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- Poland

Title: Hope dies last – the longest rescue operation conducted after a high energetic rock burst in the underground coal mine.

Hope - the feeling that what is wanted can be had or that events will turn out for the best.

Summary:

In the year 2015 in one of the underground coal mine in Poland a high energetic rock burst (with the energy of 4×10^9 J) occurred because of which two workers were trapped in a gallery. In consequence an rescue operation was undertaken. The rescue operation was proceeding in difficult geological and mining conditions, in high temperature (circa 32°C), a large amount of methane desorption and continuous bump shock danger. During the rescue operation a 740 m long rescue gallery was built and a borehole from the surface was drilled in the length at 1050 m. The rescuers after 67 days reached the trapped mine workers. The article presents how the polish mine rescue service works and the way that the rescue operations are conducted.

Key words: rescue action, mining rescue in Poland.

Admission

Conducting mining work in the rock mass always leads to the violation of the natural balance and leads to the appearance of various natural or technical hazards. Depending on the local nature of the rock mass, the way mining (exploitation) works, the type of the extracted mineral, the level of the aforementioned risks may be very diverse. Threats can vary widely. The level of threat is also influenced by, and sometimes above all, the used prevention and the people employed in the given circumstances. The interrelation between these factors is the nature and magnitude of the co-occurrence of threats. Sometimes, when one of these factors crosses the limits of accepted standards, there is a dangerous event that results in people being harmed and a mining plant as well as the public safety is threatened. For rescuing people and mining plants, safety restoring a rescue action is carried out. The rescue operation is always successful when the target is reached - rescued people, mines or when general safety is restored. All people taking part in the action, managing the action, counselors and rescuers performing work in the danger zone always, **hope** that the action will be successful and that their effort, endangerment of health and life will not go to waste, because **the hope dies last**.

Mining rescue in Poland

Miners have always put their health and life at risk, but they always knew that when they needed help, other miners would come to their aid. In this way the rescue was born, which gives every miner a certainty and a guarantee that in a critical moment, regardless of circumstances, they can always count on the help of rescuers. Mining rescue in an organized

form on the present Polish lands was established in 1907. That way the mine rescue station in Bytom come into existence, which continued, after several political and economic changes, as the Central Mine Rescue Station in Bytom - sole-shareholder company of the State Treasury, which are being held by the Treasury - Minister of Energy.

The mining rescue operation in Poland is defined in the Geological and Mining Law (the Act - is the most important act adopted by the Sejm of the Republic of Poland) and in the Ordinance of the Minister of Energy. In Poland entrepreneurs that deal with mining of minerals (e.g. hard coal, copper ore, zinc and lead, salt, gas) are obliged to have their own rescue services or to entrust this task to the mine rescue unit. At present there are three rescue units operating in Poland. One, Central Mine Rescue Station in Bytom functioning outside the structures of entrepreneurs and the other two operating within structure of the entrepreneurs extracting copper and gas ore. The task of mining rescue units is, inter alia:

- providing assistance to mining companies during the rescue operations, participating in preventive works in mining plants;
- maintenance of the professional emergency services (e.g. mine atmosphere inertisation emergency service, measurement emergency service, caving emergency service, mobile rescue hoists emergency service);
- organizing and conducting training courses in the field of mine rescue;
- carrying out exercises in the field of mine rescue;
- organizing medical examinations for miners in a specialized medical examination center;
- testing and reviewing rescue equipment;
- performing specialized chemical analyzes of air samples.

In each mining plant, a mine rescue station and a rescue team are kept. The station is equipped with the necessary equipment to conduct rescue operations - including working devices, measuring instruments, machines and devices for fire, caving operation. Rescue team members are workers in the mine, employed on a daily basis in various worksites, as labourers or supervisors. They must take part at least six exercises and detailed medical examinations at least once a year.

Over the rescue services in mining rescue units and in mining plants supervision is exercised by the mining supervisory authorities - Mining Offices.

For each mining plant a document is prepared - Mine rescue plan, which describes the way of performing the duties in the field of mining rescue by the employees of the mining plant, in particular:

- organization of mine rescue services and necessary equipment,
- the manner of conducting a rescue operation

Principles of carrying out mine rescue operations

A rescue operation is an unusual situation for the entire crew, and especially for the management and supervision of the mining plant. In Poland during a rescue operation, decisions related to conducting it are made solely by the manager of a rescue operation, which is assisted by the staff of mining professionals and research units. Rescue action requires making new atypical decisions at a significantly higher risk. In most cases, the action manager and the person taking part in the action have no experience. Experience is essential, for the proper risk assessment, stress managing and making the right decisions. A quick and unequivocal assessment of risk always determines the correct course of the rescue operation and the final result of its success or failure.

In the event of threat to mining plant employees life and health, the safety of mining plant operation and common safety in connection with the mining plant operation a rescue operation is immediately undertaken and carried out.

After the rescue operation begins, the danger zone is determined and the evacuation of the crew at risk is made. In order to group together the mine rescuers and other persons as well as the material and technical resources necessary for the rescue work, proper use of these resources, as well as to ensure the continuity of the rescue work and their supervision and to provide the greatest possible security for emergency teams performing rescue work a designated location for the rescue party shall be appointed. In the base rescuers performing work in the danger zone and waiting to enter the action quarter. The number of covering patrols depends on the conditions in the zone, the temperature, the humidity, atmosphere composition.

In the underground mining plants, during the rescue operations which are conducted in difficult microclimate conditions and conducted in an atmosphere that is unsuitable for breathing a doctor is always present.

Surveillance of rescue operations is carried out by the competent mining supervisor.

Rescue operation conducted after the rock burst

In April 2015 in a hard coal mine a rock burst took place in a regional character, $E = 4 \times 10^9$ J (about 4 in the Richter scale). The mine operated a coal bed about 3m thick. Depth of about 1050m. Wall length 230m. At the end of the run of the wall remained about 30m. In the exploited part of the bed, the hazards were classified in the highest categories and grades, among other things from the rock mass was released on average over $20\text{m}^3/\text{min}$. methane.

The epicenter of the shock was located 120 m in front of the wall and about 30 m to the south of the south gallery.

The rock burst occurred when two workers were in the area of the long wall. One of them, a dozen seconds before the event, was talking to a dispatcher from a telephone located in the area of a junction long wall - with a coal gate. This was a very important information for the action manager, in setting up an action plan. After the shock has occurred, communication has been interrupted, the electricity shut down and the entire automatic gas meter system has been

damaged. Shock and its effects were recorded by the Geophysical Station equipment (recorded a shock of energy $E = 4 \times 10^9$ J) and automatic gas measuring equipment - exceeded methane concentrations and disturbances in the air flow. There was also a breakdown in telephone communications. After getting the information about the shock and exceeding the permissible concentrations of methane and airway disturbance a rescue operation has begun. According to the procedure, the rescue operation center was set up, a rescue unit was called and the mine rescue services mobilized. Rescue troops were sent to the long wall area (shock). After the penetration, the rescue teams reported the complete destruction (piling) of the central **incline** and **incline** about 600 m from the ventilation gallery (location of the excavation is shown in the diagram).

The action coordinator, in consultation with the staff, recommended manual infiltration in the central gallery and a rescue gallery. After three days of manual dressing infiltration and after the penetration with the videoendoscope the conclusion was made that the filling of the excavation was complete, it was decided to drill a new excavation - a rescue gallery parallel to the central gallery and test **incline** and a rescue bore from the surface for this reason, a few seconds before the shock, one of the missing spoke to the dispatcher (manager of the shift), hoping that the miners they were looking for had access to the fresh water supplying the combine cooling system.

Hole drilling was started on the fifth day of the rescue operation and after 13 days and after drilling through 1054m. The hole hit the exact target, crossing the long wall with the coal gate. The camera and the microphone speaker were lowered into the hole and the attempt to contact the miners was made and signs of their participation weren't established.

The salvage hitch was hollowed by a paverside digger in the traditional way as the corridor excavations. A 140mm bore hole was made every few meters to the central and test inclines, and with the use of the videoendoendoscope, their penetration and gauging instruments were studied for the composition of the atmosphere. The entire length of the central incline and test incline was destroyed, a lack of ability to navigate by mining rescues appeared. Approaching the front of the hollow salvage incline to the 4th, 3rd and 2nd spacing at the depth of 10 m and 4 m, boreholes were made through which the videoendoscope penetrated the spacing and made measurements of the composition of the atmosphere. In order to eliminate the risk of methane outbreaks at the intersection points with the hollowed salvage incline the area was filled with foam to dispel methane. After approaching the front of the hollow salvage incline to the first spacing from a distance of about 12m research holes were drilled. After performing videoendoscope penetration and finding that rescuers were unable to enter the rescuer 1, it was decided to perform the rescue decompression 2. After the execution, the rescue teams made penetration of the incline, the gallery, the long wall, the ventilation gallery and the parallel ventilation pavement. During penetration it was found that the temperature in the excavated regions exceeded 38°C, the support in the long wall was in a right condition and the gallery in generally not damaged, but the corridor excavations have been reduced to about 1.2m. During the penetration, rescue personnel in front of the ventilation door which was built at intersection found two miners, they did not give any sign of life.

On the basis of this information received from the high-penetration, high-temperature, and because of the lack of opportunity to get out the two the head of the company decided to hollow a rescue corridor 2 through which the bodies of two miners were transported and the 67-day rescue operation has ended. It was attended by an average of about 20 rescue teams per day.

During the hollowing of the rescue incline through the holes hollowed from the salvage incline to the test incline, incense-absorbing means were added, which, after being removed to the surfaces, were injected into the scent by the police track dogs. After the scent taken from the area of the commode 3 dogs trained for corpses indicated that in this area may be the corpses of the workers sought.

In the test incline (behind the corridor 3), which was drained air from the area of the wall built-in physicochemical parameters recorder with its own battery and internal memory. After the rescue operation, the recorder's memory was read and on this basis it was found that the air unsuitable for breathing was in this area about 30 hours after the event the missing miners were alive, but by cutting off the escape routes they suffocated from the lack of oxygen in the air.

Summary

- Rescue operation lasted for 67 days, involving an average of 20 rescue teams per day. The work was carried out in extremely difficult and dangerous mining and geological conditions (high temperature constant methane release and risk of re-shock).
- Despite that these facts, reason was saying something else, rescuers were hoping all the time that they will rescue the two miners.
- The question is whether it is worth exposing the rescuers to bear the costs in a very uncertain situation. The answer may be only one, so it was worth it, because it is the emergency services that give all the miners the assurance and guarantee that they can always count on them regardless of the circumstances.
- During the action drilling machines were introduced, which proved their usefulness. They allowed to make a hole more than 1050m in length, accurate to within a few centimeters.
- The excavation was safely cut which were filled with explosive mixtures by filling them with light foam. This method is used every day to eliminate the methane hazard in exploitation works at intersection with walls.