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**SYSTEMATIC APPROACH TO WORK SAFETY
MANAGEMENT IN THE WORKPLACE**

Abstract. Occupational safety management in our country no longer meets modern requirements for occupational safety in the workplace and needs to be improved, in particular through the introduction of a risk-oriented approach to the assessment of production factors. The use of risk-oriented approach system to safety management in the workplace is substantiated in this work, and it is the primary link in the management system of labor protection and its optimal (comfortable) organization significantly affects the production environment, safety and staff productivity. A structural and logical model of the incident at the workplace is proposed and possible dangerous events, the development of which in space and time can lead to its implementation are identified. Dangerous events can be caused by both - the actions of the employer and the employee, as well as external factors. All considered dangerous events are random in nature, so methods of general theory of random process control, simulation and Boolean algebra are used for their analysis. According to this model, workplace safety management involves identifying the factors that are most likely to be present in the workplace and justifying measures to reduce the frequency of their occurrence and increase the level of safety. It is shown that the use of a systemic risk-oriented approach to safety management in the workplace will allow to identify the factors that are most likely to cause accidents and to develop appropriate measures to eliminate them. In a market economy, an important point in occupational safety management at all levels is to resolve the compromise between the economic feasibility of economic activity and social responsibility of the state in a way that reduces production risk, namely - maintaining human-centric economic development. Finding such a compromise is difficult and problematic, as it is difficult to compare in commensurate units the economic performance of economic activities with social losses due to accidents and occupational diseases at work. In the conditions of decentralization, when the role of supervisory bodies over the state of labor protection is reduced, it is very important to form elements of labor protection culture in employees and managers. Improving public and cultural education on occupational safety remains a priority of our country's public policy, in particular through higher education, which trains highly qualified workers and senior managers who are personally responsible for occupational safety at each workplace.

Key words: labor safety; human factor; risk-oriented approach; workplace; safety management

Introduction

In the current conditions, human safety issues are becoming increasingly important in all areas of its activities. Modern research on these issues focuses on the idea that for their successful solution it is necessary to change the paradigm of safety management - to introduce on the basis of the system analysis risk-oriented approach for management in all areas, in particular in production [1], and provide the formation of personal responsibility

through education of both - managers and employees for their own actions during professional activities [2]. Comprehensive solution of the problem of labor protection management, formation of a modern safe and healthy production environment, minimization of production risks will contribute to the sustainable economic development of the country and its social orientation, preservation and development of labor potential of Ukraine.

Analysis of modern research and problem formulation

Labor protection management system in our country no longer meets modern requirements for occupational safety and needs to be improved, in particular through the introduction of a risk-oriented approach to the assessment of production factors [3]. Features of the labor protection management system at the present stage are considered in the work [4], in which it is presented as a complex dynamic system that is constantly changing over time. In this work the set of the indicators which characterize input influences of external environment, an internal condition of system and its initial characteristics are defined on the basis of model researches. It is expected that the results obtained will contribute to the adoption of scientifically management decisions aimed at improving the efficiency of the health and safety management system at the sectoral and national levels. The issues of functioning efficiency of some subsystems, in particular legal [5, 6], technical and human-machine [7] are discussed. Economic aspects of labor protection management in order to improve working conditions at a separate enterprise are considered in the work [8].

Peculiarities of labor protection system management at different levels: state, branch, regional and production as basic are discussed in the work [9]. Particular attention should be paid to the analysis of security management problems of critical infrastructure and other objects of traumatic economic activities in order to prevent risk situations and threats [10, 11].

The complexity of management systems and the lack of complete information about a particular state at a certain point in time requires a constant search for new approaches to the study of their individual components and change the paradigm of their management [12]. The results of the latest research on the management of any object indicate the difficulties that arise in the presence of incomplete and / or redundant information about the state of the managed object and the need for proactive management to eliminate incompleteness and / or redundancy of information [13].

In this context, the problem of security-oriented project management of complex organizational and technical systems and the impact of project complexity on security processes during their implementation and at the stage of operation of the final product is important [14]. The introduction of such project approaches in occupational safety management forms new mechanisms to ensure comfortable working conditions in the workplace and health of workers by taking into account the patterns of interaction of personnel during work with the production environment, technological processes, industrial equipment and staff [15].

Thus, summarizing the experience of security risk management, it should be noted that today the most effective is management, which is based on achieving a certain level of security with an acceptable balance of benefits and costs within an individual entity, region and country as a whole [16].

The purpose of the article

The aim of our article is to substantiate the possibility of applying a systemic risk-oriented approach to occupational safety management based on the definition of an accident at work as a set of consecutive, parallel (simultaneous) or sequentially parallel dangerous events that develop in time and in space, and under certain circumstances can cause undesirable consequences: injuries, occupational diseases, fatalities.

Presenting main material

Global experience in man-made safety management has shown that the transition from the paradigm of absolute safety of the human environment to the paradigm of risk-oriented approach and the paradigm of safety culture can significantly increase safety level by structural and logical modeling of dangerous events using methods of general theory of random processes, graph theory, simulation modeling and Boolean algebra [17]. The key to successful economic activity is the introduction of an effective system of management of industrial safety and health of workers or, in traditional terms, the management system of labor protection at the enterprise.

We have considered the issue of occupational safety management in the workplace. The workplace is the primary link in the management system of labor protection and its optimal (comfortable) organization significantly affects the production environment, safety and productivity of personnel [4]. We consider the analysis of safety in the workplace on the example of a structural and logical model of the incident - a dangerous event that affects the level of personnel safety (Fig. 1). The proposed model, like any other model, reflects only the essential (most important) links in the development of the incident in the workplace.

Any workplace incident is an accidental event and with a probability of P_1 will occur when one of the three dangerous events occurs, namely: either a dangerous event caused by an employer with a probability of P_2 , or a dangerous event caused by an employee with a probability of P_3 , or a dangerous event caused by external (relative to the workplace) factors with probability P_4 .

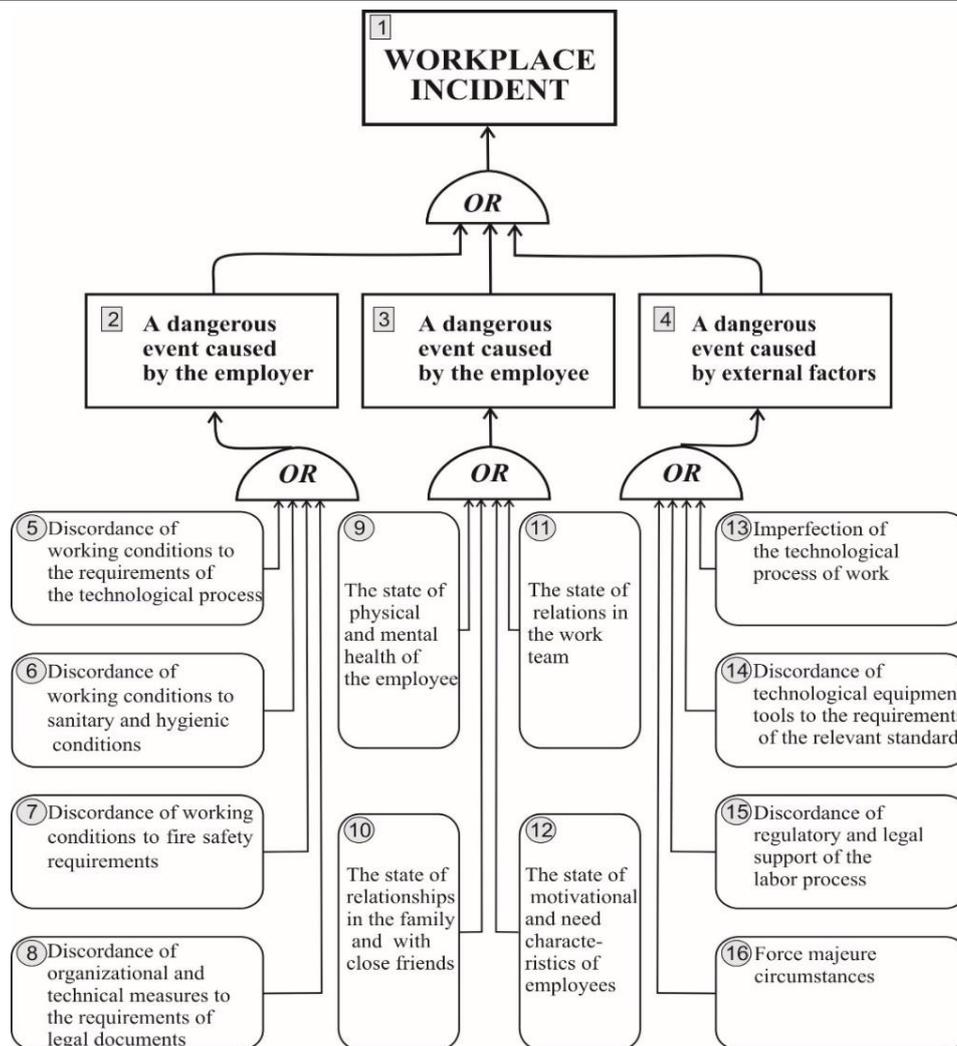


Figure 1 – Structural and logical model of the incident in the workplace

According to the rules of Boolean algebra, the probability of this incident in the workplace can be calculated by the formula:

$$P_1 = P_2 + P_3 + P_4 - (P_2 \cdot P_3 + P_2 \cdot P_4 + P_3 \cdot P_4) + P_2 \cdot P_3 \cdot P_4 \quad (1)$$

Whereas, the probabilities of occurrence of these events P_2 , P_3 , P_4 are small, the probability of occurrence of incident P_1 can be approximately estimated by the simplified formula:

$$P_1 \approx P_2 + P_3 + P_4 \quad (2)$$

The probability of a dangerous event caused by the employer P_2 depends on the presence of several random conditions (causes) that may occur in the workplace with a certain probability:

The probability of a dangerous event caused by employee P_3 also depends on the presence of several random conditions (causes) that may occur with a certain probability:

1) the state of physical and mental health of the employee with a probability of P_9 ;

2) the state of relationships in the family, with close friends with a probability of P_{10} ;

3) the state of relations in the work team with a probability of P_{11} ;

4) the state of motivational and need characteristics of employees with probability P_{12} .

The probability of a dangerous event caused by employee P_3 can be approximately estimated by the formula:

$$P_3 = P_9 + P_{10} + P_{11} + P_{12} \quad (4)$$

The probability of a dangerous event caused by external factors P_4 depends on the presence of the following random conditions (causes), which may occur with a certain probability:

1) imperfection of the technological process of work with probability P_{13} ;

2) discordance of technological equipment, tools to the requirements of the relevant standards with a probability of P_{14} ;

3) discordance of regulatory and legal support of the labor process with the probability of P_{15} ;

4) force majeure circumstances with probability P_{16} .

The probability of a dangerous event caused by external factors P_4 can be approximately estimated by the formula:

$$P_4 \approx P_{13} + P_{14} + P_{15} + P_{16}. \quad (5)$$

In summary, it should be noted that the occurrence of an incident in the workplace depends on many factors and its probability is estimated by the formula:

$$P_1 \approx P_5 + P_6 + P_7 + P_8 + P_9 + P_{10} + P_{11} + P_{12} + P_{13} + P_{14} + P_{15} + P_{16} \quad (6)$$

Although the individual probability values from P_5 to P_{16} are actually small, but a significant number of terms can cause a high probability of an incident in the workplace. Obviously, workplace safety management involves identifying the factors that are most likely to be present in the workplace and justifying measures to reduce their frequency and increase safety.

Factors related to the responsibility or irresponsibility of the employer to create safe working conditions in the workplace are characterized by approximately the same probability of their occurrence and are often the determining factors. As for the factors that characterize the psychophysiological characteristics of employees, the probability of their occurrence is usually difficult to predict and they can take extreme values. The probabilities of external factors are the most predictable among those discussed above, except for the occurrence of force majeure.

The implementation of these measures and the elimination of any dangerous factors in the workplace requires significant costs, both material and financial, so the management of safety in the workplace has a socio-economic focus.

Thus, the management of labor protection in a market economy at all levels (from government to business) should simultaneously provide solutions to both social and economic problems. The relationship between these tasks in labor protection measures is determined on the basis of a compromise between the economic feasibility of economic activity and social responsibility of the state [18]. Social dialogue between the participants in production activities plays an important role in resolving this conflict. The relationship between the economic feasibility of economic activity, social responsibility of the state and the level of production risk are presented in Fig. 2.

It is possible to raise the level of labor safety requirements so high at the state level that economic activity will be economically impractical and vice versa - it is possible to lower this level that the activity of state bodies will be socially irresponsible. From another approach, occupational safety can be guaranteed only when economic activity is economically feasible.

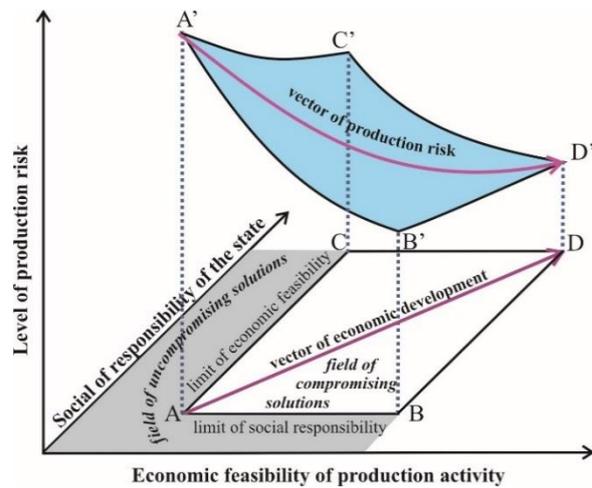


Figure 2 – The relationship between social responsibility of the state, economic feasibility of economic activity and the level of production risk

Therefore, in Fig. 2 in the coordinates "Social responsibility of the state" – "Economic feasibility of economic activity" there are two fields highlighted: the field of compromise solutions and the field of uncompromising decisions.

If the economic activity is carried out in the field of uncompromising decisions, then there are no guarantees of safety in the workplace, as any legal measures taken at the state level are ineffective, and economic entities are not economically able to provide safe conditions of labor. Obviously, only in the field of compromise solutions can social and economic problems be solved at the appropriate level using scientifically reasonable economic methods of occupational safety management in the workplace.

The conditions under which occupational safety management is carried out in the field of compromise solutions exist in economically developed countries, for which the field of compromise solutions ABCD corresponds to the response surface of the level of industrial risk in the workplace A'B'C'D'. There are many vectors of economic development in this field of compromise solutions, but only in the case of human-centered direction of economic development of the country AD, provided a scientifically reasonable risk-based approach to occupational safety management, the level of occupational injuries is significantly reduced (Fig. 2). For developing countries, in the field of uncompromising solutions, labor protection measures are usually ineffective.

In a market economy, the issue of ensuring the appropriate level of occupational safety and health management in small and medium-sized businesses, where scientifically justified economic methods can not always play the role of effective levers of labor protection management, is also problematic. This is evidenced by the significant number of accidents in these businesses.

Therefore, in the current conditions, when the role of supervisory bodies over the state of labor protection is declining, it is very important to form elements of the culture of labor protection in employees and managers. Improving public and cultural education on occupational safety remains a priority of our country's public policy, in particular through higher education, which trains highly qualified employees and senior managers who are personally responsible for occupational safety at each workplace.

Man has an instinct for self-preservation, in which the main point is the relationship between the provision of physiological (material) needs and security needs. A person's needs through a complex psychological process of motivation determine his actions in any situation, even in the most dangerous. During work, there are mainly two motives: the motive of profit and the motive of security. In the current economic conditions and the presence of polymotivation, the motive of profit often outweighs the motive of safety, which creates favorable conditions for accidents. Successfully resolving the conflict between the two motives will help to increase safety in the workplace.

A detailed (rather than formal in nature) investigation of industrial accidents, especially those that have occurred in small and medium-sized enterprises, clearly indicates that the root cause of many accidents is the desire of workers in all conditions (often obviously

dangerous and with high risk for life) to receive salary to meet basic living needs. This will continue until the socio-economic guidelines of the country's development are aimed at the main goal of economic development of society – ensuring human well-being, preserving its health and creating conditions for its self-realization and improvement. It is clear that for achieving such an economic level of development of the country, especially in the current conditions, a long period of time is required.

Therefore, the solution of this problem involves finding a compromise, which is complex and problematic, because it is difficult to compare in commensurate units of economic performance with social losses due to accidents and occupational diseases at work.

Conclusions

Thus, the use of a systemic risk-oriented approach to safety management in the workplace will allow to identify the factors that can cause accidents, and to develop appropriate measures to eliminate them. An important point in occupational safety management is to resolve the compromise between the economic feasibility of economic activity and social responsibility of the state in a way that reduces the level of production risk, namely – maintaining human-centered development of the economy.

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СИСТЕМНИЙ ПІДХІД ДО УПРАВЛІННЯ БЕЗПЕКОЮ ПРАЦІ НА РОБОЧОМУ МІСЦІ

Анотація. Управління охороною праці в Україні вже не відповідає сучасним вимогам безпеки праці на робочому місці і потребує удосконалення, зокрема шляхом впровадження ризик-орієнтованого підходу до оцінювання виробничих чинників. Обґрунтовано використання системного ризик-орієнтованого підходу до управління безпекою на робочому місці, яке є первинною ланкою в системі управління охороною праці і його оптимальна (комфортна) організація істотно впливає на виробниче середовище, безпеку і продуктивність праці персоналу. Запропоновано структурно-логічну модель інциденту на робочому місці і визначено можливі небезпечні події, розвиток яких може привести до його реалізації. Небезпечні події можуть бути спричинені як діями роботодавця, так і працівника, а також зовнішніми чинниками. Усі небезпечні події мають випадковий характер, тому для їхнього аналізу використано методи загальної теорії управління випадковими процесами, імітаційного моделювання та булевої алгебри. Згідно з цією моделлю управління безпекою на робочому місці передбачає виявлення чинників, які мають найбільшу ймовірність наявності на робочому місці та обґрунтування заходів щодо зменшення частоти їхньої появи та підвищення рівня безпеки. Показано, що використання системного ризик-орієнтованого підходу до управління безпекою на робочому місці дасть змогу кваліфіковано виявляти чинники, які найімовірніше можуть спричинити нещасні випадки, та розробляти відповідні заходи щодо їх усунення. В умовах ринкової економіки важливим моментом в управлінні безпекою праці на усіх рівнях є знаходження компромісу між економічною доцільністю господарської діяльності та соціальною відповідальністю держави у спосіб, який забезпечує зниження рівня виробничого ризику, а саме – підтримання людиноцентричного розвитку економіки країни. Пошук такого компромісу є складним і проблемним, адже важко зіставити у співвимірних одиницях економічні показники господарської діяльності з соціальними втратами у зв'язку з нещасними випадками та професійними захворюваннями на виробництві. В умовах децентралізації, коли понижується роль наглядових органів за станом охорони праці, дуже важливим є формування у працівників та керівників елементів культури охорони праці. Підвищення освіченості населення та культури з питань охорони праці залишається пріоритетним завданням державної політики нашої країни, зокрема засобами вищої освіти, яка готує висококваліфікованих працівників та ланку безпосередніх керівників, які особисто відповідають за безпеку праці на кожному робочому місці.

Ключові слова: безпека праці; людський чинник; ризик-орієнтований підхід; робоче місце; управління безпекою

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