

TECHNOSPHERE SAFETY



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Analysis of existing approaches to the assessment of hazards and occupational risks of workers of industrial enterprises of the Republic of Kazakhstan

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Introduction. Timely and effective identification and assessment of all hazards and occupational risks is one of the urgent problems in the prevention of occupational injuries of industrial workers. Both legislative and regulatory acts and a number of foreign and domestic authors offer various approaches to such an assessment, the analysis of the advantages and disadvantages of which is the subject of this article

Problem statement. The objective of this study is a critical analysis of the existing approaches to the assessment of hazards and occupational risks of workers in industrial enterprises.

Theoretical part. As the basic information, state regulatory methods were used, as well as methods for assessing the occupational risks of employees of industrial enterprises, proposed by various authors.

Conclusions. According to the results of the analysis, the ways of solving the problem of preventing occupational injuries of industrial workers on the conditions of "preliminary" assessment of their occupational risks, i.e. before the occurrence of negative events, are determined.

Keywords: workers, occupational injuries, occupational disease, workplace, dangerous and harmful production factors, occupational risk, assessment.

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Introduction. Any human activity, including labor, contains various potential hazards that are the cause of occupational injuries and occupational diseases. The consequences may be accidents, emergencies, fires, etc.

Practical experience shows that absolutely zero values of risk to human life and health are unattainable in any kind of the activity. However, there are different levels of risk depending on the type of potential hazards. Thus, the main task of occupational injuries prevention is to determine the magnitude of the potential hazard of any type of work activity. We are talking about hazard as a potential threat of negative impact on human life, health and/or the environment. Currently, we distinguish potential (hidden) and real hazards, and certain conditions or reasons are necessary for the implementation of the former into the latter [1].

The number of man-made hazards, as well as the degree of their negative impact in the modern world is constantly growing. The Republic of Kazakhstan is no exception, where more than 200 people die and more than 2,000 people are injured with various degrees of severity every year as a result of industrial injuries. About 15,000-16,000 emergencies and accidents are registered annually, and the overwhelming number of them (more than 90 %) is

man-made accidents. Out of 1.6 million employees of industrial enterprises of the country surveyed in 2019, 370 thousand employees or one in four (22 %) were employed in harmful and hazardous working conditions. One in two (45.9 %) worked in conditions of increased noise and vibration levels, one in three (32.6 %) worked under the influence of increased gas pollution and dustiness of the working area, 94 thousand people (5.6% of the number of employees of the surveyed enterprises) were engaged in physically demanding jobs [2–4].

Problem Statement. One of the problems in the field of injuries, accidents and emergencies prevention is a timely, objective and complete assessment of the existing or emerging potential hazards. At the moment, there are a large number of methods of such assessment (numerical, point, etc.). The most common assessment of hazards is risk, i.e. the probability of an undesirable event occurring in the system, which can be identified with a certain and sufficient degree of accuracy from statistical data [5]. According to another definition, risk is an objective or subjective measurement of the probability and possibility of consequences of a dangerous event concerning human or the environment well-being [6]. Most scientists and researchers in the field of life safety use the following general definition: risk is a quantitative assessment of hazards [7, 8]. English scientist V. Marshall in his book "The main dangers of chemical production" gave the following definition to this concept: risk is the frequency of the implementation of hazards, in other words, risk in numerical terms is the ratio of any number of negative situations (n) to their possible number (N) for a certain period of time [8].

For the first time, the concept of "risk" became widely used after the First World Congress on Life Safety, held in September 1990 in Cologne under the motto "Life in Safety".

In the world practice, the maximum permissible (acceptable) level of individual risk of death of an employee at work is considered to be a level equal to 10^{-6} per year, i.e. if 1 person per 1 million dies, and negligibly small — 10^{-8} per year [5]. From these positions, for a comparative analysis, we will determine the risk of death or injury of workers in the conditions of the economy of the Republic of Kazakhstan. Table 1 presents statistical data on occupational injuries for the period from 2018 to 2020 in the whole country [2]. The number of victims of industrial accidents in 2020, in comparison with 2018, did not change significantly and amounted to 2,033 people (in 2018, the number of victims was 2,160 people). However, in 2020, most enterprises of the republic did not work most of the time due to quarantine measures caused by the COVID-19 pandemic. In 2020, 203 people died as a result of industrial accidents, in 2018 — 215 people. The mortality rate decreased by 5.6%. This is explained not by an increase in the level of safety and labor protection of workers, but by the downtime of enterprises due to the quarantine.

Table 1

Statistical data on injuries of workers in the sectors of the economy of the Republic of Kazakhstan for the period from 2018 to 2020

No.	Indicator name	Value of indicators by year		
		2018	2019	2020
1	Number of people employed in the sectors of the economy of the Republic of Kazakhstan, thousand people	8 704.0	8 773.2	8 750.1
2	Number of dead workers in production, people	215	190	203
3	Number of injured workers in production, people	2 160	2 111	2 033
4	Actual risk of death of workers at work	2.47×10^{-5}	2.16×10^{-5}	2.31×10^{-5}
5	Actual risk of injury to workers at work	2.48×10^{-4}	2.4×10^{-4}	2.32×10^{-4}

The data presented in Table 1 indicate that the risk of death of workers at work in the republic as a whole is more than 2 times higher than the generally accepted world level of acceptable risk. Moreover, the calculation was

carried out for the economy as a whole, both in more and less traumatic industries. If such a calculation is made for the most traumatic industries of the country, it will be: for the construction industry — 9.43×10^{-5} , for the mining industry — 11.1×10^{-5} , for the engineering industry — 5.48×10^{-5} . All this indicates an unacceptably low level of occupational safety and health (hereinafter referred to as OSH) of industrial enterprises workers of the Republic of Kazakhstan.

Although the above risk assessment according to the method of V. Marshall is elementary and simplified, it is quite effective and widely used.

The objective of the conducted research was a critical analysis of the existing state regulatory documents in the Republic of Kazakhstan, methods or approaches proposed by various authors to assess occupational risks, as well as the development of priority areas for their improvement.

Theoretical Part. Paragraph 2 of Article 182 of the Labor Code of the Republic of Kazakhstan obliges the employer to constantly monitor the level of occupational risks in order to prevent it, as well as to replace the used hazardous technologies and production equipment with safer ones [9]. In this regard, the relevant OSH services of enterprises should have fairly simple and effective methods for assessing the occupational risks of employees. The review of regulatory documents and scientific literature on the subject of the study allowed us to identify the main approaches and methods of assessing hazards and risks in the field of industrial safety (hereinafter referred to as IS) used in the republic.

Regulatory methods for hazards and risks assessment based on statistical data on occupational injuries and accidents. Currently, there are several state methods in the Republic of Kazakhstan, which are mandatory for all state control and supervisory authorized bodies, as well as enterprises and organizations. The regulatory methodology recommended at the state level for assessing the level of industrial safety of an industrial facility is set out in Order of the Acting Minister for Investment and Development of the Republic of Kazakhstan of December 26, 2014 No. 300 [10]. The main purpose of these Rules is to determine the degree of protection of individuals and legal entities, the environment from hazardous and harmful production factors (hereinafter referred to as HHPF) by monitoring the IS level both by the state authorized bodies in the field of IS, and by the relevant departments of enterprises and organizations. The general level of hazard of a production facility (hereinafter referred to as HPF) is determined by the enterprise operating this facility once a year by the calculation method according to the following indicators: the condition of industrial buildings and technological structures; the condition of technical devices, including dangerous ones; accidents and incidents that have occurred; the frequency of accidents at work; fatal accidents that have occurred at work. The final overall level of hazard of the object is determined by the sum of the above indicators.

The use of the presented methodology for assessing the level of industrial safety of production facilities is difficult for the following reasons:

— out of the recommended seven calculated indicators, four are indicators of accidents and incidents that have occurred, the frequency of accidents and fatal accidents that have occurred at work. They are statistical and do not reflect the real state of affairs. These negative events can also occur in modern well-equipped production due to erroneous, incorrect actions of personnel, as well as in case of gross violation of safety regulations. At the same time, at a small enterprise with a small number of employees, outdated technologies and equipment, accidents may not occur at all. As a result, it is possible to draw an incorrect conclusion about the low level of industrial safety of the first one. In addition, in real life, many statistical data are displayed unreliably when reporting to the authorized state bodies, it is extremely difficult to get their real picture;

— generalization and consolidation into a single statistical array of all the events under the general indicators "accidents that have occurred" and "incidents that have occurred" creates the problem that within these indicators all the events that have occurred are the same, i.e. equated to each other. In accordance with this, an explosion at an enterprise with the death of a large number of people and the destruction of any equipment without casualties are the equivalent events. However, there is no exactly the same accident or incident, i.e. based on this indicator, it is practically

impossible to draw any conclusions about the IS level of a particular enterprise or facility. The situation is similar with the indicator of fatal accidents at work. Past experience shows that for most industrial enterprises during the reporting period (a year or more) it is either negligible or practically zero. Based on the above, it can be concluded that using only accident and injury indicators to assess the level of hazards and risks of an industrial enterprise as a whole, and to determine the level of industrial safety of individual hazardous production facilities leads to unreliable and erroneous conclusions;

- a number of important indicators are missing, such as, for example, ensuring the safety of the technological process, the timeliness of routine maintenance and the level of their organization, the qualification and knowledge of the personnel of the IS requirements, which directly affect such an assessment;

- there is no doubt that this methodology has been developed only for state supervisory bodies that conduct only an external assessment of production safety as a whole, without delving into the causes and consequences of its low level, as well as without assessing the occupational risks of employees.

Another state regulatory methodology for assessing the level of hazard and risks of a production facility is set out in the joint order of the Minister for Investment and Development of the Republic of Kazakhstan No. 1206 of 15.12.2015 and the Minister of National Economy of the Republic of Kazakhstan No. 814 of 28.12.2015 [11]. Evaluation indicators are formed here by means of objective and subjective criteria. According to objective criteria, the subjects or objects subject to verification are divided into 2 groups — high and not classified as high risk. For subjects or objects of the first group, a special procedure for inspections based on semi-annual schedules, unscheduled inspections and other forms of control and supervision is applied. For subjects or objects of the second group — only unscheduled inspections and other forms of control and supervision. According to the indicators of subjective criteria, a mechanism is used to encourage bona fide subjects or objects in the form of exempting them from a special procedure for checking the IS state. In the document under consideration, these criteria for significance are divided into 3 degrees of violations according to IS: gross, significant and insignificant. When determining the indicator of the degree of risk, the specific weight of each of the unfulfilled IS requirements is assessed. Then they are summed up and a general indicator of the degree of risk of the subject or object of high risk is found, depending on the magnitude of which such a subject or object is exempt from a special procedure for conducting inspections based on semi-annual schedules (from 0 to 60 points) or is not exempt (from 60 to 100 points).

At the same time, if at least one unfulfilled requirement of a gross degree of IS is revealed, then the overall indicator of the degree of risk of the subject or object being checked is equated to the indicator 100 and no further calculation is made.

The criteria for assessing the degree of risk, according to which the above calculation is made, are given in the annex to this order. It contains more than 1000 evaluation indicators.

The application of this technique in the work of the OSH service of a manufacturing enterprise for internal use to assess the level of danger and risks is difficult for the following reasons:

- it is fully focused on the external assessment of the enterprise as a whole by the state supervisory bodies;

- this technique is very time-consuming, since in order to determine the overall indicators, it is necessary to evaluate more than 1000 additional evaluation indicators given in this methodology.

Following on from the above-mentioned methods, there are Guidelines on risk management at the HPF, approved by Order of the Committee for State Control over Emergencies and IS of the Republic of Kazakhstan No. 46 of October 1, 2013. It establishes the general procedure for conducting a comprehensive analysis and assessment of the IS state at the HPF [12].

So, according to them, the main stages of risk analysis are: identification of risk; analysis of its level or quantitative magnitude of the degree of danger to workers, equipment and production environment or the environment; final assessment by comparison with the acceptable levels.

The main stages of risk analysis are: determination of the frequency of occurrence of initiating and all undesirable events; assessment of the consequences of the occurrence of undesirable events and a generalized risk assessment. To solve the first of these tasks, statistical data on accidents, occupational injuries and occupational diseases at the HPF, as well as expert assessments of specialists are used. The final (generalized) risk assessment determines the actual state of the IS level, taking into account the risk indicators from all negative situations that may arise at the HPF.

The main disadvantages of the considered Guidelines are the difficulty of collecting reliable initial data for calculations, as well as the fact that the error of a certain value of the risk value, even with all the necessary initial data, is very big. For this reason, it is very difficult to use the results of risk analysis for periodic and continuous monitoring of the IS level at HPF in order to determine the impact of certain measures taken on this condition.

If the above Guidelines regulates risk management only at hazardous production facilities, then later the Rules of Occupational Risk Management of 11.09.2020 provides for such management at all industrial enterprises of the Republic of Kazakhstan [13]. These Rules stipulate the procedure for occupational risks management, and unlike other methods, they include not only the stages of their identification and assessment, but also the stages of carrying out corrective measures, as well as control and monitoring the levels of occupational risks.

The risk identification stage is provided for each profession or workplace of the enterprise by type of activity and includes the collection and analysis of information, a comprehensive survey with technical measurements, determination of all harmful production factors based on the results of the survey with filling in the Register of Occupational Risks approved by the head of the enterprise.

All previously identified harmful production factors are subject to assessment, according to the results of which the level of their hazard is determined according to 5 degrees of occupational risk: degree 1 — acceptable, degree 2 — low, degree 3 — medium, degree 4 — high and degree 5 — very high risk.

To determine the occupational risk degree, the following analytical expression is used:

$$ПП = 0.7 \cdot \frac{B+T}{2} + 0.2 \cdot \frac{O_6 + C_{из}}{2} + 0.1 \cdot 3,$$

where B — an indicator of harmfulness of working conditions, characterizing the probability of impact of harmful production factors on working ability of an employee of this profession at the workplace; T — an indicator of injury risk of working conditions, characterizing the probability of impact of hazardous production factors on working ability of an employee of this profession at the workplace; O_6 — an indicator of safety of production equipment used by an employee at the workplace; $C_{из}$ — an indicator of provision of the employee with personal protective equipment; 3 — an indicator of morbidity of workers in this profession [13].

The next stage of corrective measures provides for their implementation according to the developed Action Plan of the enterprise for effective management of these risks in order to reduce the identified levels to lower and acceptable.

The final stage of control and monitoring of occupational risks provides, firstly, control and verification of all the developed corrective measures, and secondly, monitoring of risks by collecting and analyzing analytical indicators of the results of the assessment to form complete information on reducing the degree of their danger.

The advantage of this technique is that it is precisely its content that meets the requirement of preliminary determination of the levels of occupational risks and the development of measures to reduce them before emergencies occur. The disadvantages include the following:

- the frequency of such an occupational risks assessment by the enterprise has not been determined;
- it is not clear why, with the requirements for a comprehensive survey of working conditions with instrumental measurements identical to the existing workplace certification methodology (which will be discussed below), these Rules were not combined.

Methodology for occupational risks assessment developed in the system of workers' accident insurance.

In accordance with Paragraph 14 of Article 182 of the Labor Code of the Republic of Kazakhstan, it is the duty of the employer to insure employees against accidents in the performance of their labor (official) duties. The mechanism of such insurance is described in detail in the following regulatory documents:

- Law of the Republic of Kazakhstan "On compulsory insurance of an employee against accidents in the performance of labor (official) duties" of 07.02.2005 No. 30 [14];

- "Rules for classifying economic activities as occupational risk classes" of 30.06.2005 [15].

Thus, according to these documents, in case of an insured event (accident), an insurance premium is paid to the injured (insured employee), the amount of which is determined by the agreement of the parties (the employer and the insurance company) on the basis of an insurance tariff differentiated by types of economic activity of enterprises, depending on the class of occupational risk multiplied by the insurance sum under the insurance contract. The assignment of economic activities is provided for 22 different classes of occupational risk. The indicator of occupational risk for a specific type of economic activity in the analyzed year is defined as the ratio of the value of the annual actual amount of accrued payments for compensation for damage caused to the life and health of an employee in the performance of labor (official) duties to the size of the annual wage fund.

The assessment of occupational risk degree of a particular type of economic activity of an enterprise or organization is based on the following statistical indicators: the number of victims of accidents during the year; the annual actual accrued amount of payments to victims of accidents, including the average amount of accrued payments per victim; the annual number of victims of occupational diseases; the amount of accrued payments to victims of occupational diseases per year, including the average amount of accrued payments per victim; the number of deaths in accidents per year; the annual amount of actually accrued payments in case of death of employees, including their average size; the annual wage fund for this type of economic activity; the average annual number of employees for this type of economic activity [15].

Although it is possible to draw conclusions about the degree of injury risk of various industries by types of economic activity according to the considered method of occupational risk assessment, its use by the OSH services of enterprises is difficult due to the narrow focus on the insurance sector. Also, all the calculations are made here based on the negative consequences that have already happened (the number of deaths, victims of accidents and occupational diseases, etc.).

The legislation also provides for the right to apply to the insurance company in certain cases for help from experts in this field to establish the degree of occupational risk.

Expert methods of hazard identification and risk assessment. Currently, various expert methods are widely used in the problem of hazards and occupational risks assessment. The use of such methods becomes particularly relevant in the absence of statistical data on injuries and occupational diseases, as well as basic indicators for determining the risk by calculation. The main tasks of experts, who, as a rule, are attracted from among leading scientists or experienced practitioners in this field, are: identification of hazards and objective assessment of occupational risks of employees based on the characteristics of the production process and environment, the existing labor organization and other factors, including a criterion assessment of the degree of acceptability and unacceptability; assessment of measures and technical means used for their effectiveness in protecting employees; documentation of all the procedures.

Expert methods of hazard identification and risk assessment, for all their simplicity and clarity, are characterized by a high degree of dependence of the results of such identification on the subjective opinion of specific persons involved as experts. In this regard, such methods are insufficient for a full-fledged study of the actual state of OSH in production. The accumulated experience in the field of IS shows that reliable and complete information about working conditions and levels of occupational risks cannot be obtained without instrumental measurements of the values of HHPF indicators of the production environment.

Matrix methods of occupational risk assessment. Direct quantitative assessment of occupational risk levels can be implemented through the risk assessment method using the "probability-damage" matrix. The essence of this method is that for each specific situation, the probability rank of its implementation is determined — low, medium or high (matrix columns) — and the potential damage from its occurrence — small, medium, great (matrix rows). The optimum zone is located at the intersection of the corresponding column and row. But this method is also characterized by the disadvantages of the above methods. It is detached from the conditions of real production, does not take into account the state of the production environment, production equipment, etc.

Methods of risk assessment based on the classification of working conditions in the workplace during the certification of workplaces. In accordance with Paragraph 2 of Article 183 of the Labor Code of the Republic of Kazakhstan, the employer is obliged, at his own expense, to conduct periodic, at least once every 5 years, workplace certification (hereinafter referred to as WC) according to working conditions in accordance with the rules, recommendations and methodology approved by the authorized state body in the field of labor relations and industrial safety [9]. Such a document in the Republic of Kazakhstan is the "Rules for mandatory periodic certification of production facilities according to working conditions" of 28.12.2015 [16]. According to these Rules, the certification of workplaces and production facilities of enterprises and organizations is a comprehensive assessment of the compliance with the rules and regulations in the field of OSH and includes the following stages: instrumental measurements and assessment of the levels of harmfulness and danger of labor; instrumental measurements and assessment of the levels of severity and intensity of labor; assessment of the level of injury safety and provision of employees with collective and individual protection means; provision of training and instruction means.

The object of study at the WC is the system "production environment – technological equipment – employee". Production environment is analyzed from the side of the presence of physical, chemical, biological, psychophysiological HHPFs in it, technological equipment — according to the level of safety of the production process as a whole, and the employee — according to the indicators of severity and intensity of work, which allow us to assess the state of his/her health at the workplace.

In the complete absence of HHPFs in the workplace or in their presence, but the compliance of the actual levels with sanitary and hygienic standards and safety requirements (for example, MPC, MPL), as well as when meeting the requirements for injury safety and PPE provision of workers, it is summarized that the working safety conditions in the workplace comply with the established requirements of OSH in accordance with Article 184 of the Labor Code of the Republic of Kazakhstan and they can be assigned, according to the Hygienic criteria for assessing and classifying working conditions, to the 2nd (permissible) class of working conditions [17].

Workplaces are considered not to meet the established OSH requirements if they have one of the following factors or a combination of them:

- the actual values of any harmful factor exceed the existing requirements and norms;
- the requirements for workplace injury safety are not met;
- the PPE provision of employees does not comply with the current standards.

Depending on how much the levels of the actual values of HHPF exceed the existing norms, the working conditions, according to Hygienic criteria, should be assigned to the following classes of working conditions: 3.1; 3.2; 3.3; 3.4 and 4, and subsequently the measures to prevent or localize them should be developed [17].

Thus, the WC covers all the main components of the production process (workers – equipment – production environment), and according to its results, the OSH service of the enterprise can successfully assess the occupational risks of its employees. Another advantage of this method is that, using it, it is possible to assess possible hazards and occupational risks "before" the occurrence of negative incidents and take measures to prevent them, unlike other methods considered, focused on such an assessment "after" the incidents have occurred, based on the analysis of already dead, injured workers, occurred accidents, etc.

However, there are also a number of disadvantages of the risk assessment methods based on the WC, namely:

- such certification is a rather expensive event, and although it is legally imputed to the duties of employers, the latter, whenever possible, evade it, which is facilitated by the restrictions adopted over the past years for supervisory functions in the field of IS by the Industrial Safety Committee of the Ministry of Emergency Situations of the Republic of Kazakhstan as a result of the moratorium on inspections announced by the President of the Republic of Kazakhstan in 2014 for subjects of small and medium-sized businesses and extended until January 1, 2023;

- formal certification, unreliability of the results obtained. Accredited organizations are engaged in WC, with which the employer enters into an agreement to conduct it, but, as the saying goes, "he that pays the piper calls the tune," therefore, in the results obtained, such organizations do not reflect the actual state of affairs, but the wishes of the employer. It comes to the point that a number of organizations accredited in the field of WC do not even have specialized laboratories and material equipment. Therefore the Ministry of Labor and Social Protection of the Republic of Kazakhstan has imposed restrictions on the certification of workplaces according to working conditions by organizations that do not have their own accredited laboratories, and initiated a mechanism to deprive them of the relevant license;

- all these circumstances predetermine not only difficulties, but also the impossibility of an objective assessment of occupational risks based on unreliable WC results.

Conclusions. The analysis of the existing approaches and methods to the assessment of hazards and occupational risks of industrial workers in the Republic of Kazakhstan allowed us to draw the following conclusions:

- the main aspect in solving this problem is to conduct a preliminary stage and the nature of such an assessment, i.e. such a mechanism that makes it possible to conduct risk assessment "before" the occurrence of negative events, and not "after" their occurrence (emergencies, accidents, etc.);

- currently, there is no single approach among scientists and practitioners to the category of occupational risk, the mechanism of its identification and measurement. The very content of the concept of risk may vary depending on the specifics of the employee's profession, the nature of the work performed, etc.;

- the considered regulatory and proposed by various authors methods or approaches to occupational risk assessment have certain disadvantages. For example, some of them are limited only to assessing the condition of individual workplaces and do not take into account the size of possible accidents (the methodology for determining the IS level by accident rate), others are characterized by a certain subjectivity (expert methods), some methods are abstract in nature and do not use sufficient factual statistical data during such an assessment (matrix methods), some are complex in application (normative and probabilistic assessment methods);

- the results of the analysis of various approaches to occupational risk assessment indicate that none of them individually provides objectivity and conditions for the "preliminary" assessment, i.e. before the occurrence of negative events, with the exception of two of them: "Rules of occupational risk management" and "Rules of mandatory periodic certification of production facilities for working conditions". However, the latter also require improvement;

- the search and development of new methods for occupational risk assessment that have sufficient simplicity and reliability when used in real production conditions, preventing the occurrence of injuries to workers, and in general, man-made accidents are quite relevant.

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