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Case study

Military technology in mine rescue

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ABSTRACT

The sense of security is an individual's one-sided personal expression referring to one's awareness of existing threats and potential possibilities of their prevention. Thus we can observe a permanent development of technologies developed to meet the needs of military operations aimed at neutralizing threats related to explosives of military origin, as well as any improvised explosive devices. Threats are the events that adversely affect life, health, property or the environment, therefore, the mentioned technologies can be used in the civilian market as well. This article presents military systems that have been developed by Alford Technologies Ltd. ('The World's Leading Provider of User-Filled Explosive Chargers and Disruptors'). The systems that have been named ReBar Cutters™ and DIOPLEX™ have been developed to save the lives of soldiers, military equipment and any relevant infrastructure while conducting a wide scope of combat operations throughout the world. The systems can for example be easily used as an alternative support for mining rescue teams during mine rescue operations. The authors intend to present the above-mentioned systems due to their precision, accuracy, and most importantly, because the products are user-filled and therefore can be prepared on site and ready to use very fast. Tests of systems named ReBar Cutters™ and DIOPLEX™ presented in the study were carried out in Zakłady Górnicze Polkowice-Sieroszowice Oddział KGHM Polska Miedź S.A. at a depth of 850 m in order to check their effectiveness in the future environment (pressure, humidity, temperature, dust). The presented shaped charges with cumulative insert were elaborated with explosives used in mining – RIOPRIME 25 (Mini Primer) and ERGODYN 22E – and used for the cut steel structural elements (steel anchor rod), steel leveling cable, sheathed electric mining cable and an element form bucket loader type LKP 903. The tests were not financed, and the obtained results were part of the research in one of the author's PhD dissertation.

KEYWORDS

shaped charges, ReBar Cutter™, DIOPLEX™, explosives

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Introduction

Underground mining in Poland is characterized by difficult geological mining conditions along with a whole spectrum of natural hazards that through their manifestations or occurrences possess catastrophic features.

Operation in underground mines involving mechanical or explosive execution of dog headings or mining excavations affects the natural state of rock mass balance, whereas the high intensity of works generates operational stress additionally to the already existing natural stress. These factors are a frequent cause of accidents during work or rescue operation.

The most common hazards in underground mining include [1; 2]:

– rock burst (crumps),
– rock mass relaxation (fall of roof),
– fires,
– methane,
– squealer and rock outbursts,
– coal dust explosion,
– water.

Quite frequently a coincidence of the above-mentioned threats occurs.

The authors focused primarily on the risks associated with the following:

– rock burst, i.e. dynamic phenomena caused by the rock mass bounce, leading to the excavation or its section to become rapidly destroyed or damaged, which results in total or partial loss of its functionality or the safety of its use,
– rock mass relaxation – a stroke in the excavation is understood as an unintentional, gravitational displacement of rock masses or minerals from the ceiling or wall to the extent that it is impossible to restore the original function of the excavation in less than eight hours,

due to the fact that it is during these disasters when the technical infrastructure of the heading or shaft (broken steel equalization ropes, hanging steel anchors and power cables) and the trapping of the mining machines and their operators occur.

Mines owned by KGHM Polska Miedź S.A. operates at depths from 600 m to 1250 m below surface. During extraction at these depths rock burst phenomena occures. KGHM management considers rock burst to be phenomena of particular importance from the point of view of safety, as their consequence may occasionally lead to fatalities, machine damages, underground equipment/infrastructure and downtime in production.

The historical frequency of significant rock bursts and rock mass relaxations in KGHM's mines is graphically presented in Figures 1 and 2.

The analysis of rock bursts, tremors and seismic data indicates that the frequency of seismic events is not increasing with depth of mining. Factors contributing to the occurrence of a rock burst hazard are the high strength parameters of roof rocks and their natural ability to accumulate elastic energy. The scale of this threat is also determined by the original state of stresses in the rock mass resulting from the depth of mining, the rich tectonics of the deposit and the geometry of the mining fields and the worked-out areas [3].

The principal method of securing mining excavations in active mining areas is to anchor their roofs, usually with the use of 1.6 m long glued anchors, in the 1.5×1.5 m anchoring grid system, as shown in the Figure 3.

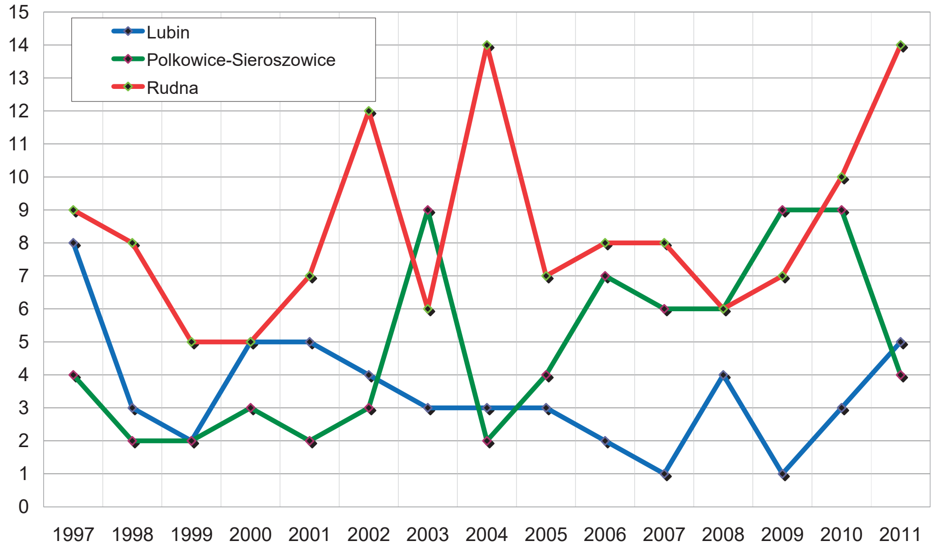
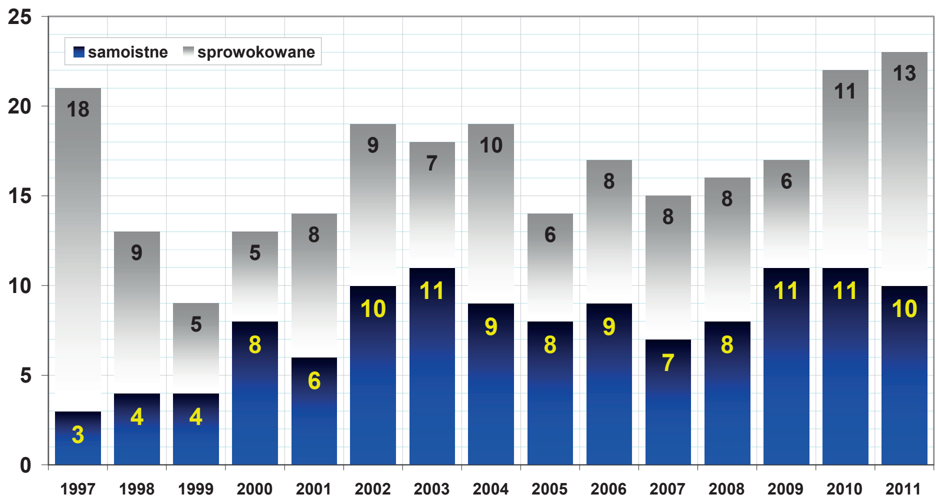


Fig. 1. The number of rock bursts and rock mass relaxation recorded annually by Mine
Source: [3, p. 79].



Grey: bursts and rock mass relaxations induced after blasting.
Blue: spontaneous bursts and rock mass relaxations during operation.

Fig. 2. The number of rock bursts and rock mass relaxation annually (incidents after blasting works prior to re-entry of workers)
Source: [3, p. 80].

It should be noted, however, that although anchoring is an adequate method of securing the roof, it cannot provide a high degree of protection against rock bursts.

In instances in which the roof is likely to deteriorate, and in some primary tunnels or excavated service and auxiliary chambers, supplementary support is installed, using additional rock bolts, shotcrete and/or wire mesh, as shown in the Figure 4.

Fig. 3. Anchor housing
Source: [4].

Fig. 4. Anchor housing reinforced with mesh
Source: [5].

Despite the continuous development of modern technologies to improve and increase workers' safety, the rate of accidents is still high. The following Figures 5 and 6 clearly illustrates that each year, despite the introduction of continuously improved rescue system equipment, procedures and staffs involvement, people still lose their lives.

Newly introduced military technologies and weapons can be successfully used on the civilian market as well. Widely used on the battlefield or on training grounds systems of various types of charges designed to neutralize unexploded ordnance, overcoming or destroying steel elements of structures, armor of vehicles and armament equipment can provide indescribable support for mining rescue when overcoming obstacles in the form of steel elements when it is not possible to use conventional equipment and devices provided by the rescue team. The alternative use of military technologies by teams of mine rescuers during rescue operations,

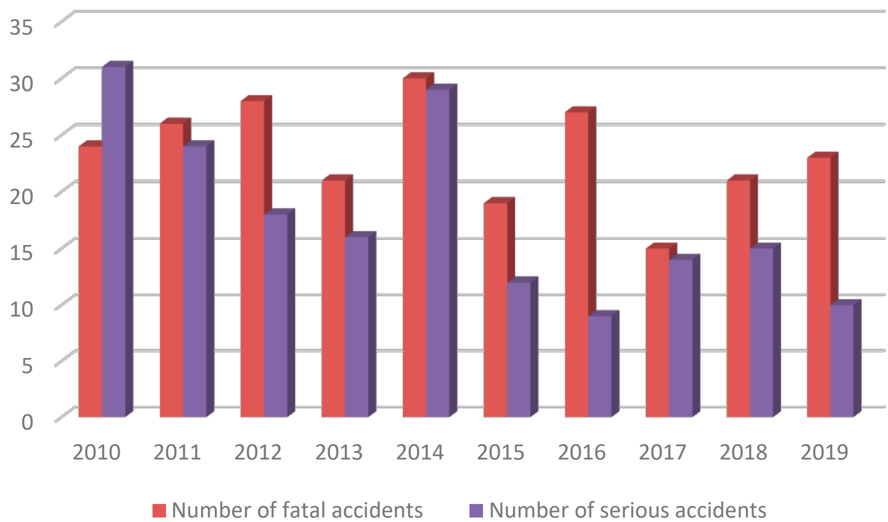


Fig. 5. Number of fatal and serious accidents in Polish mining industry in 2010-2019
Source: Own study based on [6].

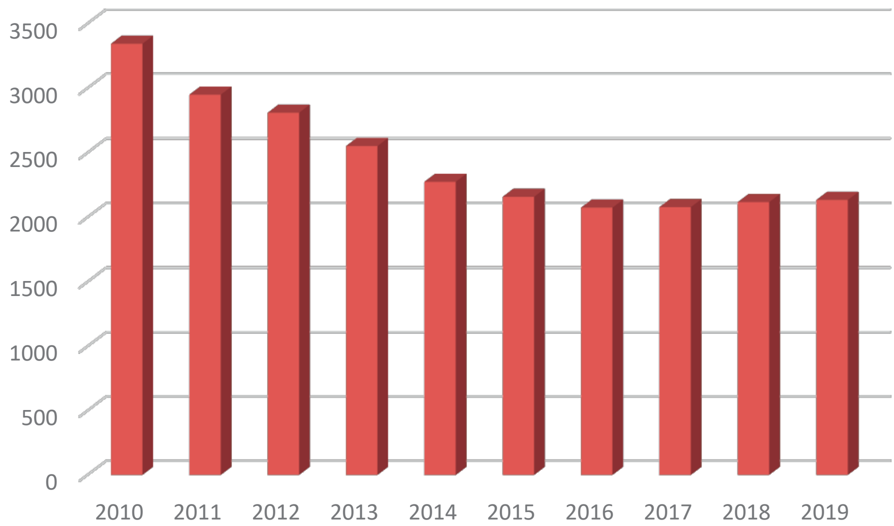


Fig. 6. Total number of accidents in Polish mining industry in 2010-2019
Source: Own study based on [6].

when human life is at risk and time is a key factor, prompted the authors to cooperate with KGHM Polska Miedź S.A. and at O/ZG Polkowice-Sieroszowice conducted a demonstration along with practical tests of the ReBar Cutters™ and DIOPLEX™ systems developed by Alford Technologies Ltd. elaborated with explosives used in mining, i.e. RIOPRIME 25 (Mini Primer) and ERGODYN 22E.

The presented shaped charges with cumulative insert can be successfully used during rescue operations when clearing collapsed headings in order to reach trapped miners, when the break down is made of infrastructure steel elements which are used to protect miners (steel anchors, mesh), providing electricity (sheathed electric mining cable) or an immobilized (buried) mining machine.

1. RIOPRIME 25 (Mini Primer)

RIOPRIME (Fig. 7) is a high energy mini primer designed to produce high velocity of detonation and high detonation pressure, ensuring reliable initiation of bulk and cartridge explosives in underground nonflamable environments.

RIOPRIME has been designed to improve the charging work. The introduction of the detonator in the mini primer, makes charging into the bottom of the hole a more secure, faster and easier process, also ensuring detonation of bulk products.

RIOPRIME has been designed for simple handling. Its oil and water resistance, supplemented by a slow aging curve, gives it characteristics that make it suitable for use in extreme working conditions [7].

Physical form and dimensions:

- material form: plastic material,
- material color: red,
- color of packaging: transparent (plastic),
- form of use in the form of cartridges: plastic packaging (⌀ 15 mm).

Fig. 7. RIOPRIME 25 general view
Source: [7].

Tactical and technical data of RIOPRIME 25 is showed in Table 1.

Table 1. RIOPRIME 25 tactical and technical data

RIOPRIME 25 tactical and technical data	
Density	1,6 g/cm³
Velocity of detonation	≥ 5500 m/s
Sensitivity to impact	≥ 15 J
Sensitivity friction	≥ 216 N

Source: [7].

2. ERGODYN 22E

ERGODYN 22E (Fig. 8) is nitroester rock blasting explosive intended to be used in underground and open pit mines as rock blasting explosives. ERGODYN cannot be used where a coal dust and/or methane explosion hazard exists, can be loaded into dry and wet blasting holes [8].

Physical form and dimensions

– material form: plastic material,
– material color: reddish brown,

Fig. 8. ERGODYN 22E general view
Source: [8].

– casing color: red,

– form of use in the form of cartridges: in paper casings (⌀ 25-38 mm).

Tactical and technical data of ERGODYN 22E is showed in Table 2.

Table 2. ERGODYN 22E tactical and technical data

ERGODYN 22E tactical and technical data	
Density	1,40±14 g/cm^3
Velocity of detonation (paper casing ⌀ 36 mm)	4500 m/s
Velocity of detonation (steel pipe ⌀ 34 mm)	5500 m/s
Velocity of detonation (minimum)	3500 m/s
Sensitivity to impact	≥ 2 J

Source: [8].

3. ReBar Cutters™

One of the systems capable of supporting rescuers during a rescue operation when a bar, steel balance rope or an anchor rod is in the way is the ReBar Cutter™ (Fig. 9, 10 and 11).

The elements of the described system are produced in three sizes corresponding to the diameters of the elements to be destroyed: 5-15 mm, 10-32 mm and 20-50 mm (Table 3). The device is elaborated with a plastic explosive and can be used both in the air and under water (the space between the copper cumulative cone and the damaged element is protected by a waterproof case). The lightweight plastic body design allows one to easily move even more fittings of different sizes.

Fig. 9. Fitting the ReBar Cutter™ (RBC) on a steel bar
Source: [9].

Fig. 10. ReBar Cutter™ fitting on a ⌀ 55mm steel balance line
Source: Private gallery (P. Hałys).

Fig. 11. ReBar Cutter™ fitting on a ⌀ 20 mm steel anchor
Source: Private gallery (P. Hałys).

Table 3. Basic tactical and technical data of ReBar Cutters™

Type of fitting	ReBar Cutter™ 15 mm	ReBar Cutter™ 32 mm	ReBar Cutter™ 50 mm
Weight of hollow fitting	40 g	70 g	180 g
Weight of solid fitting	58 g	140 g	350 g
Dimensions	140×28×28 mm	180×52×46 mm	233×58×64 mm
Amount of plastic explosive (PE)	18 g	70 g	175 g

Source: [10].

A very big advantage of the system is its uncomplicated construction and a simple way of elaborating the fitting with the explosives (Fig. 12), which does not pose any problems for the user even after basic training.

Fig. 12. Construction and method of ReBar Cutters™ elaboration
Source: [9].

The load is made of a plastic casing containing a cumulative insert, which the user has elaborated with an plastic explosive, which is then attached to the steel rods with plastic jaws, anchors or balance ropes in order to cut them.

Each charge has its own integrated channelfor the fuze, so that the charges can be initiated using standard electric initiators, fuze detonators or a non-electric detonation system.

In addition, it should be emphasized that a significant advantage of plastic fittings is the lack of dangerous elements in the form of debris, thanks to which the probability of causing damage to the back and sides of the detonating load has been reduced to almost zero.

4. Test results for ReBar Cutters™ and different explosives

4.1. Test 1

First attempt was made using the following:

- – fitting – RBC with a diameter of 50 mm (Fig. 13),
- – rock blasting explosive – ERGODYN 22E – RBE 180 gr,
- – element to be destroyed – STEEL LEVELING CABLE – ⌀ 55 mm (construction: T6×16 + 12×16 + Ao Z/z N II G 1180).

As a result of the test, a slight deformation (crushing of the cable) was obtained in the steel leveling cable, one of the only 2 mm thick wires forming the braided wire cable of was cut

Fig. 13. 50 mm in diameter RBC charge attached to the still leveling cable ⌀ 55 mm filled rock blasting explosive ERGODYN 22E weighting 180 gr
Source: Private gallery (P. Hałys).

(Fig. 14). The lack of intersection was caused by the insufficient detonation speed of the explosive used (the minimum detonation speed is 3500 m/s), which did not allow the formation of the cumulative stream necessary for correct operation of the set charge.

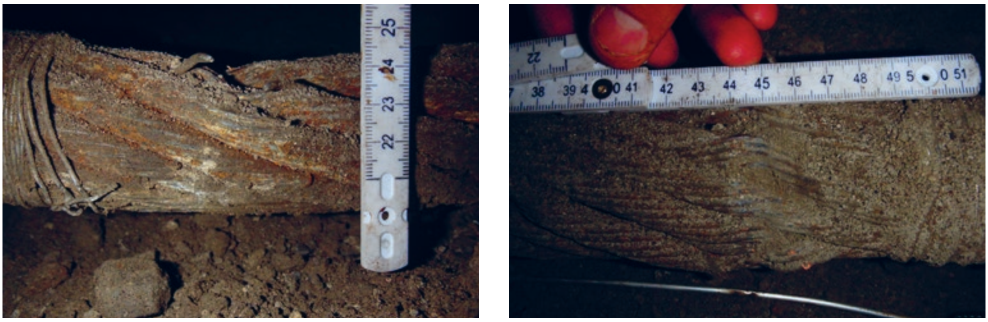


Fig. 14. Test 1 result
Source: Private gallery (P. Hałys).

To sum up:

Rock blasting explosive ERGODYN 22E does not have sufficient detonation speed necessary to generate a cumulative stream, and therefore may not be used for RBC elaboration.

4.2. Test 2

Second attempt was conducted using the following:

- – fitting – RBC with a diameter of 50 mm (Fig. 15),
- – plastic explosive – RIOPRIME 25 – PE 180 gr,
- – element to be destroyed – STEEL LEVELING CABLE – ⌀ 55 mm (construction: T6×16 + 12×16 + Ao Z/z N II G 1180).

As a result of the test, more than 90% cut of a steel leveling cable of the damaged element was obtained (Fig. 16). The obtained result (nearly 100% cutting) was achieved due to the use of a plastic explosive RIOPRIME 25 with a higher detonation velocity (about 5500 m/s) than rock blasting explosive ERGODYN 22E, which was enough to create a cumulative stream necessary for proper operation of the set charge.

To sum up:

PE RIOPRIME 25 has the necessary detonation velocity to create a cumulative stream, and thus can be successfully used for RBC elaboration.

4.3. Test 3

Third attempt was conducted using the following:

- – fitting – RBC with a diameter of 32 mm (Fig. 17),
- – plastic explosive – RIOPRIME 25 – PE 75 gr weight,
- – object to be destroyed – STEEL ANCHOR ROD ⌀ 20 mm.

As a result of the test, a complete clean cut of the steel anchor was obtained (Fig. 18), the expected effect (as in Test No. 2) was achieved by using PE with a detonation velocity of about

Fig. 15. 50 mm in diameter RBC charge attached to the still leveling cable ⌀ 55 mm filled plastic explosive RIOPRIME 25 weighting 180 gr
Source: Private gallery (P. Hałys).

Fig. 16. Test 2 result
Source: Private gallery (P. Hałys).

Fig. 17. 32 mm in diameter RBC charge attached to the still anchor rod ⌀ 20 mm filled plastic explosive RIOPRIME 25 weighting 75 gr
Source: Private gallery (P. Hałys).

Fig. 18. Test 3 result
Source: Private gallery (P. Hałys).

5500 m/s (RIOPRIME 25), which was sufficient to create the necessary cumulative stream for the proper operation of the prepared charge.

Conclusions:

- ReBar Cutter™ should be used when elaborating explosives fittings with a detonation speed above 5500 m/s to obtain the appropriate speed in order to create a cumulative stream during detonation of the charge,
- fittings are produced in standard sizes, easy to fit (they have jaws for attaching them to a damaged elements of the structure), watertight and factory-fitted with a steaming tool for plastic explosives elaboration,
- when the damaged item exceeds the size of the manufactured fitting (the largest jaw size is 50 mm), several are mounted on the perimeter (Fig. 19).

Fig. 19. Fixing RBC fittings on the damaged item of diameter bigger than the largest fitting produced
Source: [10].

5. DIOPLEX™

DIOPLEX™ is yet another system that can be utilized when there is a need to cut steel structure elements (Fig. 20).

DIOPLEX™ is a family of linear cutting charges with aluminum casings. They are supplied in complete standard sets, which the user can self-elaborate with plastic explosives, the same way as in the case of the ReBar Cutters™ system (Fig. 21). The charge casings are made in sizes suitable for specific tasks, e.g. a DIOPLEX™ 400 load cuts a 20 mm thick steel plate.

DIOPLEX™ charges are assembled from pre-prepared aluminum fittings of 1 or 0.5 m lenght. Fittings are manufactured in 6 sizes (Table 4), which have a factory-fitted and sealed copper cumulative cone. The only requirements when preparing a charge are a flat work surface and a hacksaw. The user, if needed, cuts the fitting to the appropriate length, elaborates with his own plastic MW and puts on plastic caps closing each end of the charge.

The basic advantages of the system are its simple construction, ease of explosive elaboration and the possibility of initiating the prepared charge at both or one end using a fuze or

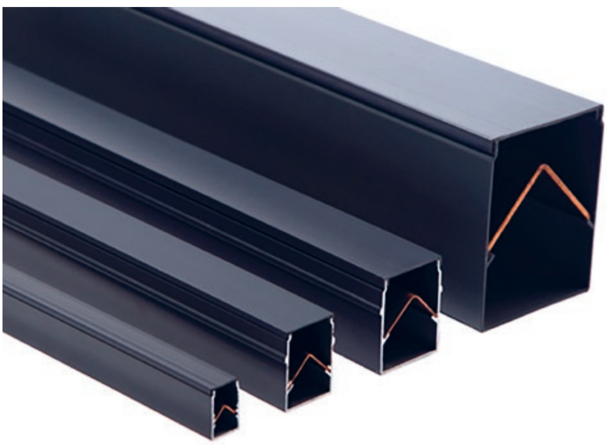


Fig. 20. View of standard produced DIOPLEX™ fittings
Source: [11].

Fig. 21. Elaboration of the fittings of the DIOPLEX™ 400 system with PE RIOPRIME 25
Source: Private gallery (P. Hałys).

Table 4. Basic data of the DIOPLEX™ system

DIOPLEX™	DIOPLEX™ 300	DIOPLEX™ 400	DIOPLEX™ 900	DIOPLEX™ 1200	DIOPLEX™ 3000	DIOPLEX™ 5000
Explosive weight	300 g/m	400 g/m	900 g/m	1200 g/m	3000 g/m	5000 g/m
MAX cut	12 mm	20 mm	30 mm	40 mm	60 mm	80 mm

Source: [12].

a non-electric detonation system. Alternatively or additionally, it is possible to initiate charge anywhere along the centerline of the back of the fitting using the Clip-on Initiator.

The charge can be initiated by a fuze, a detonating cord fuze activator or a detonating cord. The initiator has been designed so that it can be easily fitted even in the absence of visibility.

Other very important advantages of the system are the aluminum body and the lid of the charge, which during detonation are transformed into very small and light debris. Therefore, they are dispersed over a short distance, and thus do not pose a great threat in the area behind the charge and on its sides. In order to attach charges to the item that is to be destroyed, you can use the attached double-sided adhesive tapes. Alternatively, there are attachment loops on the end caps.

Additionally, by using an opposing pair of charges it is possible to cut steel twice as thick. Relative performance significantly reduces the amount of explosive stored, which would otherwise have to be delivered to the job site. When the properties of the target material are not well known, it is advisable to carry out a test before using the cutting charge.

DIOPLEX™ system fittings were used to carry out test 4 and 5.

5.1. Test 4

Fourth attempt was conducted using the following:

- – charge – DIOPLEX™ 400 150 mm long (Fig. 22),
- – plastic explosive – RIOPRIME 25 – PE 60 gr weight,

Fig. 22. 150 mm long DIOPLEX™ 400 charge attached to the sheathed mining cable ⌀ 75 mm filled plastic explosive RIOPRIME 25 weighting 60 gr
Source: Private gallery (P. Hałys).

– object to be destroyed – OnGcekż/w-GW type SHEATHED MINING CABLE of rated voltage value up to 3.6/6 kV ⌀ 75 mm.

As a result of the test, a complete cut was made on the OnGcekż/w-GW type mining cable of 3.6/6 kV ⌀ 75 mm rated voltage, the expected effect (as in Test 2 and 3) was achieved due to the use of a plastic explosives with a detonation velocity of about 5500 m/s (RIOPRIME 25), which was enough to create the cumulative stream necessary for the correct operation of the set charge (Fig. 23).

Fig. 23. Test 4 results
Source: Private gallery (P. Hałys).

5.2. Test 5

Fifth attempt was conducted using the following:

– charge – DIOPLEX™ 400 350 mm long (Fig. 24),

– plastic explosive – RIOPRIME 25 – 140 gr weight,

– object to be destroyed – ELEMENT FROM BUCKET LOADER TYPE LKP 903 40 mm thick made of wear-resistant steel of the Hadrox 500 type.

As a result of the test a partial cut of the element was obtained from a bucket loader type LKP 903 40 mm thick made of wear-resistant steel Hadrox 500 type at 20 mm depth (half

Fig. 24. 350 mm long DIOPLEX™ 400 charge attached to the element from bucket loader type LKP 903 40 mm thick filled plastic explosive RIOPRIME 25 weighting 140 gr
Source: Private gallery (P. Hałys).

the thickness), what considering high quality steel is a satisfactory result (Fig. 25). A full cut would probably be obtained if equal charges were attached from both sides of the item to be destroyed.

Fig. 25. Test 5 results
Source: Private gallery (P. Hałys).

Conclusions:

- – the DIOPLEX™ system should be used when elaborating the fittings plastic explosives with a detonation speed above 5500 m/s to obtain the appropriate speed to generate a cumulative stream during detonation of the charge,
- – fittings are produced in standard sizes, they are easy to cut with an ordinary hacksaw to obtain the required length, watertight, easy to fix to the damaged elements,
- – in order to affix them one can use the attached double-sided adhesive tapes, it is possible to initiate the charge anywhere (not only in the factory-made sockets) along the central line of the rear of the fitting using the Clip-on type initiator and are also factory equipped with a set of tools for plastic explosive elaboration.

Summary

First presentation of the new technologies as well as the practical tests conducted in KGHM Polska Miedź S.A., O/ZG Polkowice-Sieroszowice were well received by the participants.

Conducted research and tests using explosives utilized in mining industry have brought more than satisfactory results which, in turn, means that the assumed direction of the research has been right from the start and therefore encourages more thorough analysis and farther tests of the specialized equipments used to break through steel bars.

The utilized Systems that have been named ReBar Cutter™ and DIOPLEX™ (family of the linear shaped cutting charges for best precision and accuracy) which can be filled by the user with different plastic explosives used in mining has been tested on:

- – steel compensatory line of ⌀ 55 mm,
- – steel anchor rod ⌀ 20 mm,
- – power cable of ⌀ 75 mm,
- – element from bucket loader type LKP 903 40 mm thick made of wear-resistant steel of the Hadrox 500 type.

Advantages of having access to the presented equipment are following:

- – ease of installation on elements being demolished,
- – possibility of use in water environment,
- – possibility of initiating utilizing standard detonators used in mining,
- – very small number of lightweight fragments which do not fly far, so there is a very little danger of fragmentation damage behind and to the sides of the charge,
- – small amount of explosives used,
- – lightweight, plastic construction that allows easy transport and storage for any length of time,
- – an ideal equipment, which will complement rescue systems at times when usage of pneumatic tools is impossible or ineffective,
- – quick and easy way to fill with different explosives by the user.

Positive results of the conducted tests clearly indicate that System which contains linear cutting charges can successfully be used in mine rescue. Such equipment may be used to break through metal obstacles such as: elements of casings, machinery parts, power cables, steel anchors, steel leveling cables etc.

Unfortunately, a few weeks after the tests, a representative of KGHM Polska Miedź S.A. with whom the authors cooperated while conducting the research, died in accident while performing their official duties [13], which made further tests impossible.

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Conflict of interests

All authors declared no conflict of interests.

Author contributions

All authors contributed to the interpretation of results and writing of the paper. All authors read and approved the final manuscript.

Ethical statement

The research complies with all national and international ethical requirements.

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References

1. *Vademecum Ratownika Górniczego*. Lubin: KGHM PM SA O/Jednostka Ratownictwa Górniczo-Hutniczego, 2014.
2. Rozporządzenie Ministra Gospodarki z dnia 12 czerwca 2002 r. w sprawie ratownictwa górniczego (Dz. U. Nr 94, poz. 838, z 2004 r. Nr 102, poz. 1073 oraz z 2007 r. Nr 204, poz. 1476).
3. Bartlet SC, Burgess H, Damjanović B, Gowans RM, Lattanzi CR. *Technical report on the copper-silver production operations of KGHM Polska Miedź S.A. in the Legnica-Głogów copper belt area of southwestern Poland*. Toronto Ontario, Canada: Micon International Limited; 2013.
4. *Obudowa kotwiowa*, [online]. Available at: https://pl.wikipedia.org/wiki/Obudowa_kotwiowa [Accessed: 3 September 2020].
5. *Obudowa wyrobisk górniczych*, [online]. Available at: http://www.czek.eu/strona%20eksploatacji/strona%20zaszyfrowana/07obudowa.html/ [Accessed: 4 September 2020].
6. *Statystyki wypadków*, [online]. Available at: http://www.wug.gov.pl/bhp/statystyki_wypadkow [Accessed: 7 January 2020].
7. *RIOPRIME 25*, [online]. Available at: https://www.maxam.net/mapa_ceprods_descarga.php?idDocumento=10477&idPais=9770 [Accessed: 9 January 2020].
8. *ERGODYN 22E, ERGODYN 31E, ERGODYN 35E*, [online]. Available at: https://nitroerg.pl/produkt/ergodyn-22e-ergodyn-31e-ergodyn-35e/ [Accessed: 9 January 2020].
9. *Rebar Cutter™*, [online]. Available at: https://explosives.net/rebar-cutter/ [Accessed: 12 January 2020].
10. *Rebar Cutters™ Product Datasheet*, [online]. Available at: https://porcupine-potato-6cht.squarespace.com/datasheets [Accessed: 12 January 2020].
11. *Demolition. Dioplex*, [online]. Available at: https://www.explosives.net/demolition [Accessed: 12 January 2020].
12. *Dioplex™ Product Datasheet*, [online]. Available at: https://porcupine-potato-6cht.squarespace.com/datasheets [Accessed: 12 January 2020].

13. *Informacja Nr 4/2017śm./EW o wypadku śmiertelnym, zaistniałym w dniu 29 marca 2017 r. o godzinie 856, w zbiorniku retencyjnym U-12, w KGHM Polska Miedź S.A. O/ZG „Polkowice-Sieroszowice" w Kaźmierzowie*, [online]. Available at: https://wug.intracom.com.pl/bhp/29_03_2017/ [Accessed: 3 September 2020].

Biographical note

Piotr Hałys – Col. MSc. Eng., Chief of the Specialist Training Department at the Command of Territorial Defense Forces. He graduated the General Tadeusz Kościuszko Military Academy of Land Forces, Wroclaw University of Technology, Faculty of Civil Engineering, as well as the Wroclaw University of Economics, Faculty of Management, where he completed post-graduate studies. Currently a PhD student at the Wroclaw University of Science and Technology at the Faculty of Mechanical Engineering. Participant of several military missions in Iraq and Afghanistan, many times decorated with medals for exemplary service in the country and abroad. He is the author of few articles mostly connected with improvised explosives devices and new military technologies which can be also used in civilian environment.

Piotr Kowalczyk – LTC MSc. Eng., Senior specialist in the Military Engineering Branch at the General Bronisław Kwiatkowski Operational Command of the Armed Forces in Warsaw. He is a graduate of the General Tadeusz Kościuszko Military Academy of Land Forces (engineering studies) and Jarosław Dąbrowski Military University of Technology (MSc. Eng.). Additionally he completed postgraduated studies at the Wroclaw University of Science and Technology (Geographic Information Systems – GIS). Participant of several military missions in Iraq and Afghanistan. Currently he has opened doctoral dissertation in the Faculty of Geoengineering, Mining and Geology at the Wroclaw University of Science and Technology connected with safety of critical infrastructure (on an example of KGHM Polska Miedź S.A. object), terrorist attack's and crisis management using GIS. All the above mentioned issues and additionally military engineering, explosives and countering improvised explosives devices remain the areas of his scientific interest. He is the author of few articles mostly connected with improvised explosives devices and new military technologies which can be also used in civilian environment.

Technologia wojskowa w ratownictwie górniczym

STRESZCZENIE Poczucie bezpieczeństwa to wyraz jednostronnego aspektu podmiotu, odnoszący się do świadomości istnienia zagrożeń i wiedzy o możliwościach zapobiegania niebezpieczeństwom. Stąd zauważyć można permanentny rozwój technologii opracowywanych na potrzeby działań wojskowych ukierunkowanych na neutralizację zagrożeń związanych z przedmiotami wybuchowymi pochodzenia wojskowego, jak i improwizowanych urządzeń wybuchowych. Zagrożenia to zdarzenia, które mogą wpływać niekorzystnie na życie, zdrowie, mienie lub środowisko, więc jak praktyka wskazuje, technologie te mogą również być używane na rynku cywilnym. Opisywane w artykule systemy ReBar Cutters™ i DIOPLEX™ opracowane przez firmę Alford Technologies Ltd. mające w praktyce ratować życie żołnierzy, sprzęt i infrastrukturę w rejonach konfliktów zbrojnych mogą stanowić realne, alternatywne wsparcie systemu ratownictwa górniczego. W ramach realizacji zadań związanych z ratowaniem życia ludzkiego może zaistnieć konieczność pokonania przeszkód w postaci stalowych elementów stanowiących infrastrukturę techniczną wyrobiska. W przypadku braku możliwości użycia standardowego sprzętu ratowniczego (np. pneumatycznego) może zaistnieć konieczność użycia systemów wykorzystujących materiały wybuchowe, o których istnieniu, jak i możliwościach warto wiedzieć. Intencją autorów jest zaprezentowanie powyższych systemów używanych w wojsku ze względu na ich precyzję działania oraz łatwość, szybkość i prostotę przygotowania gotowego ładunku w miejscu jego użycia. Przedstawione w opracowaniu testy systemów ReBar Cutters™ i DIOPLEX™ przeprowadzone zostały w Zakładach Górniczych Polkowice-Sieroszowice Oddziale KGHM Polska Miedź S.A. na głębokości 850 m w celu sprawdzenia ich skuteczności działania w przyszłym środowisku (ciśnienie, wilgotność, temperatura, zapylenie). Kształtki obu systemów elaborowane były górniczymi materiałami wybuchowymi RIOPRIME 25 (Mini Primer) oraz ERGODYN 22E i użyte do przecięcia stalowych elementów konstrukcyjnych (kotwy), stalowej liny wyrównawczej, kabla elektroenergetycznego oraz elementu z lemiesza ładowarki łyżkowej typu LKP 903. Testy nie były finansowane, a uzyskane wyniki stanowiły element badań w pracy doktorskiej jednego z autorów.

SŁOWA KLUCZOWE ładunki kumulacyjne, ReBar Cutter™, DIOPLEX™, materiały wybuchowe

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