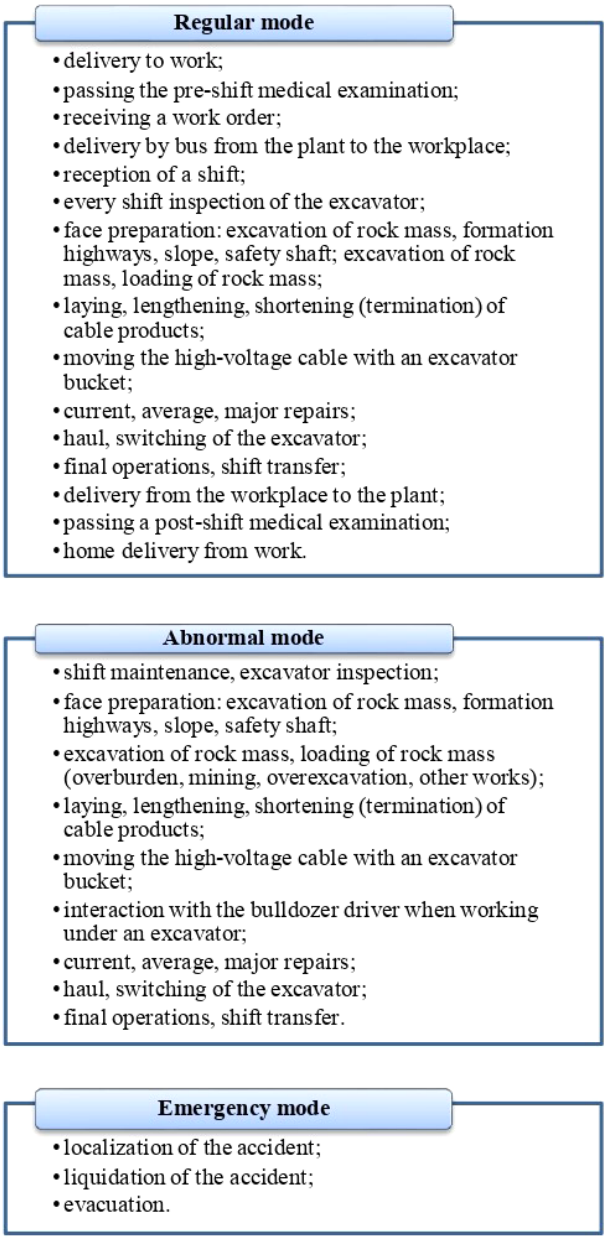

Fig. 4. Typical works for different modes of technological operations

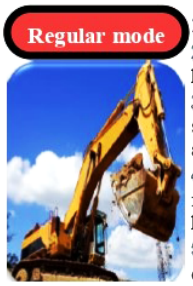

Fig. 5. Examples of hazards in regular mode

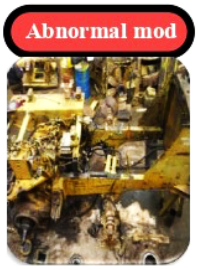

Fig. 6. Examples of hazards in abnormal mode

Fig. 7. Examples of hazards in emergency mode

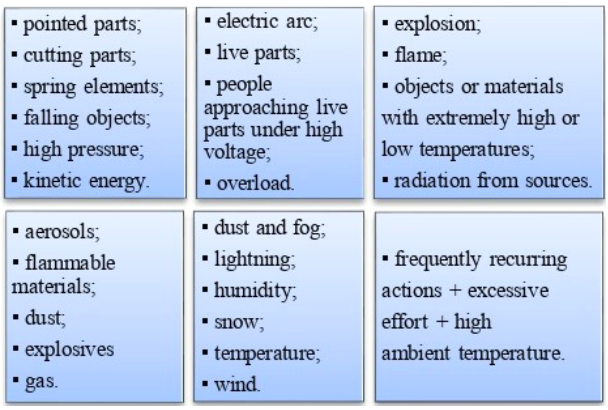

Fig. 8. Classifier of main hazards:
01 – mechanical; 02 – electrical; 03 – thermal; 04 – hazards from materials and substances; 05 – hazards from the environment in which the machine is operated; 06 – combination of hazards

conditions for each identified hazard, including those potentially possible in normal, emergency and emergency situations.

Matrix method. The assessment of risk levels using the matrix method is based on the score indicators of the possibility of hazard realization and the severity of the consequences.

To begin with, the possible implementation of this hazard is determined, which manifests itself as a negative impact on

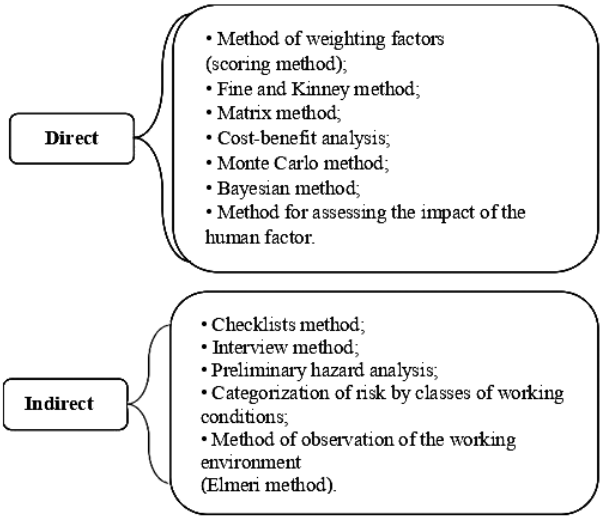

Fig. 9. Classification of risk assessment methods for OSH management purposes

the worker – P, point (in accordance with the scale presented in Table 1). In addition, it is necessary to determine the severity indicator of the adverse consequences of situations that can potentially be realized and lead to an aggravating effect on the body of the worker – Q, point (in accordance with the scale presented in Table 2).

The implementation of a direct risk assessment requires related information that can be obtained through the use of the situational method, in particular, the questionnaire method used to identify hazards (risks) in the workplace. This assessment is based on a survey of the employees themselves. The method allows a comprehensive approach to risk assessment by taking into account the opinions of workers who are directly exposed to the impact of hazardous production factors, thereby allowing a more accurate assessment of the duration and nature of the impact of these factors. Thanks to this interaction between workers and specialists in the field of labor protection, the effectiveness of the measures used to protect against the manifestation of damaging factors on the human body increases.

In this work, the register of incidents over the last 10 years of the existence of the mine was also involved, which helped to identify the frequency of occurrence of the hazard that is possible during the performance of labor activity.

Risk matrix. When assessing the level (degree) of risk for each of the identified hazards, a risk matrix is used, which is a combination of score indicators of the possibility and severity of the hazard.

The value of the level (degree) of risk is determined by the risk matrix at the intersection of the indicators of the severity of the consequences and the possibility of the hazard realization in accordance with the expression

$$R = P \cdot Q.$$

The assignment of risk levels R to one of the risk categories is made by comparing its value with the risk tolerance scale presented in Table 3.

The procedures for identifying hazards and assessing the level of occupational risks should be constantly improved and maintained in order to ensure the effective implementation of measures to reduce them.

Based on the performed risk assessment, the authors of the study proposed a developed risk assessment map for the chosen profession – a dragline excavator driver (Table 4).

For greater clarity, let us consider the principle of obtaining the final value of the level (degree) of risk with the justification of the used values of the point indicators of the possibility of realizing the hazard and the severity of the consequences for all possible situations arising during the performance of tech-

Table 1

Score indicator of the possibility of hazard realization

Frequency of occurrence of a hazardous situation or event	Qualitative indicator of probability	The value of the indicator of the possibility of realizing a dangerous situation or hazardous event P, score
Less than once every 10 years (possible under exceptional circumstances)	Unlikely	1
From 1 time in 10 years to 1 time a year	Rarely	2
From 1 time a year to 1 time a month	Likely	3
From 1 time a month to 1 time a shift	Often	4
1 time per shift and more	Very often	5

Table 2

Score indicator of severity of consequences

Potential harm or damage to health	The value of the indicator of the severity of adverse consequences Q, score
Microtrauma requiring only first aid	1
Injury without disability, temporary deterioration in health (without loss of ability to work), requiring the provision of professional medical care	2
Minor accident, temporary transfer to another job, occupational disease	3
Severe accident, poisoning (acute occupational disease)	4
Fatal injury, group accident	5

Table 3

Risk categories

Risk degree R, score		
1–2	3–9	10–25
Low risks (green zone)	Acceptable risks (yellow zone)	Unacceptable risks (red zone)
Admission of employees to work without the use of special safety measures	Admission of employees to work applying special safety measures	Employees are not allowed to work until the prompt adoption of protective measures and the transfer of hazard to the acceptable risk category (yellow zone) or low risk category (green zone)

nological operations, which include regular, abnormal and emergency operating modes.

Having analyzed the register of incidents at the enterprise in question and taking into account the opinions of the direct workers operating this type of equipment, we give a conclusion on the assessment of the level (degree) of risk, based on our own opinion and the experience of the authors.

Regular mode. Situation:

1. Injury to a worker within the radius of the excavator due to pieces of rock falling out of the excavator bucket while excavating rock mass. The likelihood of getting bruises, injuries, fractures prevails.

2. The likelihood of an accident with bruises, injuries, fractures due to pieces of rock falling out of the excavator bucket within the radius of its operation can be assessed as "The event is unlikely", less than once every 10 years (possibly under exceptional circumstances), with an estimate probability $P = 1$ point.

3. Injury due to pieces of rock falling out of the excavator bucket can be assessed as "Minor accident" with a severity score of $Q = 3$ points, or can be assessed as "Severe accident" with a severity score of $Q = 4$ points. The maximum value $Q = 4$ points is entered into the risk map, based on the fact that in the presence of uncertainty in the manifestation of a negative factor, it is necessary to provide for the worst case.

4. The risk indicator is determined by the calculation method according to the expression $R = P \cdot Q$ or visually according to the risk matrix: the cell with the required indicator R is determined at the intersection of the established indicators of the severity of the consequences Q and the probability of the event P, points

$$R = P \cdot Q = 1 \cdot 4 = 4,$$

where $R = 4$ corresponds to the category "Acceptable risks", it is possible to admit employees to work, provided that special safety measures are applied.

Abnormal mode. Situation:

- injury to a worker while servicing an excavator due to metal splinters getting into the eyes as a result of being thrown out of operating equipment without protective goggles being used;

- the likelihood of an accident with injury to the eyes of a worker due to metal splinters, exacerbating it by the absence of protective glasses, can be estimated as "Rarely" from 1 time in 10 years to 1 time per year with an assessment of the probability $P = 2$ points or can be as "Likely" from 1 time per year to 1 time per month with an estimate of the probability $P = 3$ points. The maximum value of $P = 3$ points is entered into the risk map;

- injury to the eyes of a worker due to metal splinters, aggravated by the absence of protective glasses, can be assessed as "Minor accident" with a severity score $Q = 3$ points or can be assessed as "Severe accident" with a severity score $Q = 4$ points. The maximum value $Q = 4$ points is entered into the risk map, points

$$R = P \cdot Q = 3 \cdot 4 = 12,$$

where $R = 12$ corresponds to the category "Unacceptable risks", with risks of this degree, workers are not admitted to work until the prompt adoption of protective measures and the transfer of the hazard to the category of acceptable risk (yellow zone) or low risk category (green zone).

Emergency mode. Situation:

- injury to a worker when the excavator tilts over the safety shaft when it collapses, as a result of the excavator being within the collapse prism due to personal negligence;

- the probability of an accident when the excavator overturns over the safety shaft due to personal negligence can be assessed as "Rarely" from 1 time in 10 years to 1 time per year with an estimate of the probability $P = 2$ points or can be assessed as "Likely" from 1 once a year up to once a month with an estimate of the probability $P = 3$ points. The maximum value of $P = 3$ points is entered into the risk map;

- injury when the excavator tilts over the safety shaft due to personal negligence can be assessed as "Minor accident" with a severity rating of $Q = 3$ points or can be assessed as "Severe accident" with a severity rating of $Q = 4$ points. The maximum value $Q = 4$ points is entered into the risk map, points

Table 4

An example of a professional risk assessment map for a chosen profession – dragline excavator driver

Structural subdivision	Position	Operation mode	Work operation performed (stage of technological operation)	Place of work operation	Source of danger	Danger, hazardous situation or hazardous event	Reason for the realization of a dangerous situation or dangerous event (cause of danger)	Hazardous conditions	Potential harm or damage to health	Frequency of occurrence of a hazardous situation or hazardous event	Risk level and category	Risk management measures
Mining site	Dragline excavator driver	Regular	Excavation of rock mass	Excavator cab	Increased air temperature	Heat stress	Faulty conditioning system in the excavator cab	Prolonged exposure to high ambient temperature	**2**	**2-**	**4**	1. Diagnostics of the excavator conditioning system and repair of faults. 2. Conduct of an audit of the condition of the air conditioning system on excavators
		Regular	Excavation of rock mass	Excavator cab	Vibration	Impact of vibration on the driver's body	Poor-quality vibration damping system	Malfunction of the anti-vibration chair	**2**	**3**	**6**	1. Carrying out measures to improve the quality of vibration protection of the excavator cab
		Abnormal	Excavator maintenance	Repair site	Human movement on a slippery surface	Trauma caused by slipping and disequilibrium from height	Ice on pedestrian paths adjacent to the repair site	Personal negligence	**3**	**3**	**9**	1. Putting the pedestrian paths in proper condition
		Abnormal	Excavator maintenance	Repair site	Metal parts of the excavator body	Head injuries on metallic parts of the body	No helmet	Presence of metal body parts in the area of head movement	**3**	**4**	**12**	1. Conducting an emergency inspection of knowledge of occupational safety and industrial safety requirements
		Emergency	Excavation of rock mass	Working platform	High voltage wire	Breakage of a high-voltage wire by an excavator, followed by a short circuit to metal parts of the body	35 kV high-voltage wire sag above the road	Failure to comply with the distance from the phase wire to the ground	**4**	**3**	**12**	1. Elimination of high-voltage wire slack. 2. Carrying out an audit of the state of electrical communications on the territory of the enterprise. 3. Conducting additional briefing for excavator drivers in terms of actions when detecting a sag in electrical communications

$$R = P \cdot Q = 3 \cdot 4 = 12,$$

where R = 12 corresponds to the category "Unacceptable risks".

Occupational risk management planning. Measures to eliminate or reduce the levels of professional risks are [6]:

- elimination of hazardous work (procedures);
- replacement of dangerous work (procedure) with less dangerous;
- implementation of engineering (technical) methods to limit the risk of workers' exposure to hazards;
- implementation of administrative methods for limiting the time of workers' exposure to hazards;
- use of PPE;
- professional risk insurance;
- measures aimed at improving the safety culture of employees (informing employees about existing dangers and risks, training in the basics of risk management at workplaces, preventing unsafe behavior, and so on).

Measures to eliminate or reduce the levels of professional risks are planned and implemented in the following order of priority:

- elimination of hazard/risk;
- limiting the hazard/risk at its source by using technical means of collective protection or organizational measures;
- minimization of hazard/risk by designing safe production systems, including measures of administrative limitation of the total time of contact with harmful and hazardous production factors;
- where the remaining hazards/risks cannot be limited by collective protective equipment, workers are provided with appropriate PPE and measures are taken to ensure their correct use and maintain them in good condition.

Results. The risk assessment map is:

- the final document summarizing the results of hazard identification and professional risk assessment and completed for all identified hazards;
- the basis for planning measures to eliminate, reduce or control risk levels;
- material for the implementation of the procedure for confirming or improving knowledge in the field of labor protection (training, briefings, internships);
- a source for informing employees about existing hazards and occupational risks, as well as about measures to eliminate, reduce or control risk levels.

Based on the analysis of the professional risk map (Table 4), the main causes of injuries at the mining enterprise were identified, and are presented in the diagram (Fig. 10).

From Fig. 10, Classification of the causes of injury [5]:

1. Personal negligence:

- personal negligence of the injured who, prior to the start of work, were not convinced that the workplace was in a safe condition.

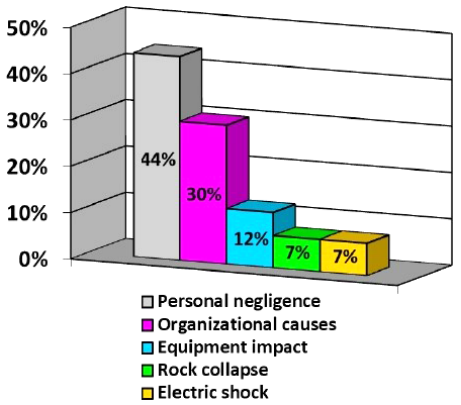

Fig. 10. Causes of injury

2. Organizational causes:

- lack of control over the observance of technological discipline by the workers of the site;
- insufficient control by the management over the observance of the requirements of the instructions for labor protection and industrial safety by employees.

3. Causes of injuries associated with the impact of machines and mechanisms:

- the location of the employee directly under the excavator bucket;
- the excavator driver, not being convinced of the safety of a crew member who is within the excavator range, has begun turning without a warning sound signal;
- the excavator driver has carried out mining operations with a deviation from the passport requirements regarding the unauthorized decision to move the excavator, without notifying the technical supervision person, and also set the excavator in violation of the minimum distances to the ledge slope relative to the excavator counterweight.

4. Causes of rock collapse injuries:

- non-compliance of mining documentation with mining technical conditions;
- shortcomings in the organization and conduct of training in safe methods and techniques for performing work;
- failure to comply with the documentation requirements for mining operations.

5. Causes of injuries associated with electric shock:

- carrying out of work without performing organizational and technical measures when working in electrical installations;
- lack of supervision over the carrying out of work on high-voltage equipment;
- operation of faulty equipment.

The analysis of the causes of incidents shows that regardless of the presence of technical (impact of machines and mechanisms; electric shock) and technological (collapse of rocks) reasons, at present, emphasis should be placed on multi-faceted and multi-level work with personnel.

The list of approaches in this direction is very representative, but the most significant ones, from our point of view, should be considered the advanced training of employees, additional education and a mentoring system at all workplaces, which will help to achieve the required level of safety and production efficiency.

The main idea is to improve professional knowledge and skills, as well as to develop personal qualities for occupational safety. This approach aims to prioritize working in a safe environment. Obtaining sufficient knowledge aimed at improving the safety level of production operations that are not accompanied by the presence of accidents, contributes to an increase in the interest of workers to continue production activities in conditions in which their life and health are not potentially threatened by anything [8, 9].

For a systematic tendency to reduce risk, it is necessary to make and implement rational management decisions to improve the quality of labor processes [10, 11].

One such approach can be found in [12], where the authors emphasize the cluster approach, which focuses on the regrouping of productive forces and factors of production, which could lead to an increase in the total capitalization of the territory. By trying to maximize the effectiveness of their development through factors of the internal environment, the clusters stimulate the creation of a kind of regional framework, which determines the direction of development of various branches of the economy and ultimately acts as the unit of territorial administration. An important aspect of the clustering process is the market mechanism, manifested in the creation of a high level of domestic competition, which is the main driving force behind the cluster's effective performance. According to the authors themselves, this will lead to improved working conditions through the introduction of advanced

technologies, thereby significantly reducing the risk of injury while improving working conditions.

Continuing the idea of a study on the modernization of the occupational safety management system, it is proposed to draw up training modules on the assessment of occupational risks, primarily for the operation of internal dump operation on the example using the work of a dragline-type excavator driver.

The existence of such training modules will make it possible to provide workers with the necessary level of skills, to provide them with the necessary knowledge to reduce occupational accidents and diseases and to ensure proper safety at work at the enterprise as a whole.

The materials of the modular system are constantly updated in connection with the adoption of new normative legal documents in the field of labor protection. In this connection, it is worth drawing attention to the heuristic rather than the formal approach of training workers in the field of labor protection and industrial safety, which is based on the existing aspects, both from a normative point of view and on the laboriousness of all training.

The use of such modules will enable employees to understand the harmful and hazardous production factors in the enterprise in an accessible form, to study the specifics of occupational risk assessment and to familiarize themselves with measures to prevent incidents in the facility, Thus, improving the quality of work processes that increase safety and efficiency.

The identification and concomitant elimination of factors leading to the development of hazardous and emergency situations [13, 14], even at the early stages of their inception, will make it possible to control the risk of injury during work.

Discussion. Today, Russian mining companies do not have a definite formed concept of industrial risk management. However, all companies understand that they need to take a new, more effective and systematic approach to managing industrial safety and health. In this regard, the transition of the current system to a single one (UISS) will expand the company's capabilities to ensure proper control over the activities of all internal structures involved in preserving the life and health of workers.

To modernize the OSH management system, which currently needs to be created on the basis of occupational risk management, it is recommended to use risk assessment maps, a possible embodiment of which was presented in the work.

The presence of such an integrated approach will allow the company to cover a significant area of control, divide it into components and simplify the monitoring process itself, increasing the quality and timeliness of measures taken.

Conclusion. The problem of modernizing OSH management systems at modern Russian mining enterprises is really relevant, since the success of measures that ensure the life and health of employees depends on the effectiveness of their implementation, against the background of the priority of these concepts in relation to economic efficiency.

As one of the approaches to solving this problem, the authors for the first time proposed a specific type of maps for assessing the professional risks of employees, which allows considering the general situation of exposure to harmful and hazardous production factors on employees with the possibility of classifying: sources of danger; negative events with the reasons for their manifestation; risk management measures; assessing the severity and likelihood of such events.

Early identification and elimination of situations that can adversely affect the health of an employee of the enterprise allows one to control the risk arising in the process of professional labor activity, that is, this activity is of a preventive nature.

The use of an innovative, but grounded from a regulatory point of view, approach in the form of occupational risk maps as the basis for the functioning of modern OSH management systems at mining enterprises can have a positive effect on the microclimate in the team and on the image of the mining company as a whole.

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Карти професійних ризиків як основа функціонування сучасних систем управління охороною праці на гірничих підприємствах

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Мета. Розробка підходів з модернізації системи управління охороною праці в гірничій компанії на основі впровадження ризик-орієнтованого підходу, що дозволяє знизити ймовірність виникнення інцидентів і поліпшити якість умов праці персоналу.

Методика. У даному дослідженні доцільне використання матричного методу, заснованого на бальних оцінках умов праці для кожної ідентифікованої небезпеки. Для підготовки карти оцінки професійних ризиків був ретельно проаналізований Реєстр порушень (інцидентів) за останні 10 років на розрізі, врахована думка працівників, безпосередньо пов'язаних із виконанням технологічних операцій, також були задіяні сторонні експерти, завдяки яким вдалося структурувати отриману в ході дослідження інформацію.

Результати. Основним результатом є складена за реальними даними, пов'язаними з інцидентами, карта оцінки професійних ризиків для машиніста драглайна, що складається з 90 небезпечних ситуацій, на підставі якої були виявлені основні причини виникнення травматизму на реально діючому гірничому підприємстві, а також запропоновані заходи щодо поліпшення умов праці.

Наукова новизна. Авторами запропоновано конкретний вид карти оцінки професійних ризиків співробітників, що дозволяє розглянути загальну ситуацію впливу шкідливих і небезпечних виробничих факторів на співробітників із можливістю класифікації: джерел небезпеки; негативних подій із причинами їх прояву; заходів з управління ризиками; оцінки тяжкості та ймовірності прояву таких подій. Особливість полягає в тому, що оцінка ризиків повинна проводитися за всіма основними технологічними операціями, що застосовуються при розробці вугілля відкритим способом. Запропонований підхід дозволяє виявити проблемні місця за кожною операцією та направити основні зусилля на вирішення конкретних завдань із залученням відповідальних осіб. Таким чином, у керівництва з'являються певні рекомендації щодо підвищення якості умов праці. Карти оцінки ризиків виступають проміжним елементом при розрахунку індексу безпеки (індексу Елмері). Таким чином, можливо отримати підсумковий висновок не тільки з безпеки при виконанні конкретних технологічних операцій, але й надати висновок з безпеки на підприємстві в цілому. Подібна інформація є актуальною для страхових компаній у зв'язку з виставленням тарифних коефіцієнтів для отримання послуг, які включають комплексні програми захисту інтересів підприємства, що для компаній гірничої галузі є невід'ємною складовою.

Практична значимість. Завчасне виявлення та усунення виникнення ситуацій, які можуть згубно позначитися на здоров'ї працівника підприємства, дозволяє контролювати ризик, що виникає у процесі професійної трудової діяльності.

Ключові слова: *гірничодобувні підприємства, управління охороною праці, карта професійних ризиків, метод бальних оцінок, матриця ризику*

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