



# A Proposal of Rock Burst Control Measures at the Coalface No. 1 4064 at the Mining Plant 1, in OKD, A. S. Czech Republic

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## Abstract

*The paper describes a proposal of rock burst control measures for excavation and mining of the area the Coalface No. 1 4064, which is located in the 1st mining block of the Mining Plant 1, locality Karviná. It is an area that has been left in place as a protective area for safety reasons due to the high risk of rock bursts, and it is bordered on both sides by old workings.*

*The aim of the proposal is to extract the retained area by using rock burst control measures to reduce this risk. As a measure, extensive disintegration of the rock massif in the overlying rocks of the seam by blasting works was chosen, both in driving mine workings and in mining of the coalface.*

*The article describes the methods and scope of implementation of active and passive rock burst control measures in standard situations and in the case of detection of an unfavourable stress level.*

**Keywords:** rock burst, active and passive means of rock burst control measures, mine working management technology, edges of non-stopped-out areas

## Introduction

The future of the company OKD a.s. (Ostrava–Karviná Mines) is mainly represented by the coal reserves in its mining space that can be securely extracted through the available means. There are two ways to mine the new resources. The first way is to make the deposits in the mining areas accessible through conventional development work. The second option is to extract the deposits left in the mining area due to technological or safety reasons. In the Mining Plant 1, these are areas with a high concentration of stress and a high risk of rock bursts. In order to protect employees against the possible effects of rock bursts, high demands are placed on rock burst prevention.

For the proposal of rock burst control measures for excavation and mining, the area of the Longwall Face No. 1 4064 was selected, which is located in the 1st mining block of the Mining Plant 1, Karviná locality. [1]

The area of the Longwall Face No. 1 4064 belongs to unexcavated blocks left for safety reasons. This is an area with a high risk of rock bursts. The aim of the proposal for rock burst control measures is the extensive disintegration of the rock massif in the overlying rocks of the seam by blasting work during driving and excavation of the longwall face. [9]

## Geology

The Coal Seam No. 40 is a sub-horizontal deposit with an inclination of 5° to 10° the north or northeast. In the western part of the 1st block and in the eastern part of the 2nd block, this seam is partly eroded to the north-east. The seam thickness ranges from 3.2 to 5.1 m in the area of the Breakthrough No. 4064. In the immediate overlying rocks of the Seam No. 40 there is a local occurrence of the Prokůpek Seam, which

reaches the thickness of up to 1 m and it is located approximately 1.35–1.8 m from the Seam No. 40. [2]

The immediate overlying rocks of the Seam No. 40 consists of a siltstone layer with the thickness of about 1.5–8 m, which extends to the north, and of the layers of various sandstones and conglomerates with an average thickness of about 40 m. The Seam No. 39, which follows, is partially extracted. The northern part the Seam No. 39 is affected by erosion. The position of sandstone with the thickness of about 20 m to 40 m is increasing to the north. This is followed by the extracted Seam No. 37. [2]

The underlying rock of the Seam No. 40 consists of siltstone with a very high proportion of quartz, immediately below the Seam No. 40. Siltstones and arenaceous siltstones continue below. The Seam No. 40 is sometimes penetrated by a band from 0 to 0.6 m thick. [2]

## Geomechanical conditions

The rock massif of the 1st block in the Karviná locality (formerly the Doubrava Plant) is bordered in the north by the Doubrava Fault with an amplitude of about 500 m and with a dip of the fault area of 80° to the north, an eastward depth fault with an amplitude of about 5 meters and a dip of 65° to the east. To the south, the Eleonora Deformation with an amplitude of about 30 m, and a dip of the fault area of 75° to the north. In the west, the border is formed by the protective pillar of the north-south cross-cut of the 10th Level No. 1036. Due to the preparation and mining of the overlying Seams Nos. 34b, 37 and 39, the area of the 1st block was divided, by artificially created boundary from the already destroyed Blind Shaft No. 931 along the Seam Bases No. 1 3730 and 1 3930, driven approximately in the centre of the area, into two

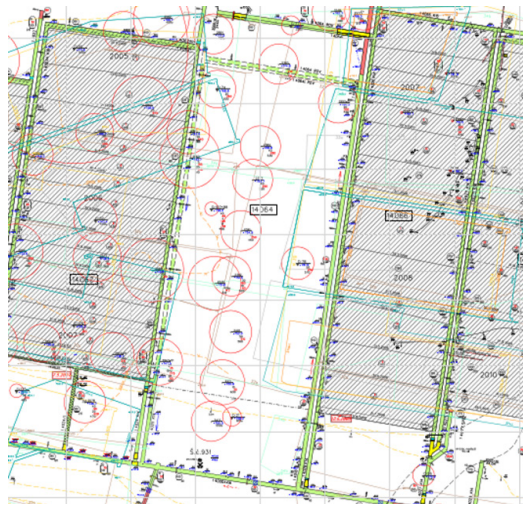


Fig. 1. Map of the Seam No. 40, the 1st block with the proposed Longwall Face No. 4064  
 Rys. 1. Mapa pokładu nr 40, 1. blok z proponowanym wyrobiskiem ścianowym nr 4064

Tab. 1. Determination of the weight of the charge in individual boreholes  
 Tab. 1. Określenie ciężaru ładunku w poszczególnych otworach wiertniczych

Length of bore (m)	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Charge weight (kg)	3	3	4	4	5	6	7	7	8	8	9	9	10	10

separate Blocks 1 and 2. However, the protective pillar near the two bases was not extracted in any of the above-mentioned seams. [3]

The stress level in the remaining pillar in the area of the Longwall Face No. 1 4064 is influenced mainly by the edges of the finished longwall faces (Figure 1) on the southeast and the west side. The Seam No. 34b was finished on the west side with a pillar 50 m to 70 m wide between the former 2nd block and the 1st block; moreover, from a ground plan point of view, the pillar is shifted to the east compared to the other two underlying Seams No. 37 and No. 39. In the remaining two seams, a pillar up to 200 m wide of irregular shape is left. On the west side of the 2nd block, mining was terminated very irregularly. This created a very unstable pillar in which it is very difficult to estimate the magnitude of the stress. This pillar fundamentally affects stress fields not only in their immediate surroundings but throughout the area of the present 1st block. [3] In addition to the above-mentioned fundamental influence on the stress level, local stresses from adjacent old workings of the Longwall Faces No. 1 4062 to the west and No. 1 4066 to the east of the planned Longwall Face Block No. 1 4064. [3] The width of the Longwall Face Block No. 1 4064 reaches 240 m, which exceeds twice the value of “L” (125 m – the impact range of the additional stresses). During preparation and mining, the areas lining the gate roads of the planned longwall face, especially the Gate Road No. 1 4025, must be regarded as critical and the risk of the shock as real. The rock burst control measures will consist mainly in the massive use of the non-productive blasting operation in the overlying rocks of the Coal Seam No. 40 [3] [4] [5] [6].

**A proposal of rock burst control measures for the first driving in standard situations and in the case of the detection of an unfavourable stress level**

**Active means of rock burst control prevention**

*Pressure-relief by blasting (PRB) for driving a gateway and breakthrough in standard situations*

This pressure-relief by blasting (PRB) will be conducted in boreholes test drills (TD), while a continuous section affected by the PRB at the sides of the mine working must at no point move away from the face more than 10 m and the bore spacing at which PRB is conducted must not exceed 5 m. The DBT partial charge in individual boreholes will be determined according to Table 1 below.

When extending the Breakthrough No. 1 4064/1, PRB will be realized with the borehole length of “N + w” (m), where w = width of the extension and with a spacing of 5 m. Minimum advance of PRB before the extension face will be “N + predicted day-to-day expansion face advance” (m). The partial explosive charges in the individual boreholes are determined according to Table 1. Documentation on precaution measures will be kept in the section of drilling until driving the extension of the Breakthrough No. 1 4064 has been completed.

*Measures in the case of unfavourable drill tests*

In all boreholes executed at the face or in the road behind the face, PRB will be carried out in the event of adverse results of the drilling tests. The DBT I partial charges will be determined according to Table 1. In case of unfavourable results of the verification drill tests, further steps will be specified by the geomechanics specialist in cooperation with the professional staff of Green Gas, DPB, a. s. [8] [9] [11].

*Measures for anomalous development of seismological activity (SL)*

In the case of anomalous seismological development, further steps will be specified by a geomechanics special-

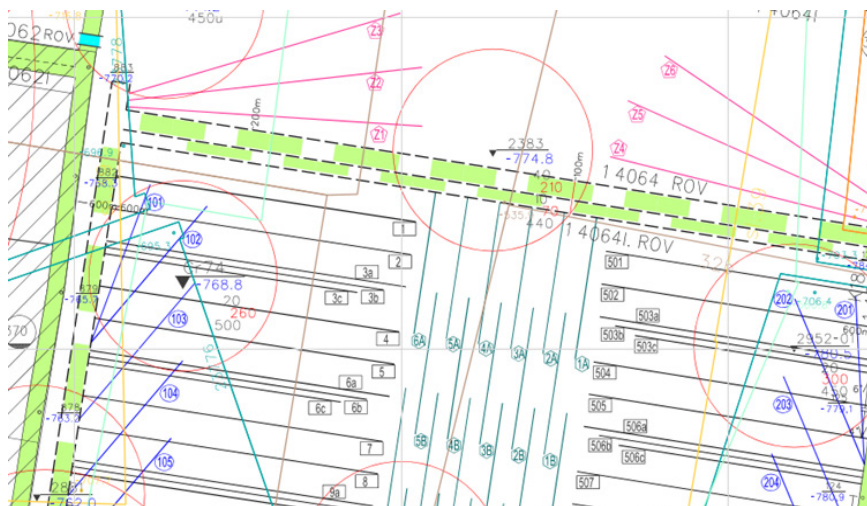


Fig. 2. Drilling diagram of non-productive large-scale blasting operation in the overlying rocks of the Longwall Face No. 4064  
Rys. 2. Schemat wiercenia w wyrobisku ścianowym nr 4064

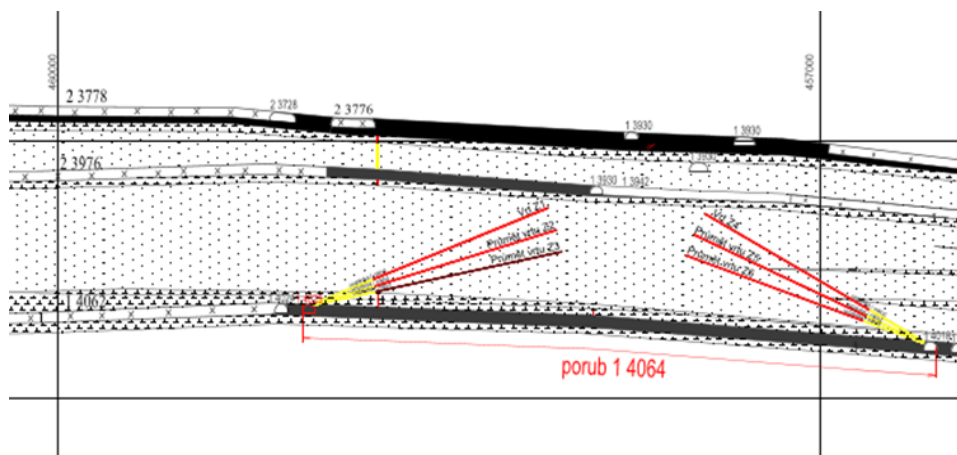


Fig. 3. Drilling diagram of the caving boreholes of the Longwall face No. 4064. Legend: vrt – borehole, průměr vrtu – borehole diagram, porub – longwall face  
Rys. 3. Schemat wierceń w wyrobisku ścianowym ścianowej nr 4064. Legenda: vrt – otwór wiertniczy, průměr vrtu – schemat otworu wiertniczego, porub – ściana czołowa

ist in cooperation with professional staff of Green Gas, DPB, a. s.

### Methods and scope of passive means of rock burst control *Determination of a vulnerable area*

A driven road or a breakthrough, or adjacent mine workings within 50 m of the face, or 50 m on both sides from the point of unfavourable individual observation is considered to be a vulnerable area. The area under threat must be marked with a “Vulnerable area” board.

### *Maximum permissible number of employees*

The maximum permissible number of employees throughout the shift in the vulnerable area is determined as follows:

- at the time when the work with the intervention into the massive is carried out up to 6 employees
- at the time when there is no intervention into the massif and if forecasting and prevention is realized in standard situations – up to 17 employees

- at the time when an unfavourable stress level is defined (verified) – up to 4 employees
- at the time when an unfavourable stress level is eliminated by active means of rock burst control prevention – up to 3 employees

The highest permissible number of employees does not include the supervising staff or higher supervision authorities (State Mining Administrations, Green Gas DPB a.s., OKD Administration, trade unions, Expert and Scientific Organizations, etc.).

Only the necessary number of employees (foreman, miner, machine operator, etc.) will be involved in handover work at the face, but the maximum permissible number of employees in the vulnerable area must not be exceeded.

### *Impermissible coincidence of activities*

When working with a rock mass (coal extraction at the face or robbing TH-support), it is not possible to carry out work in the area at risk, except for the necessary work to ensure safety. [6]

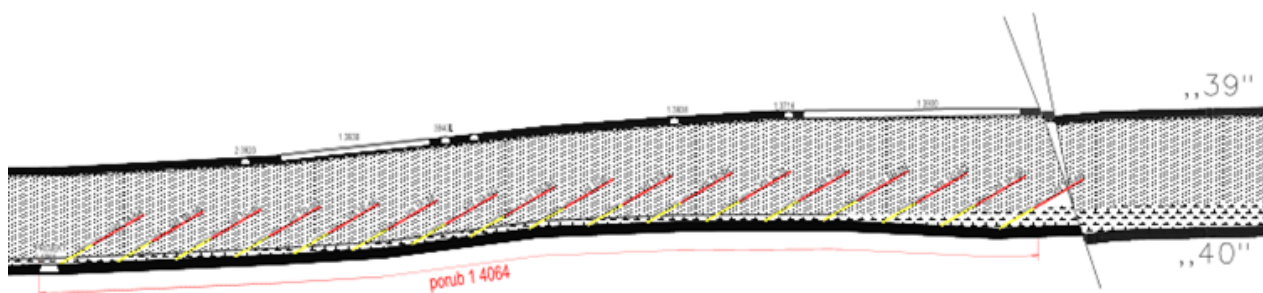


Fig. 4. N-S section of the boreholes for NPLSB in the Longwall Face No. 4064. Legend: vrt – borehole  
Rys. 4. Przekrój N-S otworów dla NPLSB w ścianie nr 4064. Legenda: vrt - otwór wiertniczy

In the case of unfavourable results of a continuous forecast of rock bursts, no work other than the work associated with the removal of this condition can be done.

#### **Ensuring the resistance of the support**

The side arcs of the TH-support in coal, or possibly in loose band will be built on steel prop bases and the support will be stabilized by at least five steel bracings.

In places of increased pressures, the load-bearing capacity of the support will be increased by the longitudinal timbers supported by pit props placed on wooden sole pieces, or the mutual spacing of TH-support arcs will be reduced.

#### **Ensuring the passability of escape routes**

Necessary material in the vulnerable area must be placed in such a way that safe passage is preserved, and it must be secured against movement.

#### **Continuous forecast for long mine workings in the post-driving period**

After driving the Roads Nos. 1 4018 and 1 4025 and the Breakthrough No. 1 4064, or its Extension No. 1 4064 I, continuous seismological monitoring of this area will continue. The evaluation of the data obtained will be carried out in accordance with the valid methodological procedure GF/05/PIS.

#### **Other measures**

- The drill test results must be reported to the seismic (geophysical) central in the same shift in which the tests were carried out at the latest.
- The results of the drill tests, pressure-relief by blasting and any other rock burst control measures must be clearly documented. The results of individual observations must be recorded in the shift books of the shift technicians. [7]
- After the drill tests have been carried out at the face, the face stationing must be marked on the face board, after which the creation of the protection zone has been verified.

The pit crew, technical supervision and other staff in the vulnerable area, to the extent relevant to them, must be demonstrably familiarized with the Appendix to the Technological Process - Special Rock Burst Control Measures – based on the project rock burst control. [12].

#### **Proposal of rock burst control measures during longwall face mining**

##### **Method and technology of mine working conduct**

The Longwall Face No. 1 4064 will be mined using a method of longwall working along the strike from the mining field to controlled caving. It will be equipped with a mechanized support, a power loader and a conveyor. The width of the longwall face will be 240 m and its length will be 497 m. Termination of the longwall face is expected in the Road No. 1 4025 and in the Road No. 1 4018 at the stationing of 120 m. The average extracted thickness of the Longwall Face No. 1 4064 is 3.8 m. In the Road No. 1 4018, conveyor extraction will be installed, and the exhaust air will be led through the Road No. 1 4025.

##### **Methods and scope of implementation of active rock burst control measures in standard situations**

##### **Non-productive large-scale blasting operations (NPLSB) in overlying rocks**

The NPLSB will be executed in the overlying rocks according to the drilling diagram (Figure 2). The aim of this NPLSB is the extensive degradation of the rock massif in the overlying rocks of the Seam No. 40.

Set goals:

- Influence on the physical and mechanical properties of the overlying rocks in the front zone of the longwall face and the creation of failure zones in the area of the initial Breakthrough No. 1 4064 to the height of the effective overlay, thus helping to create the first caving after the start of the longwall face from the initial breakthrough and initiating the process of regular cutting of the overlying rocks in the further longwall face mining process.
- Influence on the physical and mechanical properties of the overlying rocks and the disruption of the solid layers in the overlying rocks of the Seam No. 40 in order to partially eliminate the influence of edges and non-stopped-out areas in the Seams Nos. 39 and 37.
- Release of flexible potential energy, possibly accumulated in the massif, at the time when there are no employees in the area.

Prior to commencement of mining the Longwall Face No. 1 4064, the NPLSB will be executed within the maximum distance of 70 m from the initial Breakthrough No. 4064. The

individual stages of the NPLSB will be carried out in such a way that the Vertical Boreholes are blasted at a maximum distance of  $L_0 = 38$  m to  $L = 100$  m in front of the advancing coal head of the Longwall Face No. 1 4064.

Prior to the commencement of mining, the Caving Boreholes Nos. Z 1 – Z 6, see Fig. 3, and the Vertical Boreholes Nos. 1A – 6A from the Breakthrough to the front zone of the longwall face will be blasted. From the Road No. 1 4018, the Vertical Boreholes Nos. 501, 502, 503a, 503b, 503c, 504, 505, 506a, 506b, and 506c, see Fig. 4, and Mop Boreholes Nos. 201 and 202 will be blasted. From the Road No. 1 4025, Boreholes Nos. 1, 2, 3a, 3b, 3c, 4, 5, 6a, 6b, and 6c, and Mop Boreholes Nos. 101 and 102 will be blasted.

Other vertical boreholes that will be drilled and blasted from the Longwall Face No. 4064 will always be drilled after 30 m of the longwall face advance.

The Vertical Boreholes Nos. 503a, 503b, 503c and 3a, 3b, 3c have the “cut-off” character and they will be repeated in regular cycles. The regular development of the caving in the whole area of the Longwall Face No. 1 4064 is facilitated by the continuous disruption of the overlying rock layers of the Seam No. 40.

If drilling boreholes for NPLSB leads to verification of the presence of tectonic faults, which manifest themselves, e.g. by repeated caving of the borehole, loss of flush water, or increased water inlet, the boreholes will not be blasted, or the planned charge will be proportionally reduced for these boreholes.

Another method of blasting may be specified by a geomechanics specialist depending on the development of the seismological activity after consultation with Green Gas DPB, a.s. professional workers.

#### ***Irrigation of the coal seam***

Before the commencement of mining, the coal head must be irrigated with pressure water in advance within the distance of “L” (m), and within the distance of “L<sub>0</sub>” (m) in the front zone of the coal head, it must not be older than 3 months, otherwise additional irrigation must be done. Irrigation will be carried out by the long borehole method from the opening drift and air gate with a spacing of 10 m. In cases where the whole coal head length cannot be covered by long boreholes, or for other operational reasons, it is necessary to carry out irrigation using medium-sized boreholes from the longwall face with a spacing of 5 m and a length of daily advance +0.5 m.

During irrigation, the amount of water injected into the borehole will be measured by the flowmeter and documented. Each irrigated long borehole must be closed, for example with a wooden plug. Individual boreholes must be marked with boards indicating the number, length, water quantity, and irrigation date.

The required amount of water to irrigate each borehole (Q) was determined according to [10]:

$$Q = 2 \cdot M \cdot B \cdot V \cdot (D + B) \text{ (litres)} = 2 \cdot 3.8 \cdot 5 \cdot 10 \cdot (120 + 5) = 47\,500 \text{ (litres)}$$

where

M – average thickness of the seam in the irrigated block (m),

D – length of the irrigation borehole (m),

B – irrigation range (5 m),

V – specific quantity of pressure water (10 l/1 m<sup>3</sup> of coal),

The amount of injecting water to be pumped is set at 75% of the original calculated value, that is 35 625 (litres).

#### ***Active rock burst control measures in the seam in longwall gate roads***

Active rock burst control measures performed during the excavation of longwall gate roads by the PRB, which will no longer be carried out.

#### **Methods and extent of implementation of active rock burst control measures in the case of the detection of an unfavourable stress level**

##### ***Active rock burst control measures in the event of unfavourable drill test results***

In the event of unfavourable drill test results, the PRB will be executed in all boreholes. The partial charge in the individual boreholes will be determined according to Table 1.

##### ***Active rock burst control measures in the event of detecting anomalous development of a seismo-active or seismological activity***

In the case of anomalous development of a seismo-active activity, the PRB will be performed, the specific parameters of which will be determined by a geomechanics specialist. Check drill tests after the performed PRB will no longer be carried out. In the case of anomalous development of a seismological activity, further steps will be specified by the geomechanics specialist in cooperation with the professional staff of Green Gas, DPB, a. s.

#### **Method and extent of passive rock burst control measures**

##### ***Determination of a vulnerable area***

The Longwall Face No. 1 4064, Gate Roads Nos. 1 4018 and 1 4025, and other roads up to a minimum distance of “L” (m) before the coal head are considered vulnerable areas.

##### **Determination of impermissible overlapping of activities and restrictions on the movement of employees**

###### ***Impermissible concurrent activities in the vulnerable area***

At the time of execution of the work with intervention in the rock massif in the longwall face, all works in the gate roads are prohibited, except for the works absolutely necessary for ensuring safety. Intervention in the rock massif means:

- Coal extraction and loading of a power loader
- Transferring longwall support

In the case of unfavourable results of a continuous rock burst forecast, it is forbidden to carry out activities that are not related to works intended to eliminate this condition.

###### ***Restrictions on the movement of employees***

- At least at the distance of “L” (m) from the longwall face, an openable gate must be placed in the coal heads with the warning board with the notice “Entry Prohibited – Endangered Area”. A red light signal must be set up there to

indicate the time of the intervention into the rock massif. The openable gate will be equipped with alert signalling its opening and closing at the inspection service site. Entering the area behind this gate towards the vulnerable area is possible only with the permission of the inspection service. Consent is issued verbally based on the development of seismic activity in the vulnerable area.

- Entering the section of roads in the vulnerable area at the time of intervention into the rock massif and staying there is possible only if it is absolutely necessary to ensure occupational and operational safety.

- Tracking the movement of persons in the roads of the vulnerable area and persons entering the affected area, i.e. the sections of the gate roads and roads in the front zone of the longwall face in the same seam within a minimum distance of "2 L" (m) from the coal head has to be provided by electronic sensors with the data output at the inspection service site. The sensors must provide a continuous overview of the movement of persons in the vulnerable area and must permanently record the entry time, identification of the persons entering and the time of leaving the vulnerable and affected areas.

- Drilling work in the seam and in the accompanying rocks in the roads within the same seam up to the distance of "1.5 L" (m) from the coal head is not allowed at the time of the intervention into the rock massif.

- An acoustic warning will be installed in the longwall face area and in the gate roads within the distance of L" (m) from the longwall face.

#### **Maximum permissible number of employees**

The maximum permissible number of employees in the vulnerable area is 22 in the mining shift and 45 in the preparatory shift. When verifying the increased stress zone by additional drill tests, it is up to 6 employees. In the implementation of active rock burst control measures in order to eliminate dangerous situations, the maximum number of employees in the vulnerable area will be reduced to 4 and no other operations can be carried out.

The highest permissible number of employees does not include the supervising staff or higher supervision authorities (State Mining Administrations, Green Gas DPB a.s., OKD Administration, trade unions, Expert and Scientific Organizations, etc.).

Changing shifts will take place outside the vulnerable area. Only the necessary number of employees in the main professions will be present during handover of work in the workplace and their number must not exceed the maximum permissible number of employees.

#### **Securing the coal pillar in the longwall face**

The coal pillar in the longwall face must be permanently secured against slipping out by means of pillar plates of the longwall support sections, with the exception of the area in which coal extraction has just been carried out (about 20 m in the vicinity of the power loader). Employee move-

ment across the longwall conveyor will be limited to technologically necessary operations such as securing the roof, repairing the longwall conveyor belt or support plates, and test drills. Employees performing test drills in the longwall face are obliged to secure the coal pillar at the site of the test drill with support plates, or possibly with wooden shredding.

#### **Strengthening the bearing capacity of gate roads**

Strengthening the support of the Gate Road No. 1 4025 will be made by means of strand anchors according to the high anchor project. The Road No. 1 4018 was already supported with strand anchors during driving.

#### **Ensuring escape routes**

In the gate roads in the vulnerable area "L" (m) in front of the longwall face, no material may be stored on the seam floor except the materials necessary to ensure the daily operation of the longwall face. This material must be stored and fixed to TH-support so that safe passage is maintained. The material must not be kept on the suspension groove in the vulnerable area, either.

#### **Signalling of unfavourable stress levels**

In the event of a hazardous situation signalled by the intermittent acoustic signal, it is the duty of all employees in the vulnerable area to hide immediately in the sections of the longwall support, and the other staff in the adjacent gate roads will leave the designated vulnerable area. Pursuant to Section 15, Subsection 3 of the State Mining Administration Decree No. 659/2004 Coll., as amended, the State Mining Administration Decree No. 282/2007 Coll., the State Mining Administration Decree No. 35/2010 Coll., switching off of electricity with cable distributions above 1 kV in mines classified in the 2nd or 3rd degree of rock burst hazard must be equipped with a device for automatic shutdown in the case of

- rock burst, or
- exceeding the permitted methane concentration in the mine air. The shutdown must occur within 2 seconds of exceeding the set limit of any sensor located in the specified mine workings.

Location of sensors and areas of automatics shutdown will be specified by the mine manager. The organization will mark them in the emergency plan.

#### **Conclusions**

The area of the concerned Longwall Face No. 1 4064 is situated in the last layer of saddle layers of the Karviná formation, characterized by solid compact rocks and very thick deposits located at a depth of about 1000 m below the earth's surface. The Longwall Face No. 1 4064 will be the last extracted block in the Seam No. 40 in the 1st mining block at the Mining Plant 1, Karviná locality, and it will be situated between the old workings of the Longwall Face No. 1 4062 from the west and the old working of the Longwall Face No. 1 4066 from the east.

Since the concerned longwall face is bordered on both sides by the old workings of the already extracted longwall

faces, increased stresses can be expected to occur in the concerned area. Without the use of active and passive rock burst control measures, rock bursts could occur in the concerned area. For this reason, it is essential to comply with the principles of rock burst control and to apply all available steps with regard to the implementation of active rock burst control measures and all available steps in terms of passive rock

burst control measures. The primary active rock burst control measures, which should be used when mining the Longwall Face No. 1 4064, is the non-productive blasting operation in the overlying rocks.

The main aim of the article is to familiarize the readers with the proposal of rock burst control measures for safe extraction of the above-mentioned longwall face.

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### *Propozycja sposobu pomiaru ruchów górotworu w ścianie węglowej nr 1 4064 w kopalni nr 1 w OKD, Czechy*

*W pracy opisano propozycję sposobu kontroli tępań skał w obszarze górniczym wydobycia w ścianie nr 1 4064, która znajduje się w 1. bloku wydobywczym Zakładu Górniczego nr 1, miejscowość Karwina. Jest to obszar, który pozostawiono jako filar ochronny ze względów bezpieczeństwa z uwagi na na wysokie ryzyko przemieszczania się skał, po obu stronach graniczących ze starymi wyrobiskami. Celem opracowania jest zbadanie obszaru filara za pomocą środków do kontroli tężenia. W artykule opisano metody i zakres wdrażania aktywnych i pasywnych środków kontroli tężenia w skałach w standardowych sytuacjach oraz w przypadku wykrycia niekorzystnego poziomu stresu. Jako sposób wybrano rozległy obszar masywu skalnego gdzie obserwuje się ruchy górotworu wywołane przez roboty strzałowe. W artykule opisano metody i zakres realizacji aktywnych i pasywnych środków kontroli tężenia w warunkach standardowych oraz w przypadku wykrycia niekorzystnego poziomu naprężeń.*

**Słowa kluczowe:** tężenie, aktywne i pasywne środki kontroli tężenia, technologia zarządzania pracą w kopalni, krawędzie obszarów bez przeszkód