

Risk Management at the Enterprises of Subsoil Use

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Abstract—Industrial safety at the enterprises of the mineral resources complex is ensured by the methods of the theory of reliability of the “man-machine” system. This forms a risk-based approach to industrial safety. The risk-based approach is based on preventive measures aimed at ensuring the reliability of the system, its human and technical components. At the same time, the key components of the production activity of the enterprise such as human and technical ones are studied. The article substantiates the position that the reliability of production and commercial activities of the enterprise is determined by the reliability of the functioning of all production factors in the economic process, i.e. material factors and human capital. The authors identified both external and internal factors that need to be considered in industrial safety management. Particular emphasis is placed on the systematization of risks and the need to minimize them using the tools of probability theory based on conceptual theory of reliability. In this case, control actions in the form of preventive measures in the functioning of the economic system of the enterprise play an important role.

Keywords: risks, hazards, threats, industrial safety, risk management, “man-machine” system, reliability, prevention, damage insurance

I. INTRODUCTION

Human and technical components of the production process of an enterprise are the collective image comprising two spheres: human, i.e. the personnel of the enterprise setting in motion all types of equipment within the existing technological ways of its use; and technical, i.e. all active and passive fixed assets which are engaged in product creation or creating conditions for its production. In the process of industrial safety management, it is necessary to take into account a number of factors noted in the article, which are constructively divided into internal and external. Together, these factors determine the types of risks, hazards and threats

to industrial safety. Types of risks are represented by two groups – workers' health risks and technical risks. All these risks are of equal significance – they pose significant threats to industrial safety. The authors consider the methods and tools of the risk-based approach to solving the problem of minimizing the risks of the production system of the enterprise. The lower the probability of risks in the operation of the production process, the higher its reliability and, as a result, its industrial safety. Besides, the authors substantiate that the security system in vertically integrated mining companies is provided by a high level of outsourcing, which is due to objective reasons. Also special attention is paid to risk prevention, insurance and industrial safety in the “man-machine” system at the enterprises of the mineral resources complex. Moreover, insurance should perform a stimulating function, i.e. to promote compliance with safety regulations, the personnel to lead a healthy lifestyle, to properly operate the equipment, to follow strictly preventive maintenance modes. All this leads to a qualitatively new level of industrial safety.

II. METHODS AND MATERIALS

The production and commercial activities of enterprises of mineral resources complex are accompanied by many risks. Risk is a potential event that causes certain damage - material or to human health. Risks generally result from entropy, i.e. the uncertainty of the system. Industrial risks are only those risks that are generated by objective organizational and technological factors of the enterprise. In turn, the risks take the form of hazards and threats, which predetermines the need to ensure industrial safety at the enterprises of the mineral resource complex starting from mines and oil fields to mining and processing plants and refineries.

Risks are neutralized or minimized through effective management – risk management, which in general is a risk-based approach to industrial safety.

The decisive role in risk management is played by the human factor, i.e. employees of enterprises and organizations such as workers, specialists, managers, management personnel. The purpose of risk management is to prevent the occurrence of risk events, and as a result the maximum possible industrial safety [1].

The probability of risk occurrence is influenced by many factors that are under direct control of risk management.

In modern conditions, industrial risks are manifested in the so-called “man-machine” systems, since workers perform their labor processes using technical means. Depending on the job responsibilities, such technical means are machine tools and equipment, including computer equipment and peripheral devices. The working staff, from workers managers, is referred to as the collective term of “man”. All kinds of equipment, including mining equipment, are denoted by the concept of “machine”. Both concepts are generally considered inseparable as the “man-machine” system [2].

To date, work has become highly mechanized and automated and is performed by specialists of various professions. In other words, industrial safety management is reduced to ensuring the reliable functioning of the “man-machine” system.

Industrial safety management takes into account many factors [3, 4]. First of all, there are internal and external factors relative to the “man-machine” system.

Internal factors (subsystem “man”) include:

- employee qualification, i.e. the level of their professionalism;
- experience, i.e. work experience in the specialty;
- skills, i.e. accumulated skills or competences;
- intuition, i.e. the ability to adequately perceive their work process;
- employee training, including the system of professional development;
- training and testing of workers;
- discipline and self-control;
- compliance with safety regulations.

External factors (subsystem “machine”) include:

- applied technological processes;
- equipment used, its physical and moral wear;
- organization of production and labor;
- maintenance and repair of equipment;
- ensuring labor protection requirements;
- -control by the Supervisory and inspection bodies.

The factors mentioned above determine the types of risks, hazards and threats to industrial safety in the “man-machine” system. Violations of industrial safety are due to the occurrence of risk events. In risk management the main ones are:

1. Employee health risks:

- workplace injuries (of various severity level);
- harm to health when violating occupational health rules;
- occupational diseases;
- industrial accidents with severe consequences for people;
- accidents;
- emergency situations with harm to human health.

2. Technical risks:

- failures in operation of technical equipment;
- violation of regulatory requirements during mining operations;
- downtime of equipment and workers;
- poor quality maintenance and repairs;
- violation of safety and health regulations;
- production fault;
- environmental pollution.

Central to risk management are preventive measures aimed at ensuring the reliability of the “man-machine” system, its human component (subsystem “man”) and technical component (subsystem “machine”) [5]. Prevention of risks in both subsystems should ensure the reliability of the system as a whole at the level of not less than 90-95 %.

The fundamental concept of the theory of reliability is failure. In the aspect under consideration it is a real risk case (event) that causes some damage [6]. For each of the types of risk failure has its specific expression. For example, for a person it may be an injury, illness or an accident. Equipment failures can be very numerous, for example, machinery breakdowns, accidents, interruptions of electric power supply, fires, explosions, landslides, gas pollution, emissions of harmful substances, car accidents, etc.

III. RESULTS

Reliability is a property of the system, due to its freedom from failures and ensuring the performance of its functions in the prescribed amount, i.e. achieving the goal of a given production and commercial activity of the enterprise [7].

A quantitative measure of reliability $R(t)$ is the probability of failure during time t . Knowing the density of the distribution of the time of failure-free operation of the system $f(t)$, the value of its reliability is determined.

The main characteristics of reliability are failure rate, i.e. the intensity of risk events and time between failures, i.e. the average time between two risk events of the same name.

At the enterprises of the mineral resource complex, in particular, in mines and pits, the flow of operational processes is recorded in special journals, with all kinds of failures being recorded. This information serves as a source of initial data for calculating the reliability parameters of the "man-machine" system. Based on such calculations, the frequency and composition of preventive maintenance for each type of risk is determined [8].

Risk management substantiates and specifies preventive measures in the "man-machine" system. For example, for a person it can be medical examination, rest, professional retraining, testing of workers, confirmation of their category or class. For equipment it is maintenance works, preventative and predictive maintenance, life cycle monitoring and replacement of technical equipment, etc. Such works are provided for in the regulatory and special documentation in the form of regulations and special modes [9].

In risk management, the interface, i.e. man-to-machine interfacing, plays an important role. In order to minimize risks, this interfacing requires compliance with ergonomic requirements in workplace organization. Such ergonomics should take into account two important factors: 1) psychophysiological features of the worker and 2) characteristics of the labor process. The labor process is determined by the technologies applied, from the preparation of the workplace, its technical equipment, labor techniques, current quality control of the operations to the final result in the form of the finished product and the output quality control [10].

In production, there is a rule that strict execution of all operations according to the requirements of the technological process ensures industrial safety. To minimize risks, the interface should connect the worker and his workplace, i.e. the "man-machine" system, into a single whole. As it follows from the name of the system in question, "man" is put in the first place, because the human factor determines the efficiency, and as a result the safety of the entire production process [11].

It should be noted that the expression "risk insurance" is not quite accurate, since risks are objects of prevention, and therefore are potential, i.e. probabilistic in nature [12, 13]. Insurance is a relationship for the protection of property interests in the event of insured events. Insurance cases or events are already a reality. Therefore, the object of insurance is the damage caused by an event that has already occurred, i.e. an insured event.

According to the management theory, the number of control actions should not be less than the number of possible states of the controlled system, in this case, risks [14]. Consequently, risk management should include a sufficient number of control actions in the form of preventive measures. Such actions should mainly be carried during outsourcing by specialized firms. These companies are financially liable in the event of failure – a risk event.

In general, the safety system as a functional economy is characterized by a very high level of outsourcing. The high level of outsourcing in the safety system is due to the following reasons:

- independence: many safety activities, primarily inspection, supervision and maintenance functions, are carried out by independent organizations and firms [15];
- professionalism: the majority of preventive, liquidation and rehabilitation works are carried out by specialized companies, staffed by highly skilled workers and special equipment [16];
- constant readiness: in accordance with safety requirements outsourcing firms are able to perform sudden and urgent work [17, 18].;
- according to safety requirements, material and moral responsibility for the quality of work performed [19, 20].

In the safety system during outsourcing, the objects of maintenance are mining and mine-rescue equipment, automation, means of communication, control and warning, stationary and mobile technical equipment, protective devices [21].

IV. CONCLUSION

1. The effectiveness of industrial risk management in the "man-machine" system depends on the division of work between the enterprise and the outsourcers. The cost of risk management has the property of moral and economic payback.

2. Insurance conditions should have a stimulating effect, i.e. to encourage compliance with safety regulations, for employees to lead a healthy lifestyle, and for technical means to follow the rules of operation and to comply with preventive maintenance.

3. Payment of insurance sums, first of all, is directed to compensate for the material damage caused. But at the same time, as a rule, additional modernization and innovative works are also carried out, the purpose of which is to prevent similar risky events in the future [22]. In this case, a qualitatively new level of industrial safety is achieved.

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