Integrated Method for Assessing Occupational Risks at Oil and Gas Production Facilities

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Abstract. Today, the problem of ensuring safe working conditions in the workplace is relevant for any employer. At the moment, despite the introduction of advanced technologies and equipment at oil and gas production facilities, personnel are exposed to a set of adverse production factors having an industry-specific nature and features. These features influence the reliability of the results of the occupational risk assessment. The methods existing today do not fully reflect the whole picture of risk in the workplace, but give only their fragmented values. The aim of this work is to develop an integrated methodology for assessing occupational risks for oil and gas production companies. In this work, from the variety of methods, we selected four methods that together take into account a significant number of risk-generating aspects, namely: the method of assessing the individual occupational risk level, the Fine-Kinney method, the method of scoring occupational risks, and the method of sociological survey of workers. The study on the assessment of occupational risks using an integrated method was carried out at the facilities for the development of three fields - the Yarakta, Iktek, and Markovo fields belonging to Irkutsk Oil Company LLC. According to the results of applying the integrated assessment of occupational risks, most positions had a “medium” risk level, but for occupations engaged in manual labor and having a lower degree of automation of labor a “high” risk level was established. For these workplaces, it is necessary first of all to implement measures to improve working conditions.

1. Introduction

Today, the problem of ensuring safe working conditions in the workplace is relevant for any employer, because with the introduction of the “occupational risk” concept in the Labor Code of the Russian Federation in 2011, the scope of employers’ responsibilities has expanded. Occupational risk implies the probability of negative changes in the worker’s state of health during the performance of his duties due to exposure to factors of the production environment [1].

The necessity of occupational risk assessment is established by Art. 209 and 212 of the Labor Code of the Russian Federation. The very procedure for managing occupational risks is spelled out in the Order of the Ministry of Labor and Social Protection of the Russian Federation “On Approval of the Model Regulation on the Occupational Safety and Health Management System” No. 438n of August 19, 2016, including identification of all sources of harmful and hazardous effects, assessment of occupational risks (probability and severity of consequences), and implementation of measures to reduce and control risks [2]. But the current situation in the field of occupational risk assessment is ambiguous. There is still no legislatively approved methodology for assessing risks, but already today inspections
by the State Labor Inspectorate recognize the absence of a risk assessment as a violation of the Labor Code. In 2019, the Federal Service for Labor and Employment created order No. 77 “On Approval of Methodological Recommendations for Verifying the Creation and Maintenance of the Occupational Safety and Health Management System”. According to this document, in the case of inspection of the supervised objects by the labor inspector, special attention is paid precisely to the assessment of occupational risks [3].

Responsible managers are fully aware of the benefits and the main goal of assessing occupational risks, i.e. identifying the highest-risk workplaces with the further development of measures to reduce risks [4]. As known, the result of exposure of personnel to harmful and hazardous production factors is expressed in reduced life expectancy, reduced labor productivity, increased general and occupational morbidity, and the occurrence of accidents. Establishing the level of occupational risk makes it possible to predict the occurrence of occupational disease with the goal of timely implementation of preventive and prophylactic measures [5]. The results of the occupational risk assessment will make it possible to rationally distribute funds for the occupational safety and health at the enterprise, which will reduce overall costs, especially those associated with occupational morbidity and accidents.

This problem is especially relevant for oil and gas production companies. At the moment, despite the introduction of advanced technologies and equipment at oil and gas production facilities, personnel are exposed to a set of adverse production factors having an industry-specific nature and features [6]. These features influence the reliability of the results of the occupational risk assessment. The methods existing today do not fully reflect the whole picture of risk in the workplace, but give only their fragmented values. The aim of this work is to develop an integrated methodology for assessing occupational risks for oil and gas production companies.

2. Study objects and methods
In addition to the existing problem of assessing occupational risks at oil and gas production facilities, the choice of the research object is also associated with the uniqueness of this type of economic activity. This is primarily due to the recoverable minerals themselves - oil and natural gas [7]. These hydrocarbons have a wide application domain and are used in many industries, such as chemical, fuel, and food industries, as well as pharmaceuticals. And it is quite obvious that any country in the world producing these raw materials will have superiority on the geopolitical stage. Significant oil and gas deposits are concentrated on the territory of the Russian Federation, the total reserves of which are: oil - 28.9 billion tons and natural gas - 47.8 trillion m$^3$. The country is the third largest in the world in terms of their production, after the United States and Saudi Arabia.

But, despite its exclusivity and indispensability today, oil and gas production is associated with many negative consequences that affect the environment [8]. Significant negative changes in the natural environment - soil, atmospheric air, surface and underground waters, subsoil - occur on the territory of mining operations, which affects the flora and fauna of the region. But first of all, humans themselves are subject to negative influence.

The oil and natural gas production process consists of several stages - exploration, exploratory drilling, development, exploitation and liquidation. Each stage has its own specific complex of hazardous and harmful production factors [9]. The main occupations involved in the technological process that are exposed to negative impacts include drillers and assistant drillers in exploitation drilling, operators for preparing wells for workover and underground repairs, as well as operators for maintaining reservoir pressure, installers of pipelines, operators of process pumps, gas and oil production units, equipment maintenance drivers, electricians, maintenance fitters, electric welders, drivers of bulldozers, excavators and cars [10, 11].

When performing mining operations, the most significant factors are general and local vibration, chemical pollution of the air in the working environment, exposure to noise, and the intensity of labor [12]. When performing most technological operations, many automation and mechanization tools are used in the form of stationary equipment, for example, pumping units, drilling, diesel and electrical equipment, lifting devices, compressors [13]. In addition to these installations, a significant amount of
mobile equipment is used - construction equipment, hoists and loading vehicles, self-propelled earth-moving machinery, trucks for various purposes, and others [14].

The impact of the entire set of the considered production factors can lead to the manifestation of persistent deviations in the state of health of workers with the subsequent development of occupational diseases, or can cause an accident [15]. The presence of unfavorable production factors, negative dynamics of the indicators of injury and morbidity of workers employed in oil and gas production obliges the management of oil and gas production companies to conduct an occupational risk assessment procedure [16].

At the moment, there are a large number of methods for assessing occupational risks. The methods are diverse, each has its own advantages and disadvantages. But on the whole, each of the methods presents narrowly targeted or insufficiently informative results that are not applicable to some industries and types of work, for example, to the oil production industry [17]. In this case, it is necessary to develop an integrated method that would take into account the multifaceted nature of the factors underlying the definition of occupational risk [18]. In this work, from the variety of methods, we selected four methods that together take into account a significant number of risk-generating aspects, namely: the method of assessing the individual occupational risk level, the Fine-Kinney method, the method of scoring occupational risks, and the method of sociological survey of workers.

The scoring method for assessing occupational risks was developed by the Research Institute of Labor, and is based on the results of the special assessment of working conditions, as a result of which each production factor is assigned a corresponding class of working conditions [19]. Each class of working conditions is assigned a certain score and the risk level is determined depending on the degree of deviation between the total risk and the maximum allowable risk [20].

The method for assessing the level of individual occupational risk was developed by the Klin Institute of Occupational Safety, and involves the assessment of occupational risks based on the results of the assessment of working conditions, as well as the individual characteristics of each of the workers, namely the state of health, professional experience, age and duration of work in adverse conditions [21].

The Fine-Kinney method is based on a set of indicators characterizing an adverse event of labor activity, namely, the probability of the worker’s exposure to a certain impact, the probability of this event and the severity of the consequences [22]. These indicators are determined for each of the labor operations, and are presented in the form of a matrix card with assignment of scores reflecting the severity of an event in the general list [23].

The method of sociological survey of workers was developed by P. Makarov, and is based on a questionnaire survey of workers [24]. Questionnaires given to each worker contain a list of questions that allow assessing the state of working conditions and problem areas in the labor protection system from the position of the worker himself.

Each of the presented methods has its own characteristics, and considers occupational risks from a certain position, but the results of each of them have different quantitative values and indications [25]. To consider the indications in the form of a general complex, the results are summarized as a qualitative assessment result.

This method was used to assess occupational risks at oil and gas production companies in the Irkutsk Region. The main reason for choosing this region is the strategic importance for the country's foreign economic policy in terms of vast reserves of oil (2.03 billion tons) and gas (7.2 trillion m$^3$) and borders with a large importer of raw materials. In particular, the study on the assessment of occupational risks using an integrated method was carried out at the facilities for the development of three fields - the Yarakta, Iktekh, and Markovo fields belonging to Irkutsk Oil Company LLC, one of the largest hydrocarbon mining companies in the Irkutsk Region [26].

3. Results and discussion
Assessment of occupational risks was carried out for the main occupations of each of the facilities, taking into account the procedure of each of the methods. The basis for calculating risks was the results
of the special assessment of working conditions, production control materials, actual measurements of production environment factors, as well as a survey of workers and management.

According to the results of the special assessment of working conditions, it was found that the number of workers with acceptable working conditions at the facilities under study was about 29.1%, the rest were classified as harmful conditions in different subcategories (subclasses 3.1–3.3). These workplaces require a phased normalization of working conditions [27]. But the implementation of widespread transformation and improvement can seriously affect the material well-being of the organization as a whole, therefore, it is necessary to conduct an occupational risk assessment procedure to identify the workers most exposed to negative effects [28].

In relation to our study, for the main workers ensuring the implementation of the technological process, the assessment of risks was performed using the previously discussed methods. The results were compared on the basis of the general risk profile of each of the methods, and are presented in the form of a complex (Fig. 1).

![Figure 1. Summary results of the integrated occupational risk assessment at the facilities of Irkutsk Oil Company LLC.](image)

- Very high level of risk;
- High level of risk;
- Medium level of risk;
- Low level of risk.

According to the results of applying the integrated assessment of occupational risks, most positions had a “medium” risk level, but for occupations engaged in manual labor and having a lower degree of automation of labor a “high” risk level was established. For these workplaces, it is necessary first of all to implement measures to improve working conditions, and also to carefully consider the following aspects:
- modernizing the system of the selection of workers to perform work in hazardous and harmful conditions;
- ensuring the effective functioning of medical services;
- monitoring the state of health of workers with the aim of the most objective assessment of occupational risks, reflecting the impact of working conditions on the health of workers.
The introduction of such an integrated method will allow for more accurate identification of the most high-risk occupations for which the development and implementation of measures to reduce occupational risks are primarily required. Such approach to managing occupational risks will solve the problem of rational use of labor, material and financial resources.

4. Conclusion
The task of managing occupational risks remains significant for oil and gas production companies and its solution is associated with the development of methods for assessing occupational risks. At present, the methodology for assessing occupational risks is being actively improved; new, simpler and more informative methods for risk assessment are being created, which is significant for any employer. The existing methods are aimed at quality risk assessment methods that do not reflect the full picture and do not take into account significant factors, the source of which is man himself.

The introduction of the integrated method allows us to compare the impact of various factors, to establish the integral degree of risk, taking into account the contribution of each individual factor. Using the integrated risk assessment method provides an opportunity to formulate the necessary mechanisms and strategies for achieving acceptable conditions for oil and gas production facilities.

5. References
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