Comparative analysis of fire risks in coal and oil and gas industries

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Abstract. Due to modern conditions and trends in production activities, fire risk assessment at the facilities of the coal and oil and gas industries has become of great importance in determining the conditions for ensuring fire safety. The article describes the specifics of the main causes of emergencies associated with fires in the extraction of fuel and energy resources and the application of risk assessment methods. We identified a number of illogical axioms, as a result of which the calculated fire risk values are determined non-objectively and can lead to low fire protection at the facility and even to human losses. The aim of the article is to improve the fire safety assessment applied to the facilities of the coal and oil and gas industries. In connection with the identified deficiencies in the calculation of fire risk according to regulations, it was proposed to make changes to the “Methods for Determining the Calculated Values of Fire Risk at Production Facilities”, which will make it possible to more accurately determine the value of fire risk and reduce the likelihood of emergencies.

1. Introduction
Accelerated pace and expansion of the industrial activity scale as well as the urbanization in modern conditions are inextricably connected with the use of energy-saturated technologies and hazardous substances. This increases the potential threat to human health and life, the environment, and the material base of production. The number of man-made accidents and disasters is constantly growing, among which fires hold leading positions. By the middle of the 21st century, it may turn out that together they will neutralize efforts to develop the economy. Therefore, today the majority of developed countries, including Russia, are switching to a safety strategy based on the principles of forecasting and preventing man-made accidents. In this connection, a new direction is being formed and rapidly developing - riskology, designed to become the fundamental scientific basis for achieving sustainable development of society. Today in Russia, numerous studies in the field of hazard analysis and risk assessment are being carried out [1-3].

Fire risk assessment studies are currently highly relevant. This is due to the fact that the Russian statistics year on year records the fact that over the past dozen years the number of fires and socio-economic and environmental losses from them has been steadily increasing. Among the 12 territorial entities of the Siberian Federal District, the Irkutsk Region currently has stable and high socio-economic indicators of the fire effects. As part of this work, we carried out a similar procedure for mining enterprises in the Baikal region [4].
2. Materials and methods
Analysis of statistical data for 2008–2018 in terms of the number of fires, their material and social consequences in the Siberian Federal District showed that the Irkutsk Region accounts for 13.5% of the total fires, 17.1% of the material damage from them and 14.8% of people killed in fires. Thus, there are more than 3 thousand fires in the region annually. Objects of value turn into smoke and ash: annual material damage from fires amounts to about 250 million rubles, more than 200 people are killed and about 100 people are injured in fires. Mining sites are not an exception, especially ones with fuel and energy resources, where fires lead not only to material damage, but to irreversible consequences associated with the complete cessation of the process and the destruction of the field [5].

The Irkutsk Region is located in the south of Eastern Siberia in the basins of the upper flow of the Angara, Lena and Lower Tunguska. The area of the territory is 767.9 thnd km² (4.6% of the Russian territory). Administratively, the Irkutsk Region is divided into 33 municipal areas, and 22 cities. 2,412 thousand people live in the region.

The subsoil of the Irkutsk Region holds the richest natural resources. In terms of diversity of mineral reserves and their favorable combination, the region ranks very high in the country. More than 744 deposits of minerals and building materials were discovered and explored on its territory. These are deposits of black and brown coal, oil and gas, peat, iron ore, gold, magnesite, rock salt, mica, gypsum, graphite, lapis lazuli, nephrite, refractory and kaolin clays, talc, glass and molding sand, and cement raw materials.

Fuel and energy resources are represented by black and brown coal, peat, oil and gas. The most significant for the regional economy are hydrocarbon raw materials and coal. As of January 1, 2017, there are 85 oil and gas condensate areas in the allocated subsoil reserve fund. In total, as of January 1, 2018, there are 41 hydrocarbon fields in the Irkutsk Region. All the fields are part of the allocated subsoil reserve fund. The largest are the Verkhnechonsk oil and gas condensate field and the Kovyktka gas and condensate field, in which respectively 42% of oil and 78% of gas from the explored hydrocarbon reserves in the Irkutsk Region are concentrated. Hydrocarbon production in 2017 was carried out at the Verkhnechonsk, Yarakta, Markovo, Danilovskoye, Dulisma, Zapadno-Ayanskoye, Tokminske, Severo-Danilovskoye, Ignyalinskoye oil and gas condensate fields; Sinyavsky and Ichyodinskoie oil fields; Kovyktka, Atovskoye, and Bratsk gas condensate fields.

In total, coal mining in the Irkutsk Region has 36 licenses owned by 17 enterprises. 9 enterprises carried out geological exploration at their own expense under 17 licenses. 5 enterprises carried out coal mining operations at their own expense at 12 facilities. The main scope of work was carried out by the companies Vostsibugol Company LLC, Umix LLC, Promregion LLC, and Glinki LLC. The volume of production at coal mining enterprises in the Irkutsk Region for 2017 amounted to 12,184 thnd tons. From this amount, Vostsibugol Company LLC produced 11,420 thnd tons of coal.

Such a significant geographically concentrated number of enterprises suggests an increase in the risk of emergencies, including fires [6]. Every year, accidents occur at fuel and energy extraction facilities, and the number of fires, explosions and accidents tends to increase. Specifics of the modern economy development, in particular, its dependence on the volumes of production, transportation and processing impose increased requirements to ensuring the safety in the industry. It is essential to remember that mining enterprises are classified as production facilities hazardous to humans and the environment, and in the event of a fire, this hazard increases enormously [7].

According to Rostekhnadzor, over the past 10 years, the main causes of accidents in this area can be classified both as technical and organizational. The former include [8-10]:
- Damage and defects in the construction of buildings, as well as technical problems with the equipment.
- Deviations from design solutions in the process of construction and installation.
- Heavy wear of the equipment.
- Insufficient introduction of new technologies.
- Production poorly equipped with automatic systems, as well as remote control devices.
- Active corrosion processes affecting the quality of technical and technological parts.
Low level (or complete lack) of operational communication and alarm means.

The organizational causes of accidents and technical incidents at coal and oil and gas production facilities include:

- Insufficient level of industrial and technological discipline at hazardous production facilities.
- Low qualification of personnel.
- Underestimating possible risk at a specific workplace.
- Persons without professional training present at critical workplaces.
- Solution of production problems to the detriment of safety.
- Poor organization of production work [11].

It is to prevent a fire from occurring, a fire risk assessment procedure is necessary. The calculation of risks can prevent many disastrous consequences. This procedure helps to identify and eliminate faults in fire safety, which affects people's lives. Legislation establishes that one of the reasons for making fire risk calculations is not full compliance with fire safety requirements established by regulatory documents [12].

In conjunction with modern methods of calculating fire risks in mining enterprises, fire risk management systems, methods for assessing and managing fire risks make it possible to develop a system for protecting enterprises. At the same time, there are a number of problems in the field of risk management in relation to enterprises of the mining and oil and gas industry. The specifics of fire risk management tasks require the creation of methods and fire risk management algorithms that take into account various conditions of uncertainty [13].

There are a large number of methods for assessing risks in enterprises of the coal and oil and gas industry. The analysis shows that various methods are used to thoroughly study the problem of risks at the enterprises of the coal and oil and gas industry [14].

The rules for the calculation of fire risk assessment establish that the calculated values of fire risk are to be determined according to two regulatory documents: Order of the Ministry of Emergency Situations of the Russian Federation of July 10, 2009 No. 404 “On approval of methods for determining the calculated values of fire risk at production facilities”; Order of the Ministry of Emergency Situations of the Russian Federation of June 30, 2009 No. 382 “On approval of methods for determining the calculated values of fire risk in buildings and structures of various classes of functional fire hazard”.

However, it has not been established how many methods should be used to determine the calculated values of fire risk, since any legal or natural person can develop them. An important condition is the need for methods to be approved by the EMERCOM of Russia, but even in the approved methods, many questions arise in determining the calculated values of fire risk.

Let us consider the method for determining the calculated values of fire risk (hereinafter - the method) at production facilities, approved by the Order of the EMERCOM of Russia of July 10, 2009 No. 404.

At the first stage, the potential fire risk is determined at a certain point both in the facility and in the residential area near the facility. The conditional probability of injury to a person is established in order to determine the potential risk. The conditional probability of a damage by a certain hazardous factor is supposed to be found from the values of “probit-functions”. Next, the risk for an employee being within the facility is determined [15].

The advantage of the method is that to obtain probabilistic estimates of the main events, it is proposed to use sufficiently full tabular data available in the supplements to the method, and when determining individual fire risk, the probability of an employee’s presence in the area of impact of the accident under consideration is taken into account. This is especially true at large potentially hazardous facilities (warehouses, tank farms, outdoor installations, etc.) where hazards are often mutually distant from each other so that the areas of impact of one facility do not affect others. Consequently, the personnel of one facility may not be directly affected by the risk of an accident at another, but the potential hazard remains [16].
An attempt to take into account a large number of factors affecting the risk level at the facility being analyzed (at the stage of building an “event tree”), as in other similar methods, leads to an underestimation of the results obtained, and the more factors the developer tries to take into account, the less probable the final result, which is obtained by multiplying the probabilities of intermediate events.

One of the drawbacks of the method is the questionable validity of the results obtained. The use of the specified tabular data on the frequency of depressurization of equipment also leads to an underestimation of the results obtained, since these frequencies are average and do not take into account the real specifics of the facility being analyzed [17].

3. The results of the study and their analysis

Most of the results of an individual risk assessment are in the area of acceptable and negligible risks. The method does not allow to identify controlled and unacceptable levels of individual risk. We also revealed a number of drawbacks in practical use:

- lack of a technique for determining safe distances from a source of solid combustible materials (SCM) fires under the effect of thermal radiation (q);
- lack of a technique for calculating thermal radiation from a SCM fire;
- lack of formulas for the dependence of the effective diameter of the fire load (d), depending on the geometric shape of the fire during the burning of SCM;
- failure to make fire risk calculations for non-production buildings in the production area (warehouse buildings, open warehouses, canteens, coffee shops, polyclinics, plant management buildings, administrative and residential buildings, enterprise guard buildings, kennels, etc.);
- failure to make calculations of social fire risk (death of a group of ten or more people) in the territory of an enterprise, in a recreation area, on roads outside a residential area, during commissions, construction work, changing work shifts, public events;
- need to use the initial data for calculations that are absent in the approved method;
- lack of a technique for determining the exponent that takes into account the change in mass of the burning material over time (n), depending on the nature of the flame propagation;
- lack of recommendations if the calculated fire risk values exceed the allowable values;
- failure to take into account the degree of employees’ preparation for action in case of fire, the distance from the protecting facility to the facility under protection (dislocation of the fire station), fire protection of building structures, the degree of fire resistance of the building;
- complexity of the calculations associated with the need to calculate fire hazardous emergency situations, to analyze fire hazard, to calculate parameters for each process, each location at the facility using special computer programs, often of questionable provenance [18].

The approach to the calculation of fire risk, in which the most probable scenario of fire development is considered (with the highest frequency of occurrence), is more accessible, reduces the amount of calculations and expenses of organizations. It is proposed to VNIIPO EMERCOM of Russia, in order to reduce the “barriers” in the calculation of fire risks and simplify calculations, to consider the possibility of making amendments that take into account the considered drawbacks.

4. Discussion

However, according to Rostekhnadzor, the causes of almost two thirds of all emergencies, accidents and incidents at hazardous industrial facilities in the oil and gas industry are due to technical factors. The rest are organizational in nature. At the same time, industry experts do not deny the role of man in the technical causes of accidents. This means that, in the end, a specific employee in the production and technological chain plays a leading role in the field of industrial safety [19].

Competence and professionalism are the main conditions for the effective and safe management of hazardous production facilities of the mining industry. But there is a serious problem in this matter. The fact is that today there are no specific rules and requirements that determine the professionalism
and competence of both management and specialists in the field of industrial safety. Moreover, experts say that special courses in this area in field-specific higher and specialized educational institutions also did not solve this problem. Currently, there exists training in the field of industrial safety in the framework of pre-certification activities of a specialist. However, the system of advanced training and retraining practically fails to work [20].

5. Conclusion

Today, the mining industry is facing a major problem that needs to be addressed immediately. It consists in a new, more efficient, not formal, but absolutely working approach to the training and retraining of specialists in the field of industrial safety of hazardous production facilities in the oil and gas industry.

It is necessary to correctly understand the question - what is the competence in relation to the safe operation of the production process? This is, above all, the possession of professional knowledge, experience and technical intuition, as well as logic. And the most important thing is the ability to use all these human qualities not only in preventing accidents and emergency situations at hazardous production facilities, but also in preventing their consequences. But this requires constant training with practicing all sorts of technical incidents that may occur in the mining industry.

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