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# THE BALANCE OF METHANE AND VENTILATION AS A TOOL FOR METHANE HAZARD ASSESSMENT IN THE AREAS OF LONGWALLS EXPLOITED IN HARD COAL MINES

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**ABSTRACT**

**Purpose**
This article presents an algorithm for the current assessment of methane hazards during the exploitation of longwalls in conditions where there are methane hazards. The algorithm has been developed within the framework of the international AVENTO project (Advanced Tools For Ventilation and Methane Emissions Control), carried out in Poland, inter alia, by the Central Mining Institute in cooperation with Kompania Węglowa SA (KW SA).
The algorithm was developed based on the analysis of the ventilation-methane balances for longwall areas, based on the data registered by automatic methane sensors and the velocity of ventilating air.

**Methods**
Multiple research methods were used, such as: observation, a questionnaire and statistical methods.
The questionnaire was used for the preliminary determination of methane hazards in the longwalls belonging to the industrial partner (KW SA). The polls were used to obtain relevant information about the hazards and means of prevention taken, such as: the methane content in the seam, the emissions of methane into the exploitation workings, the volume of methane drainage, the ventilation system used, and the amount of ventilation air used to combat the methane hazard.
Based on the poll's data, the longwalls with methane emissions in their environment were selected for testing, based on long-term observations of changes in the concentrations of methane in the ventilation air and in the methane drainage net.
Methane concentration measurements were based on the values recorded by the methane sensors located in the workings which were considered to be most dangerous. For data processing a statistical method was used. In the research, the average results of the indicated concentrations of methane from the methane sensors were used for the correlation between the average values of methane emission in the region of the longwall or methane drainage, with other parameters, such as absolute pressure changes on the surface, technological processes or cycles in the longwall. For the evaluation of the methane hazard, an indicator was proposed, these being the ratio of the ventilation methane bearing capacity to the criterial methane bearing capacity. An increase of this indicator indicates an increase in the level of methane hazard.

**Results**
On the basis of the average daily value of the methane hazard status indicator, an algorithm for the assessment and visualization of methane hazard in the areas of the active longwalls was developed. The algorithm contains a list of technical and organizational actions which should be taken in the event of unfavourable risk assessment of methane hazard, reflecting very high risk or unsafe conditions for conducting further work.

**Practical implications**
The proposed algorithm can be used for the ongoing assessment of methane hazard in areas of exploited longwalls in order to support staff in surface control rooms and in ventilation departments.

**Originality/value**
The current assessment of methane hazard in the areas of longwalls which are under methane conditions by means of the developed algorithm will improve the safety of exploitation.

**Keywords**
*safety, mining, ventilation, methane hazard, analysis, assessment*

## 1. INTRODUCTION

Under the conditions of methane hazard, the primary objective of the ventilation of the mine workings is to provide a sufficient amount of air to ensure the concentration of methane remains below the limit values prescribed by mining regulations. In hard coal mines, methane hazard level assessment is commonly based on the monitoring and analysis of the absolute methane bearing capacity and the ventilation methane bearing capacity. Absolute methane bearing capacity determines the methane emissions in the environment of the longwall, while the ventilation methane bearing capacity determines the methane emissions into the ventilation air (both values expressed in $m^3$/min). The development of research on the absolute methane bearing capacity of longwall environments and attempts to determine the source and intensity of methane emissions were initiated by Karl Winter (1958) some time ago. Later research on methane emission intensity during the operation of the longwalls was conducted by, among others, Klaus Noack (Noack & Hubig, 1976; Noack, 1980). These studies were focused, mainly, on German mines. In Poland, the concept of absolute methane bearing capacity was introduced by Bolesław Kozłowski (1972). It was Kozłowski who outlined the degassing functions of methane bearing seams within the coverage of the impact of the operation (for conditions in Polish mines). These functions are currently being used in the mandatory predictions of absolute methane emissions for longwalls. Currently Poland uses the Central Mining Institute Instruction No 14, titled "Dynamic prediction of absolute methane bearing capacity of the longwalls (technical guide)" (Krause & Łukowicz, 2000).

In order to fully characterize methane hazard in the region, considering only the two aforementioned parameters is not sufficient. In order to accurately determine the status of methane hazard, it is important to refer to the above parameters when considering existing ventilation conditions, i.e. the volume of the air streams in the area of the longwall or the criterial methane bearing capacity contained in "The principles of conducting of the longwalls in the methane hazard conditions" – Central Mining Institute Instruction No 17 (Krause & Łukowicz, 2004). Criterial methane bearing capacity indicates the limit value of methane emissions in the area of the longwall, which can be combated by means of ventilation and methane drainage. In the project AVENTO, the indicator $k_{KW}$ was proposed, which is the ratio of the ventilation methane bearing capacity to the criterial methane bearing capacity, in order to evaluate the methane hazard. On the basis of the average daily value of the methane hazard status indicator, an algorithm for the assessment and visualization of methane hazard was developed.

## 2. DEVELOPMENT OF THE BALANCING RULES OF METHANE BEARING CAPACITY TAKING INTO ACCOUNT THE AMOUNT OF METHANE DRAINAGE IN THE REGION OF AN ACTIVE LONGWALL

The balance of methane emission in the region of an active longwall should be based on the determination of the total methane emissions in the longwall environment, the so-called absolute methane bearing capacity $Q_c$. This includes the supply of methane into the longwall environment from the extracted seam and from the layers (seams) located in the stress relaxation zone (from the roof and floor layers present in the desorption zone) (Krause, 2003). In the case of methane drainage in the area of the longwall within the framework of prevention, aimed at limiting the flow of methane into mine workings connected with the area of longwall, in order to balance the total absolute methane content, it is necessary to determine 2 components of total absolute methane content, these being:

- the volume of methane drainage into the methane drainage networks, $Q_o$,
- the ventilation methane bearing capacity, $Q_{we}$.

$$Q_c = Q_o + Q_{we} \text{ m}^3/\text{min} \quad (1)$$

The volume of methane drainage into methane drainage networks $Q_o$ (m$^3$/min) refers to the amount of methane drained from the rock mass area under the influence of drainage holes. Due to the fact that the holes are made in the zone of exploitation impact, a significant share of methane captured by methane drainage networks derives from the surrounding methane-bearing layers located in the stress relaxation zone. The volume of methane drainage into the methane drainage network can be determined based on individual (manual) measurements of methane concentration and the flow rate of the gas mixture in the methane drainage pipeline released from the ventilation area. These measurements are performed periodically using a measuring orifice plate. The volume of methane drainage can also be measured continuously with the use of automatic sensors of methane drainage parameters installed in the pipeline. In order to compare the volume of methane drainage to normal conditions it is also necessary to measure the pressure and gas temperature in the pipeline. For the normal parameters of gas, which is similar to normal conditions, the volume of methane drainage into the methane drainage network $Q_o$ can be determined based on the simplified dependence (2):

$$Q_o = 0.01 n_o Q_G \text{ m}^3/\text{min} \quad (2)$$

where:

$n_o$ – concentration of methane in the mixture of gases in the methane drainage pipeline, %

$Q_g$ – flow rate of the mixture of gases in the methane drainage pipeline, m$^3$/min.

The ventilation methane bearing capacity $Q_{we}$ (m$^3$/min) is the volume of methane emission into the ventilation air flowing in workings in the region of the longwall. Within the area of longwalls the most intense emissions of methane into ventilation air occur mainly in the exploitation workings (longwall) during the mining process and the other workings which are in direct vicinity of the gobs. The volume of methane concentration in mine ventilation air can be found by calculating the difference between the flow rate of methane released with the air from the area of the longwall and the flow rate of methane supplied with the ventilation air to the area from other sources (3)

$$Q_{we} = 0.01(c_2 Q_2 - c_1 Q_1) \text{ m}^3/\text{min} \quad (3)$$

where:

$c_2$ – methane concentration in the air at the outlet in the area of longwall, %

$c_1$ – methane concentration in the air at the inlet in the area of longwall, %

$Q_2$ – air flow rate at the outlet in the area of longwall, m$^3$/min

$Q_1$ – air flow rate at the inlet in the area of longwall, m$^3$/min.

Flow rate at the inlet and outlet in the longwall area should be determined by individual measurements of excavation cross-sections and air velocity by means of an anemometer adopting the traverse method in daily periods or more frequently e.g. after adjusting the ventilation network.

The concentration of methane in the air at the inlet and outlet of the longwall area ($c_1$, $c_2$) should be determined based on manual measurements using individual instruments e.g. methanometers, or based on air samples used for precise