Elimination of safety risks at mined Coal faces in the paskov mine, Stařič plant- OKD, a.s. Czech Republic

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The contribution deals with the satisfaction of operating and safety conditions during the mining of coking coal at faces endangered by coal and gas outbursts in the Paskov Mine – Stařič Plant.

Underground in the mine, methane-air mixtures and coal and gas outbursts represent a high hazard. To enable mining operations at these faces at risk of this hazard, detailed knowledge of geological conditions, technical and operational data on mined faces, degree of influencing the overlying and underlying strata of the seam being mined, and a possibility of utilization of degasification as well as outburst prevention are required. These facts influence in the highest degree safety risks at mined faces.

The article informs about an engineering solution for the ensuring of mining operations at the faces No. 084 271 under conditions of high emission rates in the joint-stock company Paskov Mine – Stařič Plant, OKD, a.s.

Key words: *Degasification, gas emission rate, mining method, outburst prevention, safety risks*

Introduction

The Paskov Mine is the southernmost and simultaneously the only active mine of the Ostrava part of the Ostrava-Karviná Coalfield. The mining claim of the Mine is situated in a so-called Příbor area, 6 km west of the town of Frýdek - Místek and 15 km south of the town of Ostrava (Fig. 1).

The mining claim occupies 42.51 km^2 and is divided into the following three localities: Stařič I at Sviadnov, Stařič II at Stařič and Stařič III at Chlebovice. The Petřkovice and the stratigraphically higher Hrušov Member are there here.

Geological Conditions of the Paskov Mine

The thickness of mined seams is 120 cm on an average. The strength of coal ranges from 12 to 18 MPa; the coal is not prone to spontaneous combustion. The roofs of mined seams are composed largely of beds of siltstones containing roots, dark grey and fine-grained sandstones and sandy siltstones. The annual production of the Mine is up to 1 150 kt of coal, and for the purpose of deposit development for mining, about 14 to 16 km of mine workings are driven every year. At present, the development and mining operations in the deposit are performed at depths moving in the range from –300 m to –850 m Bpv (Baltic system of altitude after levelling), i.e. at the depth of 600 m to 1150 m below surface. The overall length of active mine workings is 131 km. (Technical documentation-mine Paskov)

Mining Methods Applied to the Paskov Mine

Considering the complicated geological conditions and the condition of a ventilation system (Rider, Colinet, 2011), a method of longwall working along the strike with controlled caving is applied.(Wempen, Cakizaya et al., 2011) Faces are ventilated by U-type or Y-type ventilation systems; in several cases also a Z-type ventilation system was used (Urban, 2009).

To disintegrate a coal pillar, exclusively plough systems (Fig. 2) with loading broken materials on a scraper conveyor and supporting a worked-out area by means of individual hydraulic powered supports with articulated steel bars or by means of self-advancing roof supports HEMSCHEIDT, GLINIK and BUCYRUS are used. The broken material is removed mainly by belt conveyors TP 630A.

During the year 2008, a test operation of a drilling mining rig VS-SEAL- 625P1 was carried out to mine remaining reserves of high-quality coking coal of Va and Vb commercial classes.

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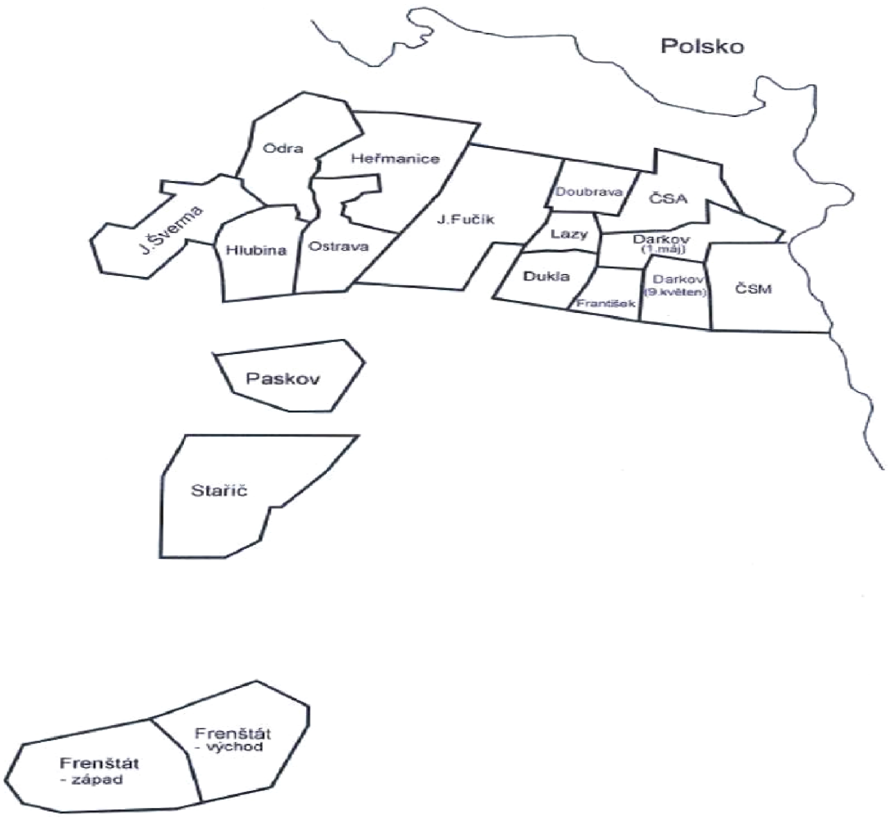

Fig. 1. Situation of the mining claim of Paskov Mine, Staříč Plant.

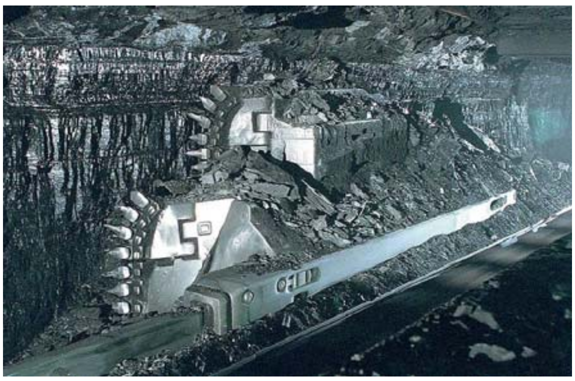

Fig. 2. Plough GH 9-38

Fig. 3. Mining rig VS SEAL 625P1.

Coal and Gas Outbursts and Degasification

The Paskov Mine, Staříč Plant as the only mine in the Ostrava-Karviná Coalfield belongs to the mines with a coal and gas outburst hazard.

According to mining legislation of the Czech Republic, every outburst or its symptom is assessed as an extraordinary event and must be reported immediately to a District Mining Office (DMO). Causes of every outburst or outburst symptom are investigated by a commission designated by the manager of the mine and results of the investigation must be recorded and sent together with a sketch to the DMO. The place of the outburst must be plotted on the plan of workings of the mine. To common methods of coal and gas outburst prevention applied to the Paskov Mine, Staříč Plant, above all infusion, relief boreholes, relief blasting and inducer shot-firing belong.

The Paskov Mine is characterised by a large gas emission rate. Per mined ton of coal, 30 – 50 m^3 of CH_4 falls. The Paskov Mine, Staříč Plant consists of three separate ventilation areas – localities (Sviadnov, Staříč and Chlebovice). In each of them there are a centrally located intake and return shafts.

The degasification system of the Paskov Mine, Staříč Plant consists of three degasification plants in the individual localities and pipes of gas mains and gas lines of the length of about 50 km connected to them. All three degasification plants are connected to the pipeline of a central gas distribution system, boiler plants and cogeneration units of the individual localities (Prokop, 1990).

Fig. 4. Staříč degasification plant.

The surface degasification plants are equipped with water ring vacuum pumps of the types RLP 62/73 and 200 SZO, see Fig. No. 4.

To the degasification system of the Staříč Plant, three groups of sources are connected:

- boreholes drilled to the roof in front of the faces – about 70 boreholes,
- degasification boreholes drilled to gob areas – about 30 boreholes,
- closing dams – about 45 dams.

At almost all faces mined in the Paskov Mine, effective degasification is carried out. In the year 2011 the efficiency of degasification from the faces ranged from 35.0 % to 67.9 %.

Face No. 084 271

The mined face No. 084 271 is there in the seam 084 (22f), which belongs, from the point of view of stratigraphy, to the lower part of Petřkovice Member of the Ostrava Formation.

The extracted thickness of the seam 084 (22f) moved in the range from 0.9 m to 1.6 m, the dip of the seam in the range from 5° to +20°, the face length was 175 m and the face length along the strike was 920 m. (Szlazak et al., 2012)

The face No. 084 271 was retreated using the method of longwall working along the strike with controlled caving. The main gate No. 084 5253 was left behind the advancing face for re-use with utilizing a chock support system, LINK-N-LOCK, and foaming. The return airway No. 084 6251 was abandoned behind the advancing face. For the face No. 084 271, a gas emission rate of 20 200 m^3 CH_4. day^{-1} at daily production of 700 t was forecasted. The efficiency of degasification was planned to be 60 %, which represented 12 120 m^3 CH_4. day^{-1}. As for the ventilation system of the Paskov Mine, Staříč Plant, the face No. 084 271 was included in the ventilation area of the return shaft No. II/3.

For the face No. 084 271, a U-type ventilation system (Berger et al., 2010) was selected (Fig. 5) with additional ventilation by means of ducting of a diameter of 1000 mm to the top dead centre of the face (was left after completing the driving of the return airway No. 084 6251).

For degasification from the face No. 084 271, boreholes drilled to the roof from the return airway No. 084 6251, the main gate No. 084 5253 and the gravity incline No. 084 7254/1 were used.

From the return airway No. 084 6251, groups of three degasification boreholes of a diameter of 75 mm were drilled at 25 m spacing. They were cased with a surface casing 9 m long and were connected to the degasification pipelines DN 150 and DN 200. The lengths of the boreholes were 80 - 100 m.

From the main gate No. 084 5253, pairs of degasification boreholes of a diameter of 75 mm were drilled at 18 m spacing. They were cased with a surface casing 9 m long and were connected to the degasification pipelines DN 150 and DN 200. The lengths of the boreholes were 90 - 100 m (Fig. 7).

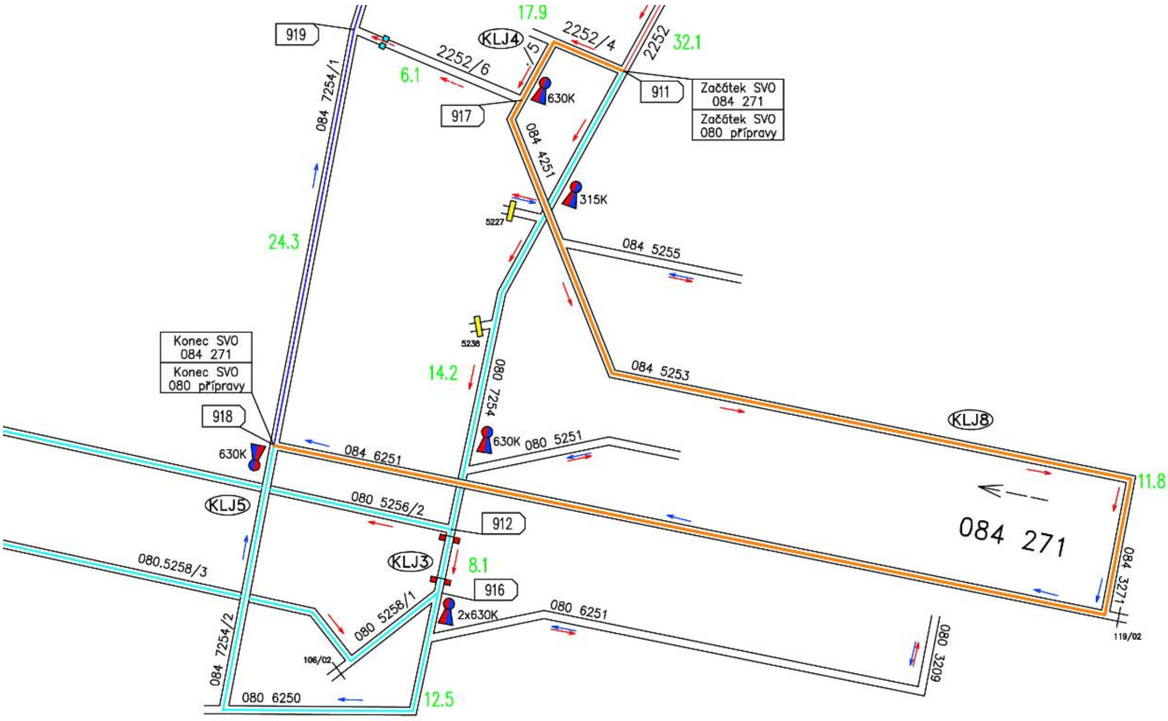

Fig. 5. Plan of the face No. 084 271 with the U-type ventilation system.

The Course of Mining Operations at the Face No. 084 271

Pillar disintegration was performed using a plough system GH-9-38 with supporting the mined-out area with self-advancing roof supports GLINIK 06/15.

Mining operations at the face No. 084 271 were launched from the eastern channel No. 084 3271/1 with a volume flow rate of 660 m^3. min^{-1} through the face and with a volume flow rate of 1 050 m^3. min^{-1} in the return airway of the face at the beginning of November 2009. With advancing mining, increasing daily production, enlargement of caved areas and main roof failures, a rise in the quantity of gas emission rate occurred gradually (both exhalation and degasification), and thus an increase in gas concentrations in return airways of the face. The approaching of the 2nd bench of the seam also played a significant role – before joining, this bench was crushed and thus gas emissions grew. By joining this bench, the thickness of the seam being mined increased from 1.1 m to 1.4 m.

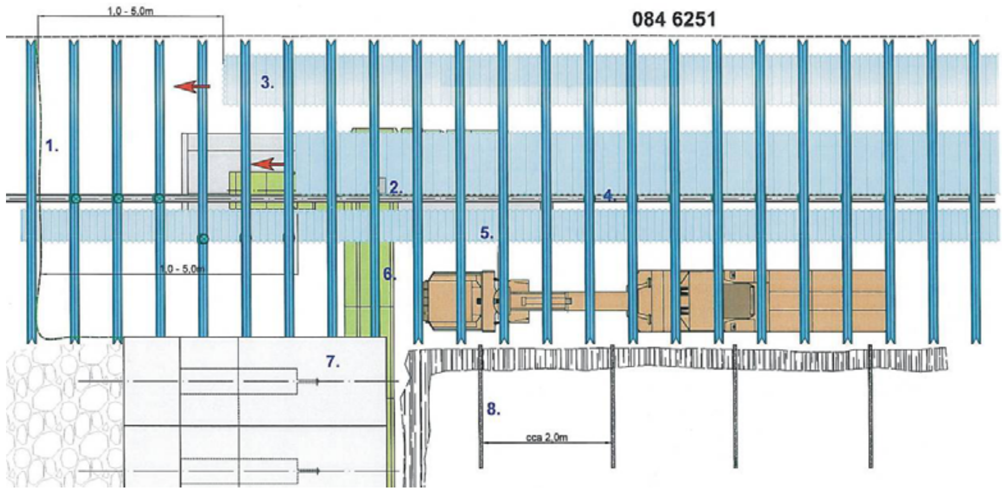

Fig. 6. Position of additional ducts of diameters of 630mm, 800mm and 1000mm in the return airway No. 084 6251

Legend:
Temporary stopping brattice separating the abandoned return airway behind the face.
Sensor of CH_4 recorder.
Additional duct of diameter of 800 mm.
Additional duct of diameter of 1000 mm.
Drainage duct of diameter of 500 mm.
Face conveyor.
Self-advancing roof support.
Grouting bolts AR-25N (IBO)

Subsequently, with the further advance of the face and an increase in worked-out area and with face main roof failures, a further rise in CH_4 concentration took place mainly in the area of top dead centre of the face and in the return airway No. 084 6251, especially in the course of coal winning and caving of the worked-out area and at a drop in barometric pressure (Prokop, Zapletal, 2011).

The applied measure consisted in the replacement of existing pairs of pipe fans APX 630 in the return airway 084 6251 by a double motor fan dGal of a diameter of 800 mm, causing an increase in volume flow rate to 1 480 $m^3.min^{-1}$, and by the installation of short drainage ducts of diameters of 630 mm and 500 mm with an air fan APX 630 V for the drainage of the methane-air mixture behind a pressure bulkhead. The outlet of the diluting duct was there about 35 m ahead of the advancing face (Fig. 6).

Degasification and Outburst Prevention at the Face No. 084 271

The degasification system of the face No. 084 271 was operated using the degasification plant in the locality of Staříč, and later also using the Chlebovice degasification plant. The drainage of methane from the face No. 084 271 using the degasification methods started as early as the eleventh day after the commencement of mining operations.

Altogether, 167 degasification boreholes of overall length of 15 044 m were drilled for the face No. 084 271. A mining and geological situation and a layout of degasification boreholes at the face (Fig. 7).

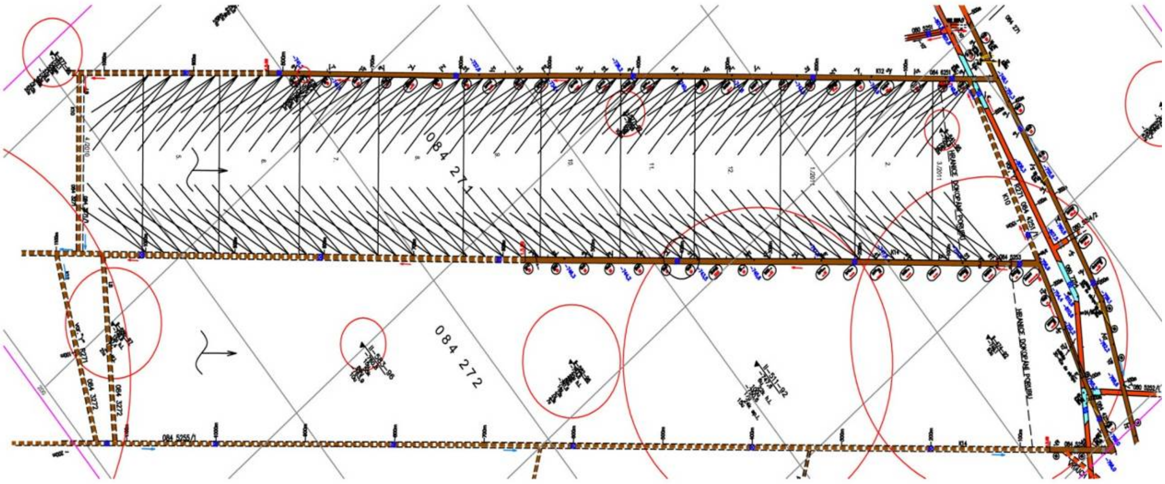

Fig. 7. Mining and geological situation and degasification borehole layout at the face No. 084 271.

In the area of the face No. 084 271, degasification boreholes were drilled to the roof and to the floor, short boreholes for additional degasification to the roof, long boreholes for degasification to the floor from the seam 080, two fans of boreholes of the central degasification system from the roads No. 084 7254/1 and 084 4251/1.

Single boreholes and boreholes in groups of two, three, four boreholes, having various angle parameters and diameters, were drilled at various spacings. For the operation of the degasification system of the face No. 084 271, 5 640 m of piping were laid in the area of the seam 084 (22f).

The face No. 084 271 and also the subsequent face No. 084 272 are classified, from the point of view of outburst problems, as of the 1st degree of coal and gas outburst hazard.

Coal and gas outburst prevention was ensured in advance by means of long infusion boreholes - LIB (at 15 m spacing) drilled from the main gate and the return airway, by pressure water infusion of the coal seam, by relief boreholes drilled into the coal pillar in tectonically disturbed places; in places where the length of long infusion boreholes from the gates was not sufficient, in the course of mining operations, short breast infusion holes 11-13 m long were used for coal and gas outburst as well as dust prevention.

LIBs were always drilled minimally 30 m ahead of the face.

Infusion:	**number of boreholes** [pcs]	**average length** [m]	**eff. affected area** [%]	**∑ lengths** [m]
R 084 271↑	63	62	about 60	4048
R 084 271↓	67	55	about 60	3698
R 084 271 breast	34	12		407

The total length of infusion boreholes for the given face was 8153 m and about 60 % of the area of the face being mined was effectively affected by infusion.

Selected Parameters of the Face No. 084 271

Average daily production	1 194 t
Maximum daily production	1 706 t
Total production	225 568 t
Length along strike	927 m
Average daily advance	6.06 $m.d^{-1}$
Average rate of gas emissions from the face	62 847 m^3 CH_4. day^{-1}
Average quantity of gases emitted from the face	29 855 m^3 CH_4. day^{-1}
Average quantity of gases drained from the face	32 992 m^3 CH_4. day^{-1}
Average degasification efficiency for the face	52.5 %
Number of degasification boreholes	167 pcs
Total length of degasification boreholes	15 044 m
Number of infusion boreholes	164 pcs
Total length of infusion boreholes	8 153 m

Face No. 084 272

It is a face neighbouring to the face No. 084 271. The extracted thickness of the seam 084 (22f) moved in the range from 0.9 m to 1.5 m at a dip of the seam of 5° to +20°, length of the face of 180 m and length along the strike of about 860 m.

The face No. 084 272 was, likewise the face No. 0840271, retreated, using the method of longwall working along the strike with controlled caving. The pillar was disintegrated using a plough system GH-9-38 with supporting a worked-out area by means of self-advancing roof supports GLINIK 06/15.

Mining operations at the face No. 084 272 were launched from the eastern gates Nos. 084 3272 and 084 3272/1 with a volume flow rate of 880 m^3. min^{-1} through the face and with a volume flow rate of 1 550 $m^3.min^{-1}$ in the return airway of the face at the beginning of September 2010. During 12 months, altogether 215.1 kt of coal were extracted. A mining and geological situation and a layout of degasification boreholes at the face (Fig. 8).

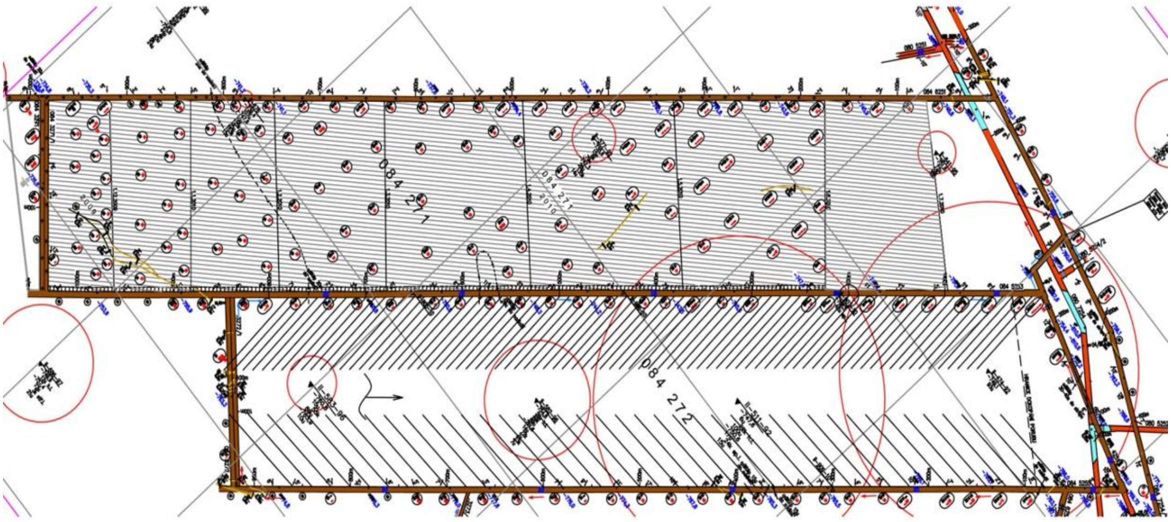

Fig. 8. Mining and geological situation and degasification borehole layout at the face No. 084 272 .

Degasification, Coal and Gas Outburst Prevention

For forecasting the rate of gas emissions from the face No. 084 272, knowledge and facts obtained during the mining of the face No. 084 271 in the seam 084 (22f) were used. For the face No. 084 272, the gas emission rate of 27 000 m^3 $CH_4.day^{-1}$ was forecasted (at the production of 700t.day^{-1}). The project of gas drainage from the face using the degasification methods was based on an urgent need to reduce methane emissions to mine airs to an admissible threshold determined by safety regulations.(Hudecek et al, 2011)

Degasification from the face was performed by parallel degasification boreholes drilled from the gates Nos. 084 5253 and 084 5255 to the roof of the seam; in the return airway No. 084 5253, by degasification boreholes of a diameter of 75 mm, lengths of 100 and 120 m, 6 m spacing and a length of the surface casing of 12 m. Altogether, 121 degasification boreholes were drilled; the total drilling length being 13 382 m.

For the main gate No. 084 5255, degasification boreholes of a diameter of 75 mm, length of 100 m, and 20 m spacing were drilled. In total, 45 degasification boreholes of the total length of 4 248 m were drilled in the main gate.

A part of the solution was so-called final central degasification by means of 7 design degasification boreholes of the lengths of 100 – 250 m.

Altogether, for the drainage from the face No. 084 272, 173 degasification boreholes with the total length of 18 880 m were drilled.

The face No. 084 272 was, from the point of view of outburst hazard, classified as of the 1st degree of coal and gas outburst hazard.

Coal and gas outburst prevention was ensured in advance by means of long infusion boreholes at 15 m spacing, drilled from the main gate and the return airway. In the case of the face No. 084 272, these boreholes were simultaneously used for dust prevention. The infusion boreholes were always performed minimally 30 m ahead of the face (Hudecek et al., 2010).

Infusion:	**number of boreholes** [pcs]	**average length** [m]	**eff. affected area** [%]	**∑ lengths** [m]
R 084 272↑	50	65	about 70	3259
R 084 272↓	57	62	about 60	3515
R 084 272 breast	10	51m only for start		513

Altogether, the infusion boreholes of the total length of 7287 m were drilled for the face No. 084 271. The effectively affected area of the face was about 70 %.

As early as the beginning of mining operations, an increased quantity of gas emissions appeared mainly at the point of top dead centre of the face and in the return airway No. 084 5253. Degasification began to be effective in the second week of mining operations (about on the ninth day). The mining operations were performed from September 2010 to August 2011.

In the studied period, the quantity of gas emitted from the face was on the average 11 801 m^3 CH_4.day^{-1}, the actual quantity of drained gas was 19 326 m^3 CH_4.day^{-1} instead of the estimated quantity of 16 200 m^3 CH_4 .day^{-1}. During the mining operations, the degasification efficiency of about 40.62 % was achieved. The average total daily gas emission rate of the face being mined in the studied period of mining operations amounted to 46 986 m^3 CH_4.day^{-1}.

The best results were obtained by degasification from the face in November 2010 and February 2011, when at an average production of 841t.day^{-1} in November and 788 t.day^{-1} in February 2011, 26 996 and 25 304 m^3 CH_4.day^{-1}, respectively, were drained. In the other periods, 10 950 to 22 724 m^3 CH_4.day^{-1} were drained using the degasification method. Results of gas conditions at the face for the duration of mining (Tab. 1).

Tab. 1. Gas conditions in the course of mining the face No. 084 272.

Period Month/year	**Production/ month** [t]	**Quantity of gas emitted from face** $\left[m^3 CH_4 \cdot den^{-1}\right]$	**Quantity of drained gas** $\left[m^3 CH_4 \cdot den^{-1}\right]$	**Total gas emission rate** $\left[m^3 CH_4 \cdot den^{-1}\right]$	**Degasification efficiency** [%]
9/2010	337	11405	12548	32636	38.45
10/2010	620	13939	22724	53137	42.76
11/2010	841	15206	26996	63313	42.64
12/2010	930	12514	22346	52068	42.92
1/2011	906	11722	22476	52241	43.02
2/2011	788	6566	25304	49496	51.12
3/2011	914	12038	22712	53355	42.57
4/2011	1159	13464	19802	48256	41.04
5/2011	1129	13464	17639	42191	41,81
6/2011	510	12355	14373	40984	35.07
7/2011	757	6739	10950	39462	27.75
8/2011	768	12197	14037	36688	38.26

Conclusion

From the assessment of the studied faces it follows that for ensuring safety in the course of mining operations, coal and gas outburst prevention as well as drainage of gas from the seam and its surroundings, including the drainage of gas from underlying and overlying beds using the degasification methods, was implemented. Thus, reliable prevention of these dangerous mining risks was achieved. Results were confirmed by safe mining operations at both faces.

The presented and evaluated methods used for ensuring operational safety utilize all known prevention methods. They use the latest knowledge of the area of degasification and the area of prevention of anomalous geomechanical events. The advantage of them is the implementation of them largely in the area ahead of the faces so that prevention need not be performed in the place of mining operations. This also contributes to a demonstrable increase in labour productivity. Thanks to the presented knowledge and operational experience, the continuity of mining operations and the safety of mining operations and employees are possible.

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