

Role of Safety Justification of Mining Development for the Regulatory Framework Formation and Mineral Resources Management

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Abstract. This article presents the successful results of the working out the safety justifications for the development of mining operations in the basis of the formation and improvement of regulatory framework in mineral resources management. The reasons of justified deviations are given in requirements of industrial safety providing proper risk assessment, in development of the compensatory measures, in some cases establishing a higher level of safety in comparison with development of mining operations according to the current legislation. This is due to the development of technology in the field of subsoil use: the creation and improvement of geotechnologies for the development of subsurface resources, the emergence of more advanced patterns and methods of deposit opening; introduction of new drilling, loading, hauling and ventilation equipment; the application of high-tech materials of a new generation; scientific substantiation of parameters of construction units of development system of mining gives the promising solutions; is taking into account in adapting mining technologies to specific natural and climatic conditions. The article is performed with the support of the Russian Academy of Sciences (project No 0138-2014-0001).

1 Introduction

The development of design methods for the deposit development is based on implementation scientifically sound innovative approaches into the practice of mining enterprises designing. Changing of mineral resource base prospects due to the depletion of rich deposits in all types of minerals, the increase of mining operations in depth, the moving of the mining area towards the overall distribution of permafrost, determines the necessity of effective mechanisms in exploration adapting new scientific knowledge to the engineering, underground and mining excavations, urban development, extraction of minerals and waste disposal [1-3].

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The development of new technologies improving the level of safe mining operations performance and working conditions improvement is often ahead of the legislatively defined safety requirements. They are mandatory for implementation. Subsoil users are facing the problem of implementing statutory instruments not compatible with the level of development of high-tech production all over the world.

2 Methods

In accordance with the requirements of the Federal Law "Industrial Safety of Hazardous Production Facilities", such industrial safety requirements can be established in the justification of the safety of a hazardous production facility [2, art.3, paragraph 4] in case of designing, building, operation, reconstruction, heavy overhaul, suspension or facility abandonment of a hazardous production facility, or such requirements are insufficient. Indeed consideration of all the features of safe operation of all mineral deposits in the Federal norms and rules is not possible to take into consideration due to many factors.

The analysis of the developing experience of more than 150 safety grounds made it possible to identify the main problems subsoil users are faced. In accordance with the analysis procedure methods, standard situations were systematized, and the main reasons for subsoil users to deviate from safety requirements were determined. The risk assessment methods were developed to justify the safety of deviations from industrial safety requirements. The principles for the development of special measures followed the compensating the risks of accidents in the event acceptance of deviations from the requirements of industrial safety. As the result, conclusions were made about as a new for regulatory improving of the mechanism and regulatory framework for subsoil users.

This method can be considered within the framework of the prevention strategy VISION ZERO and the "7 Golden Rules" as agreed tools for achieving zero harm [4].

3 Results

In course of open and underground mining of solid mineral deposits, enterprises face the need of deviations in industrial safety requirements, though in some cases these deviations do not only not increase, but reduce the risk of emergencies. The reasons are:

- the development of physical technical and physical-chemical geotechnologies, including the basis of industrial intellect methods use;
- the creation of new, more progressive schemes and methods of opening deposits;
- the introduction of new drilling, loading and hauling machines and ventilation equipment;
- the scientific of the construction unit parameters of substantiation system of mining with innovative solutions;
- the accounting and adaptation of mining technologies to specific natural and climatic conditions, etc.

With the development of equipment and technology of underground construction change the principles and technologies for equipping the mine workings. They are affecting the requirements for safe and comfortable working conditions ensuring the rapid and high-quality construction of underground facilities for minerals extraction and underground urban construction. Such requirements and technical capabilities are changing every year. The Safety Rules for the Construction of Underground Structures confirmed in 2002 [5] did not take into account and could not take into account the technologies of drifting operation and equipping mine workings with the of unmanned units, automated large sinking platforms. In practice of underground excavations in Moscow, the new, previously widely approved in the world practice shaft designs are implemented in order to provide the comfort and safety for

workers, they are equipped with elevators and stationary staircases for the sake of safety. In recent years, the shafts are equipped with high-performance insulated pocket-lifts (vertical conveyors). In this regard, the safety requirements, aimed at people hoisting in gigs, do not match the modern achievements of underground construction and engineering in mining technologies. In addition to the above mentioned, the FNP requirements for ensuring the industrial safety in underground construction the mandatory equipment is regulated for man shaft or skip winding, as well as headwork and safety slide stairs (fig.1, a-c).

As the requirements of paragraph 106 of the Federal Tax Service, Rostekhnadzor, No. 599 dated by December 3, 2013, are regulated [6] as follows (fig.1, a-b): " In the event of an accident in with a rise when sinking pit and deepening shafts, a suspension ladder with the length providing the placement of all the workers simultaneously with the largest number of crews. Suspension ladder should be attached to the hoisting cable and be located above the hanging stage. The winch must have a combined drive (mechanical and manual), and it must be equipped with brakes. " At the same time, the requirements of paragraph 5.1.8 of PB 03-428-02 "Safety Rules for the Construction of Underground facilities" is stipulated that the place driving of a pit bottom, with more than 20 m length, should begin after the equipping the shaft with a man shaft (skip winding).

Undoubtedly, that in underground mining of mineral deposits, when capital mine shafts are constructed, such arrangement of shaft is necessary to provide long-term operations. They are intended for the long-term lifting of mined rock millions of tons, other cargo, the working shift of miners, and so the construction of head frame, the equipment of dukeys and / or skips for people hoisting significant depth is necessary (in Russia the depth of underground mines exceeds 2500 m, in the world - more than 4000 m). However, when building subway workings, deviation from this requirement is possible, as the shaft is equipped with the safe elevator (fig.1, d-e). Besides, there is no need to hang a ladder of the "safety slide type", because in terms of safety it runs as the second mechanized lifting, and with the primary depth of the shaft of the subway less than 70 m so second mechanized lifting is not obligatory. In the shafts of the subway it there is a convenient stationary staircase with intermediate platforms, providing a safe man hoisting (fig.1, f). The estimated time for people to climb the ladder from the bottom of the shaft with a high safety factor exceeds the operating time of the mine self-rescuer. The main advantages providing the possibility of giving up the head frame are the new technical solutions for lifting the rock and cargo. It is envisaged, to use the combinations of vertical conveyors and a spreader bar moving loads along the guide lines of shafts with the crane help. The decisions to use the underground cranes are widespread in the world practice in underground urban and mine constructions.

The national mining companies focused on the implementation of innovative solutions and are often facing encounter the impossibility of conducting works, due to of the restrictions established by the FNP in the field of construction of mine workings in underground mines [4]. Since recent times, mining techniques are being used in Russia in sinking pits to penetrate depths of more than 2000 m. For this purpose sinking technologies are used with multi-storey hanging stages of 150 m height and more (fig.2). They are characterized by a fundamentally different order of the shaft-sinking and tunneling of cycle processes. Under such circumstances it is rather difficult to meet the requirements of the FNP, for example, item 415 "With a sinking rise, the gap between the middle guide ropes should be at least 0.3 m. When the depth of the trunk is more than 400 m it is necessary to install rubber ropes or other devices preventing the possibility of collision of gigs. These devices are not required if the gaps between the middle guide ropes are $250 + H / 3$, mm, where H is the depth of the shaft.". With the use of these sinking stages rocking of the gigs is excluded and the installation of the rubber ropes is impossible, due to the structural specifications of the hanging stage. Besides, to withstand the estimated gap between the ropes of 930 mm with a depth of shaft of 2 km seems to be impossible.

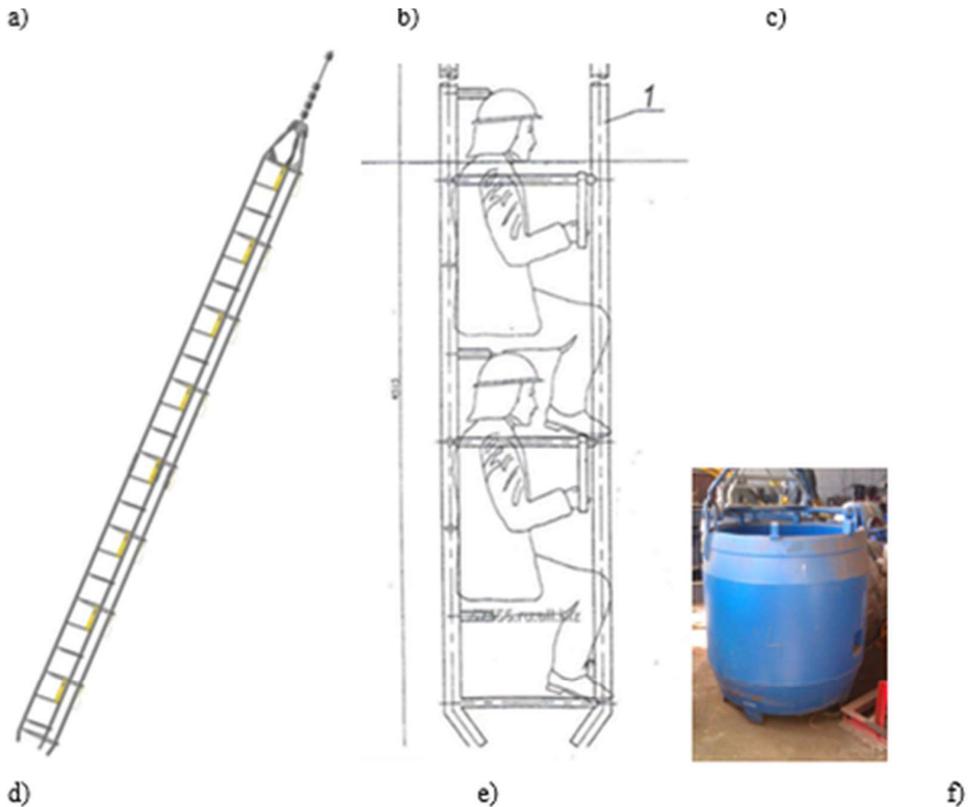


Fig. 1. Federal Tax Service's requirements (a-c) and modern construction conditions (d-f).

In order to develop the measures compensating the deviations of such safety requirements, justification of safety, according to the requirements of the federal law of the Russian Federation No. 116, all possible scenarios for the development of accidents are defined. The comprehensive overall quantitative assessment of the risk is performed concerning accidents involving the crossing of gigs during the simultaneous descent and lifting of the gigs with staff and the rocks.

Scrutiny scenarios for swaying and withdrawal, crash of gigs due to the following events may be considered: the fall of the rocks to the gig, due to the rocks fall; the dropping of the equipment and the rocks to the gig due to violating of work on the shaft collar; failure of the lifting mechanism elements (breakage of the guide ropes, malfunctioning of the guide frames).

There also may be earthquakes shock wave impact from the substance explosion; mountain bumps; violations of the rules guidance manuals of operation in lifting equipment (exceeding the permissible load on the gig, lifting gear and exceeding the licensed speed of men hoisting), power outages, terrorist attacks and others. Risk assessment is multi-levelled. To reduce the risk level to the acceptable value, a great number of compensating measures should be developed and implemented. It is important the safety rationale is developed for the specific application conditions at the given hazardous production facility. In case it is impossible to reduce the level of risk to the acceptable level, the deviations from safety requirements are not allowed.

The other example of the development in safety justification of the deviation from the requirements of industrial safety is the one from p. 499 of the FNP No. 599, regulating that "... the network of fire and irrigation pipeline of the mine must be constantly filled with the water under pressure. ...". The discovering of the conditions and the consequences of such a deviation showed that in the mining of deposits in the cryolitic zone and moreover in undeveloped regions with to substandard infrastructure and in energy supply shortage, for the network of a fire and irrigation pipeline requires the use of a circuit with a constant circulation of heated water in complex design performance. Besides, the compliance of the requirements p.499 complicates the complex geological framework structure of the mineral deposits and low operating temperatures of mine atmosphere. At the enterprises being under construction in undeveloped areas, there are serious limitations associated with the energy supply. At the same time the low temperatures of the medium lead to the water freezeup and the pipeline break, increasing the risks of its operation.

The analysis of the operating conditions of fire and irrigation pipelines in the cryolite zone mines indicates that compliance of the requirements of p.499 entails the emergence of other additional types of hazards. For example, there is a risk of the permafrost thaw in the areas the pipelines are laid with the circulation of warm water and this factor can lead to the violation of the stability of outcrops in mine workings.

To implement the deviations from industrial safety requirements, the compensatory measures should be developed to ensure the fire protection of the underground and surface complexes of the mine to the degree sufficient enough to ensure the industrial safety. In such cases the company employs the fire trucks located in places of rapid arrival to the site of possible hypothetical accident. The mines use modern dry automatic fire extinguishing systems installed at each of the unit of the equipment. The fire patrols equipped with the modern fire-extinguishing materials are operating at all mine workings. To ensure the safe operations the regular inspection of maintenance and fume detectors and alarm systems are provided regularly. It is not allowed to carry out mining operations with faulty fume detectors and warning systems.

The enterprises are also facing the need for deviations from the requirements of safety in the area of ore processing. So when processing minerals, a significant part of the production cost of marketable products is the cost of materials, where in turn the significant part of the hard igniting conveyor belts are used even for transporting crushing and screening products in the cold state. Very often, it is as the result of this process that the processing of such minerals is unprofitable in our country. The use of flame-retardant belts in conveyor galleries is regulated by No. 742 FNP [4] "... Conveyor belts difficult to ignite should be used in conveyor galleries." At the same time this requirement was formulated in the form of a rule in the middle of the 20th century when the conveyor belts were really flammable rubber

products. Today the conveyor belts for general industrial use are comparable in their technical characteristics to flame-resistant, produced in the middle of the last century. Besides, modern dressing mills take all sorts of organizational and technical measures to ensure the safe operation of conveyor transport distributing the materials in cold state.

For example, the newest means of monitoring and protection are provided for the safe operation of conveyors:

- the closed monitoring system with the output to the operator station of the fragmenting site, to the network resource and the recording on electronic media;
- the control of speed of conveyors with the disconnection of the conveyor drive when the speed of the belt decreases (conveyor belt slippage);
- the disconnection of the conveyor drive when the belt is broken as well as during a transverse or longitudinal gust of the conveyor belt;
- the run-off switch with disconnection of the conveyor drive when the belt is removed from the conveyor axis;
- the disconnection of the conveyor drive with increasing of current in the conveyor drive motor;
- the sensors of temperature monitoring and vibration of the bearing part of the drive gearbox, conveyor drive with output of information to the control unit and shutdown when the given parameters of bearing are exceeded by the predetermined temperature;
- the metal detectors are detecting the presence of metal on the conveyor belt;
- the control sensors of the temperature of bearings and windings of the conveyor drive motor with the output of information to the control unit and shutting off when the specified parameters are exceeded by the temperature of the bearings or motor windings.

At hazardous production facilities all the local safety systems of conveyor lines are combined into one common system of software and hardware diagnostic tools using modern microprocessor control and management facilities. The technological parameters of control and instruments, equipment measuring systems, analysis of the work status, malfunctioning and diagnostics are displayed to the operator screen and are available in the direct control mode.

All galleries are equipped with stand pipes to supply water from fire trucks to any point above the conveyor. The galleries are provided with industrial water supply, with the primary fire extinguishing fighting means. The different options for industrial safety are possible.

It is obviously that most of the listed conditions of operation in conveyor galleries at the time of formulation of paragraph 742 did not exist.

4 Discussion

As the result of the analysis of more than 150 safety grounds, the conclusion is made that the mechanism for accepting deviations from security requirements (or formulating new security requirements) with the development of safety justifications is an effective mechanism for improving the regulatory framework in natural resources management. The rationale for safety should be considered as the transitional stage for the approbation and the development of new and improving existing norms and rules in the of industrial safety field. The accepted deviations and compensatory measures are widely approved in specific conditions: in the cryolitic zone or in potash salt deposits in underground leaching, when handling toxic waste and new explosives, can be used for including them into the statutory instruments on permanent basis. This will simplify the methodology for designing ore mining and processing enterprises, will increase the economic efficiency and the industrial and environmental safety of mining operations.

5 Conclusions

Based on the analysis of the positive experience of justifying the safety in mining development, a conclusion was concerning on the formation of the new effective mechanism for creating and improving and the regulatory framework in natural resources management. The real examples of the safety justification proved that with the proper risk assessment the deviations from the industrial safety requirements provide the higher level of safety than the development of mining operations according to current legislation.

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