LABOR PROTECTION

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Some aspects of occupational safety at mining enterprises

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Introduction. The article discusses the issues of labor protection at mining enterprises. Timely analysis and elaboration of measures to prevent them can reduce the risks of major accidents with a large number of victims.
Problem Statement. It is necessary to choose the most effective measures to improve the level of industrial safety at mining enterprises based on a ready-made conceptual model of hazardous phenomena and accidents.
Theoretical Part. To solve this problem, the article considers a ready-made conceptual model of hazardous phenomena and accidents that may occur in mines as a result of non-compliance with the requirements of occupational safety and industrial safety of enterprises proposed by A. I. Babenko. The analysis of accidents, risk factors, potential dangerous and harmful production factors at the mining enterprise is carried out. Based on the analysis, the most effective measures to improve the level of industrial safety at mining enterprises are proposed.
Conclusions. The article considers the issues regulating labor protection at mining enterprises, as well as it identifies industrial risks and options for their elimination through the organization of measures to ensure industrial safety. Based on the results obtained, the most effective means to reduce the risks of hazardous production situations is the use of multifunctional systems to ensure occupational safety and industrial safety of mining enterprises.

Keywords: mining industry, labor protection, industrial safety, risks.

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Introduction. Occupational safety and industrial safety issues at mining enterprises are regulated by the Order of the Federal Service for Environmental, Technological and Nuclear Supervision "On approval of Federal Rules and Regulations in the field of industrial safety "Safety Rules for mining and processing of Solid Minerals" [1]. The order defines general requirements for the organization of work related to the production, storage, transportation and use of hazardous substances, the procedure for conducting an expert examination of industrial safety, measures to prevent exogenous and endogenous fire hazards and other issues related to ensuring safe work of people at these facilities.

Other sectoral and supervisory documents regulating occupational safety at mining enterprises have also been developed. One of them is Rostechnadzor Order No. 331 of 03.09.2020 "On approval of Federal Rules and Regulations in the field of occupational safety "Safety rules for explosion- and fire-hazardous production facilities for the storage and processing of plant raw materials" [2].

According to these documents, occupational safety of mining enterprises is defined as "the state of protection of vital interests of the individual and society from accidents at hazardous production facilities and the consequences of these accidents." This definition actually includes the full potential of sources of danger, while safety is determined not by the property, but by the state of the formed occupational safety system at the enterprise.

Problem Statement. The task of the authors of this article is to choose the most effective measures to improve the level of occupational safety at mining enterprises based on the existing conceptual model of hazardous phenomena and accidents.

Theoretical Part. Many experts pay special attention to the study of formal signs of possible accidents. Thus, A. I. Babenko developed a conceptual model of hazardous phenomena and accidents that can occur at mines as a result of non-compliance with the requirements of occupational safety and industrial safety of enterprises [3]. Fig. 1 shows the proposed model

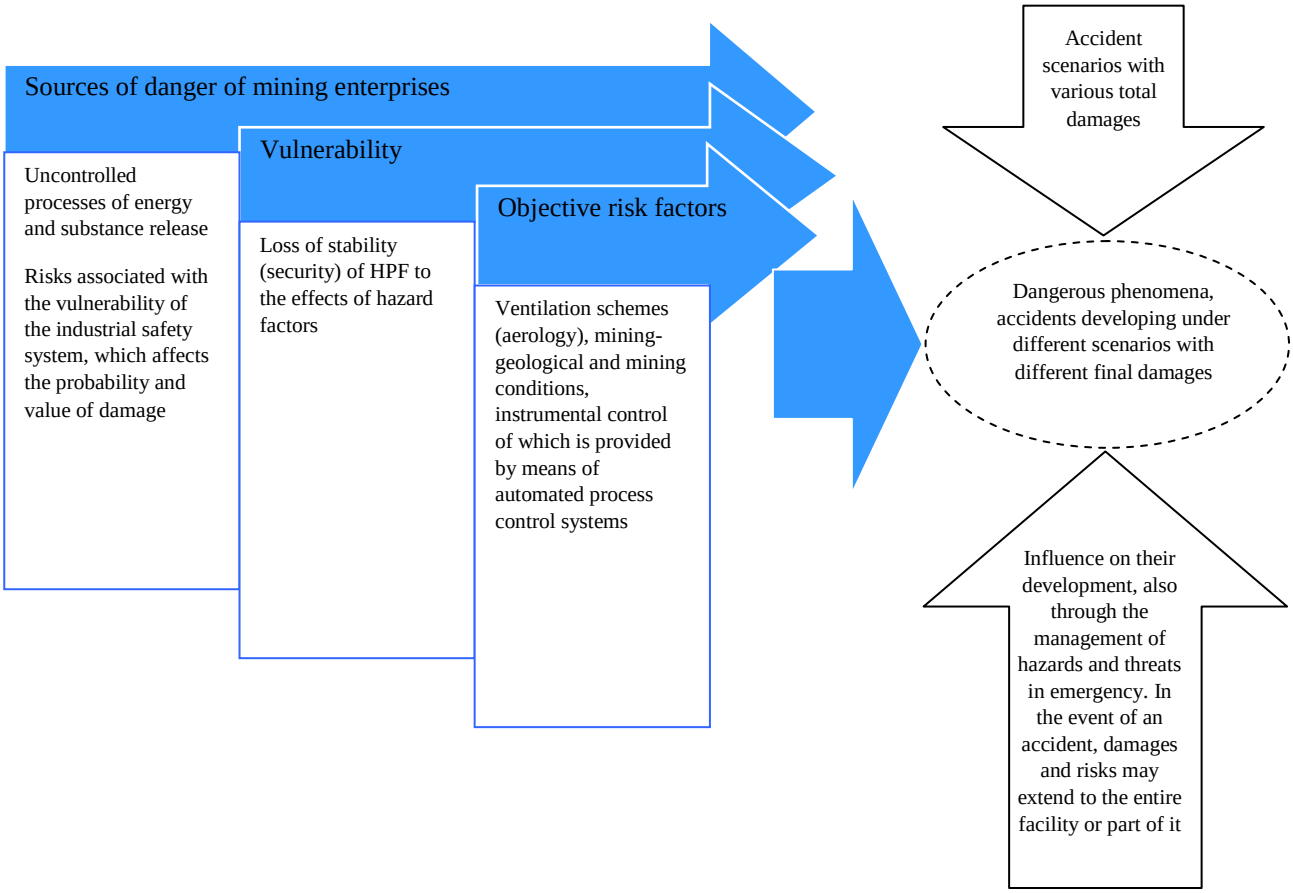

Fig. 1. Model of hazardous phenomena and accidents that may occur in mines as a result of non-compliance with occupational safety and industrial safety requirements. *Compiled by the authors according to [3]*

According to the above model, the analysis of accidents should be accompanied by the elaboration of measures to prevent them. At the same time, these actions should take into account the behavior of accidents, design and beyond-design accidents, hazardous situations and phenomena.

A. I. Babenko considers hazardous situations arising at the mining facilities to be beyond-design risks. Among the project risks, there are regime and hypothetical phenomena that may occur during the service life of the mining field.

Fig. 2 shows the most significant risk factors in the occupational safety of mining enterprises.

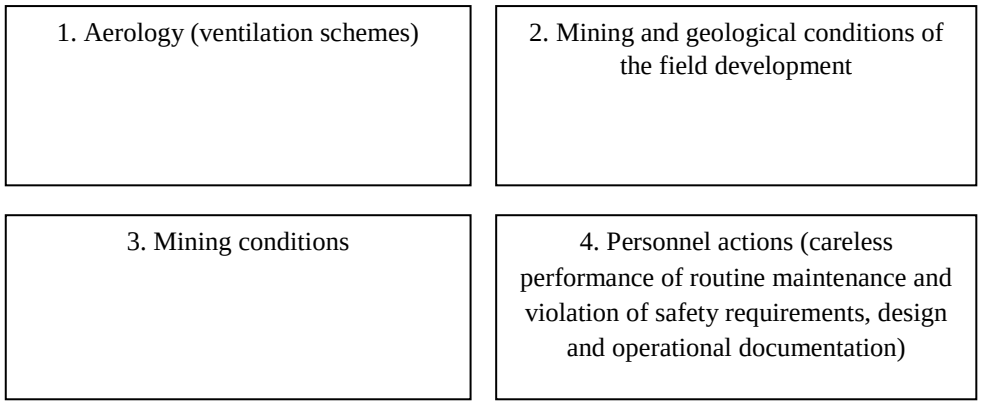

Fig. 2. Risk factors in the occupational safety of mining enterprises. *Compiled by the authors according to [4]*

In addition to possible accidents, there are many factors in the work of mining enterprises that pose threats to the health and life of personnel, as a result of which there is a need for a comprehensive review of working conditions in order to identify potentially hazardous and harmful production factors and develop effective protection measures. The analysis of potentially hazardous and harmful production factors is given in Table 1.

As it can be seen in the table, all potentially hazardous and harmful factors of production are present in mines to one degree or another; therefore it is advisable to develop measures to protect humans and the environment from them. Protection measures against potentially hazardous or harmful factors are presented in Table 2.

Table 1

Analysis of potentially hazardous and harmful production factors at a mining enterprise

Potentially hazardous or harmful factor	**Source**	**Effect on human**
Unprotected mobile elements of production equipment	Hand punchers, drilling machines and scraper winches	Mechanical injuries of different severity
Polluted air environment: — high concentrations of toxic components of dust and gas aerosols	Self-propelled drilling and loading and delivery equipment with diesel engines	Causes suffocation due to insufficient oxygen saturation of the blood
Vibration	Hand punchers, scraper winches	Reflex syndromes of the cervical and lumbar levels, sensorineural hearing loss, chronic radiculopathy of the cervical-brachial and lumbosacral levels, vibration disease
Acoustic effects: — mechanical noise — aerodynamic noise	Moving parts of machines, vibration Fans	Irritation, hearing fatigue (hearing loss and deafness), damage to the central nervous system
Unsatisfactory parameters of the microclimate of the room		Discomfort, decreased performance

Source: compiled by the authors according to [5]

Table 2

Measures of protection against potentially hazardous or harmful factors in the mining industry

Potentially hazardous or harmful factor	**Source**	**Protective device or action to eliminate harmful factors**
Unprotected mobile elements of production equipment	Hand punchers, drilling machines and scraper winches	Partial stationary devices in the form of casings and nets, enclosing drives and other dangerous areas of moving mechanisms; prohibiting signs
Polluted air environment: — high concentrations of toxic components of dust and gas aerosols	Self-propelled drilling and loading and delivery equipment with diesel engines	Innovative exhaust ventilation systems, an automatic gas analyzer of the MN type and means of light and sound notification in case of detection of low oxygen content in the air
Dangerous voltage level	VDU-1201 rectifiers, inductors and oscillators	Equipment: protective grounding, connection to the neutral wire (connection of metal current-carrying parts with a zero protective conductor); protective disconnection Additionally, the workers use dielectric gloves, galoshes, boots, mats. R<4 ohms
Vibration	Hand punchers, scraper winches	Organizational protection measures: "time protection" Technical measures: passive vibration isolation (installation of units on a vibration-insulated foundation), vibration isolation (use of spring and rubber gaskets)
Acoustic effects: — mechanical noise — aerodynamic noise	Moving parts of machines, vibration Fans	An employee performing a harmful technological operation uses a similar means of protection against vibration, as well as from noise (headphones)

Source: compiled by the authors according to [5]

The list of general organizational measures of protection against potentially hazardous and harmful production factors includes:

— regular safety training of personnel;

— providing the staff with the necessary workwear;

— compliance with the rules of equipment operation (including timely inspection and repair of equipment and testing of protective devices);

— regular mandatory medical examination of personnel in order to identify and prevent the development of occupational diseases and pathologies [6].

Multifunctional safety systems, which are being actively implemented in the mines of foreign countries, have shown the greatest effectiveness.

Fig. 3 shows the composition of such multifunctional systems.

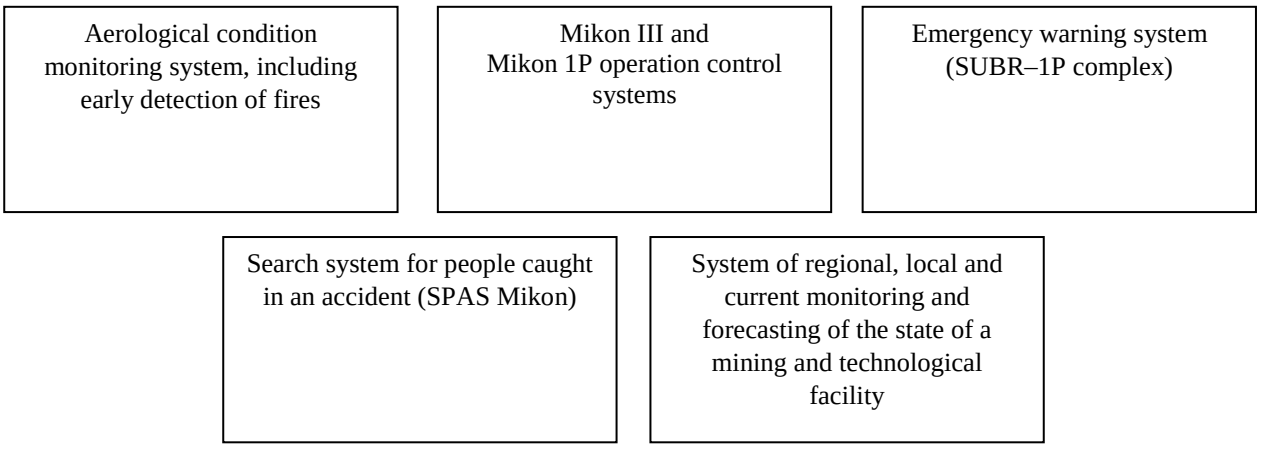

Fig. 3. Composition of multifunctional systems to ensure occupational safety and industrial safety of mining enterprises

Source: compiled by the authors according to [7]

Conclusions. The introduction of multifunctional systems to ensure occupational safety and industrial safety will prevent accidents at mines, increase the level of discipline and prevent mass deaths. At the same time, it is the use of these systems that ensures the compliance with the requirements of standards for occupational safety of workers at mines and allows for a high degree of safe work of personnel.

The most important function of such systems at mines is to notify employees and supervisory authorities about dangerous events at the mine through SMS and E-mail [7].

Multifunctional systems are based on complex programming languages using artificial intelligence and provide prompt response to the slightest violations occurring at the mine. They are the drivers of the growth of safety in the mining industry in the world and in the Russian Federation. Currently, these solutions are being tested in various departments of the mining industry of the country. An important stage is the elaboration of solutions for the conditions and specifics of the detail of each particular mine, which will prevent global and large-scale violations that entail serious consequences.

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Contribution of the authors:

A. A. Cheltybashev — formulation of the main concept, goals and objectives of the study, preparation of the text, formulation of the conclusions; S. N. Sudak — processing of theoretical material, development of recommendations, correction of the text, revision of the conclusions; I. P. Karnachev — scientific supervision, analysis of the the research results, revision of the text, correction of the conclusions.