

SAFETY OF WORK OF MINING WORKERS AND ANTI-SAVING PROTECTION OF MINING ENTERPRISE: PROBLEMS AND SOLUTIONS

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Underground and open-pit mining of minerals remains a source of a significant number of accidents and emergencies, as well as accidents, which lead to significant material losses and injuries, including fatalities to operating personnel.

Keywords: mining enterprises, labor safety, emergency protection, mine rescue service, special equipment, technical progress.

Introduction

The most potentially dangerous production processes during the mining of minerals is the excavation, ore drawing from the refining units, operation of in-mine (electric and self-propelled non-rail), railway and automobile transport, and electrical installations.

The objects and areas requiring increased attention were and remain vertical and inclined shafts, lifting systems, ventilation of extractions, emergency as well as fire protection, protection of mining enterprises.

In the recent years, the enterprises controlled by the Krivoy Rih State Mining and Industrial Supervision Territorial Administration of Ukraine (Derzhgirpromnaglyad) (currently the State Labor Service of Ukraine) have faced with several resonant accidents. So, on mine named after Frunze PJSC "EVRAZ Sucha Balka" as a result of

breakage of counterweight frame cage-lifting to cage winding plant the cage was stopped in an emergency order, in which there were 35 people. Mine-rescuers took almost 10:00 to evacuate the miners from the cage, and 18 days to eliminate the consequences of the accident itself. At the mine named after Ordzhonikidze "TsGZK", JSC due to the dumping curve skip sticking there was a rope overlap on the drum of the skip lifting device, as a result of which the dynamic hitch broke it and, as a result, the skip fell into the sump. A large-scale accident due to the skip fall took place also in the shaft of the Oktyabrskaya mine of Kryvbasszhelezhruddkom, PJSC.

Fires cause major hazards and significant material damage to the enterprises. Thus at the area conveyor ore transportation (TsPT) of one of the open pits of "PIVNGZK" there occurred a fire, which led to the suspension for a long period of the entire production process and economic losses in the amount of several tens of millions of Hryvnias.

As a result of the problems due to the inefficient ventilation of mining workings, several cases of miners' poisoning with harmful explosion products were recorded, two of which were fatal.

Analysis of the reasons of the low state of safety of miners and the emergency protection of mining enterprises

Among the reasons for this state of affairs, first of all, it is necessary to name the insufficient financing of labor protection; operation of machinery, mechanisms and other mining equipment, which has run out its service life; low level of labor mechanization; unsatisfactory functioning of the entire labor protection management system, especially at the enterprise level.

As experience shows, the success of accidents elimination that occur at the mining enterprises largely depends on the technical equipment of the mine rescue brigade. In the recent years, new types of respiratory equipment, communications equipment, fire extinguishing equipment and vehicles have been introduced into service of mine rescue brigade.

But the level of technical equipment of mine rescuers still does not meet the modern requirements of scientific and technical progress, especially due to the constant complication of the mining-geological and mining-technical conditions for the development of mineral deposits.

The lack of many types of special means forces the rescuers to use mining equipment that is not adapted to the specific conditions that are observed during accidents or emergencies. Thus, for example, in the absence of mobile, highly maneuverable vehicles for the delivery of equipment, transportation of victims directly in the mine workings necessitates the use of mining electric locomotive and mine cars. But during the accidents, electricity is basically turned off. On mine retractable lines the traffic block are formed, that considerably complicates, and sometimes completely excludes the possibility of using this technique.

For similar reasons, it is not always possible to use cargo handling machines, scraper-loading hoists and other mining equipment.

Significant problems arise in front of rescuers, when conducting rescue operations in vertical (rising) mining workings.

The existing legal framework allows enterprises owners to violate the requirements of regulatory and legal acts on labor protection and industrial safety almost with impunity. The legal framework itself is very imperfect. More than 75% of the normative acts that have been entered into the state register do not take into account the modern socio-economic relations, changes in the form of ownership, the modern legislative base of Ukraine.

3. Special equipment for improving the labor safety of miners and emergency protection of mining enterprises

Despite the state of science in general in the State, NDIBPG KNU together with co-contractors and production workers managed to solve a number of very important issues necessary for production, to propose new technical solutions in the field of optimization and improvement of safety of production processes, emergency and fire prevention of enterprises.

To prevent injuries from falling pieces of rock mass and collapses, the Institute has developed:

- New patterns of drilling and blasting operations during excavations, the use of which reduces the number of roof flaws by 1.5-1.8 times. These patterns have been tested in the mines of ShU ArcelorMittal Kryvyi Rih, PJSC, Kryvbasszhelezrudkom OJSC, and others;

- New types of roadway supports of sublevel workings with increased rigidity, which ensures their approach to mine face.

To improve the safety of ore production, it has been proposed to blast it in a variety of environments, at which the explosive energy utilization factor is almost doubled, the amount of ore lumps and the number of congestions is reduced. This method of blasting was tested during the development of research blocks in the mines of "Kryvbuszhelezrudkom", PJSC, "TsGOK", PJSC and "ArcelorMittal Kryvyi Rih", PJSC.

A significant amount of works has been carried out by the Institute in the direction of increasing the level of mechanization and miners labor safety during the carrying out of rising mine workings. There were developed the following structures that have passed successful state acceptance tests:

- KP-1 and KP-2 monorail tunneling systems with the specifications of lowering and raising operations from 100 to 160 m, which simultaneously provide 2.5 times increase in labor productivity of the drifters (Fig. 1). Serial production of such systems was mastered by the repair-mechanical plant SE "SkhidGZK" (Zhovti Vody).

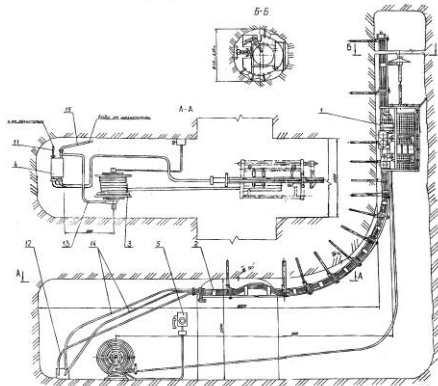


Fig. 1. Schematic diagram of the penetration of drifting of rising mining driftage with the use of monorail tunneling systems "KP-1" and "KP-2"

Fundamentally new complex of equipment for drifting of short (up to 20 m) rising driving of different purpose sinking short films (to a height of up to 20 m) of rising mine workings for various purposes (rock dumping, ventilation, material-travelling) "KOPV-20RVM" (Fig. 2).

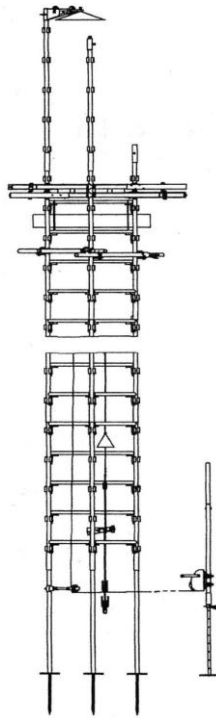


Fig. 2. Complex of equipment for travelling into one section of short-length (to a height of up to 20m) the rising mine workings "KOPV-20RVM"

- Improved version of the device for the remote sampling of air and express analysis of its qualitative composition at the drifter's workplace before starting the works PDKSP-20 / 80RVM (Fig. 3). In the conditions of the existing mines of the Krivoy Rih iron ore basin, the device has undergone extensive industrial testing, including state acceptance testing. The manufacturing company is Tehnotron, LLC (Zhovti Vody).

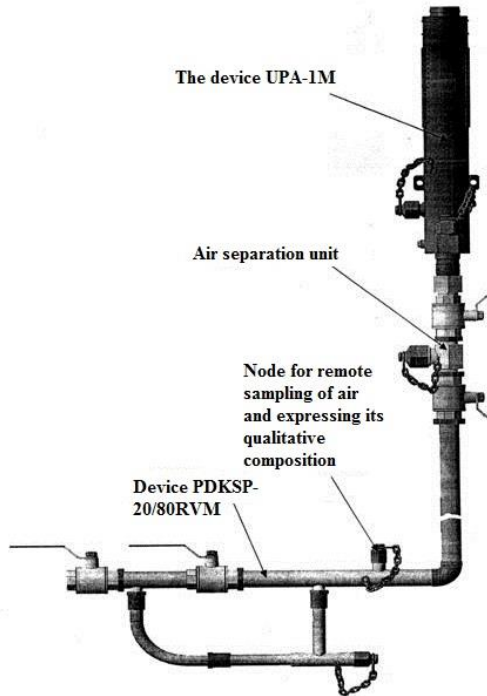


Fig. 3. General view of the device for remote air sampling and express analysis of its qualitative composition PDKSP-20 / 80RVM combined with an apparatus for ventilation and neutralizing of the explosion products UPA-1M

Normalize the sanitary and hygienic working conditions during the drilling and blasting method of mining of various purposes allow the special means for neutralizing dust and harmful gases worked out by the NDIBPG KNU:

- High-pressure ejector foam generator EPG-2PM - for horizontal mine workings;
- Universal device of the ejector type UPA-1M - for rising mine workings.

Derzhgipromnaglyad, after reviewing the test results and petitions of the most mining enterprises, allowed the constant use of specifications and ventilation schemes of mine workings using this equipment.

To protect the miners' respiratory organs from the unsuitable for breathing atmosphere, which may occur during the fires in mine conditions or entry of natural gases to the mine workings of natural origin, the Institute has developed and implemented, in addition to the previously worked out refuge chamber (KAPP) stationary and mobile miners emergency air supply stations PAPP-2 and PAPP-10.

In order to further improve the efficiency and reliability of actions of mine rescue brigade (VGRS), re-equipping them with modern technical means and equipment, NDIBPG KNU, as the main Institute for emergency rescue service together with DVGRZ DSNS (State Militarized Mine-Rescue (Rescue) Squad) of Ukraine and SE "DPI" Kryvbasproekt have worked out the " Plan of the technical progress of the mountain rescue services for the period up to 2020".

The developed Plan consists of three sections, including 15 research and developmental works (R&D).

The First section, "Preparing mines for emergency response and mines fire protection," provides for four R&D activities related to:

- Development and implementation of a modern system of radio notification of miners about the mine accidents (emergencies);
- Development of automatic fire extinguishing systems for the most fire hazardous facilities served by VGRS and other fire extinguishing equipment.

Today we have developed and successfully implemented:

- Mine radio communication and emergency alert complex "Vesna-Sh1" (manufactured by "Interinkom", OJSC, Dnepropetrovsk);
- ASP Automatic powder-gas fire extinguishing system for oil stations, power substations, cable channels;
- MUP-50 modular automatic powder-gas fire extinguishing system for fire protection of drive stations of conveyor paths located at ground surface (galleries and racks of crushing, crushing and processing plants and other facilities). Energiya LLC (c. Liman) is the ASP and MUP-50 manufacturer.
- Universal mobile (rail-mounted) water-foam-powder fire-fighting unit UPP-600/750 (manufactured by Tekhnomash, LLC (Zhovti Vody).

Figure 4 shows a photo illustration of the field tests of the developed fire extinguishing equipments.



Fig. 4. Photo illustration of the field tests of the fire extinguishing equipments

Under the second section, “Mine-rescue equipment”, 11 research and development works are carried out. Today we have successfully worked out:

- Small-sized monorail elevator PGR-350 (Fig. 5), is intended for rescue operations in the rising workings, driven by a mechanical method using complexes of KPP type (manufactured by Tekhnomash, LLC).

- LGRU-100RVM Universal Mine-rescue hoist (Fig. 6) (manufactured by Tekhnomash, LLC).

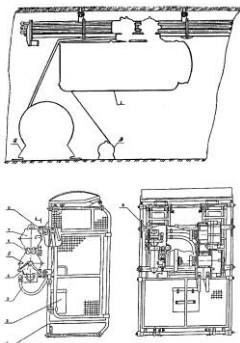


Fig. 5. Structural diagram and design of the PGR-350 small-sized monorail emergency rescue hoist cage

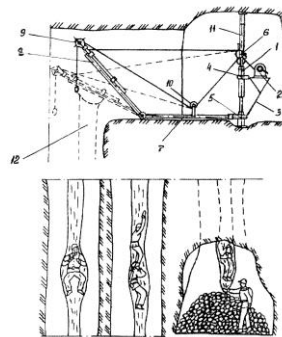


Fig. 6. General view of the LGRU-100RVM Universal Mine-rescue hoist

Demountable metal reinforcement complex for the rapid construction of the travelling channel in vertical workings with a device for miners mass evacuation in emergency situations “Khid-100 RVM” (Fig. 7) (manufactured by Tehnotron, LLC);

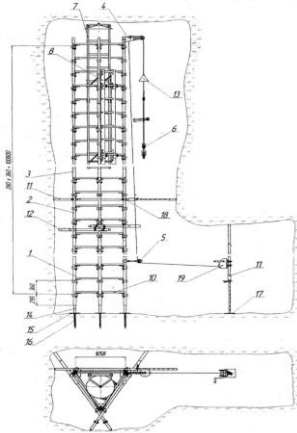


Fig.7 General view of reinforcement complex for construction of the temporary travelling channel in the ascending workings “Khid-100 RVM”

Equipment for non-explosive destruction of oversized rocks, as well as concrete or reinforced concrete building structures (for example, foundations, blocks, etc.).

Currently, NDIBPG KNU, together with DVGRZ DSNS are completing the works related to the development of a universal multi-purpose mountain rescue jumper, as well as a set of means for transporting of equipment (equipment, materials, etc.), as well as evacuating of injured people through the horizontal mine workings (small-sized trucks modular type with a lifting capacity of 50–100 kg, a universal folding cart with a lifting capacity of up to 800 kg, a mountain-rescue trolley with a foot-operated mechanical drive).

Together with the Enterprise-co-contractor “Automation and Mechanical Engineering” (Zhovti Vody) of the National power generating company “Energoatom”, the final works related to the state acceptance tests and the introduction of a MASPO 2.5 / 1500 mobile lifting facility for the accidents elimination and the salvage of people in vertical shafts of mines up to 1,500 m in depth (Fig. 8) and a complex of special equipment for television inspection of mine ventila-

- “Guidelines for the inspection arrangement of the safe state of hoisting plants and equipment for inclined shafts of mines and the TsPT (conveyor ore transportation) of mining and processing plants”;
- "Guidelines for the design of ore mines ventilation";
- "Instructions for safe execution of works when carrying out rising workings using the drifting complexes";
- "Instructions on labor protection for personnel dealing with inspection, maintenance and repair of equipment for mines hoisting equipment";
- “Methodological guidelines for the design of fire protection of mines and underground facilities of the TsPT of mining and processing plants”;
- “Methodological guidelines for the design of fire protection of quarries for the extraction of ore and non-metallic minerals, facilities of the technological cycle and other facilities of mining and processing plants”.

4. Conclusion

The organization of industrial production and the mass introduction of the developed complex of equipment, means of normalizing of working conditions and protection in emergency situations, as well as the full implementation of the VGRS Technical Progress Plan will significantly improve the safety of miners, the efficiency and effectiveness of the mine rescue service, as well as the level of emergency (including fire-extinguishing) protection of mining enterprises.