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TESTING DUST CONTROL PREPARATION WITH RESPECT TO MINE EMPLOYEE EXPOSURE TO INHALING CHEMICAL AGENTS

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Abstract

This paper presents the results of tests used in dust hazard prevention for air-water spraying devices in collieries. The purpose of the tests was to evaluate mine employees' exposure to inhaling chemical agents when the ZWILKOP ZW-10 preparation is used. The paper presents the results of the measurements of concentration, in a mine atmosphere, of the following chemical agents: hazardous substances 2-(2-butoxyethoxy)ethanol and 2-ethylhexan-1-ol, constituting ingredients of the preparation at mine employees' workstations. The tests were performed during work related to the mining of coal in inclined drift C31, seam 415/1-2 on the premises of "Borynia-Zofiówka-Jastrzębie" Hard Coal Mine, Jastrzębie-Zdrój, Poland, using the TELESTO mist systems. Using aqueous solutions for the preparation at concentrations of 15 and 20‰ causes no exceedance of the allowable mine air concentrations for the chemical agents tested.

Keywords

air dustiness, chemical agents, hazard, air dust reduction

1. INTRODUCTION

Dust hazard prevention (Lebecki 2004) and exposure by inhalation to chemical agents (PN-EN 689:2002) of employees working in mines constitutes important issues influencing the optimisation of occupational health & safety conditions at mining plants.

The increasing amount of coal which is mined leads to higher immission of dust in the workplace, creating the risk of explosion and of the development of pulmonary diseases among mining crews related to the free silica present in coal dust.

New air-water spraying systems developed and implemented in the mining industry (Prostański 2013) reduces dust in the air of mines to a significant extent. However, the water spraying which is generally used in mining plants is insufficiently effective as a dust control measure. In order to further improve occupational health & safety conditions in terms of reducing dust concentration in mining, air dampeners are also used.

2. TESTING THE ZWILKOP ZW-10 PREPARATION

Surface tension of water is reduced by adding preparations containing active substances and enhancing coal dust dampening capacity. The preparation (Patent P.394235) is an agent used to dampen coal dust in mine atmospheres.

Routine measurements performed by Ventilation Staff at the mines where the preparation was used confirmed the

reduction of total dust in mine atmospheres to 50% and of the respirable fraction to 40%.

Tests were carried out at the Central Mining Institute (Waluga, Michałek, Gasz 2011). The purpose of these tests was to demonstrate the improvement of the working conditions in terms of the reduction of coal dust volatility after using the preparation.

Tests of the effectiveness of coal dust devolatilization using water with added ZWILKOP ZW-10 confirmed the possibility of using the preparation during the mining of various types of hard coal. Coal dust devolatilization depends on the type of coal and the concentration of the preparation. For type 31 coal, the optimum concentration was 0.05%, for type 32 and 33 coal the optimum concentration was 0.15%, and for type 34 coal and above, the optimum concentration was 0.20%.

The application of the preparation was also tested (Orszulik 2013) in relation to the exposure by inhalation of mining crews to chemical agents present in the preparation.

The purpose of the tests was to demonstrate whether after applying the preparation in air-water spraying systems used for air dust control at the mine, the mining employees might be exposed to the impact of harmful substances.

Two hazardous substances were selected on the basis of the solution composition (MSDS 2013), according to (Ordinance... 2002):

- 2-(2-butoxyethoxy)ethanol
- 2-ethylhexan-1-ol

If the allowable concentrations of such substances in the air are exceeded, this may be harmful to the health of the mining crews working at the mine.

3. TEST DESCRIPTION

3.1. Testing site

Testing the concentration, in a mining atmosphere, of the hazardous substances 2-(2-butoxyethoxy)ethanol and 2-ethylhexan-1-ol were carried out in inclined drift C31, seam 415/1-2 at the “Borynia-Zofiówka-Jastrzębie” Hard Coal Mine, Jastrzębie-Zdrój.

The tests and measurements were performed at the handling points for materials and mine employees, where the TELESTO mist system devices were applied.

Figure 1 shows the layout of measurement points and the directions of flow of ventilated air in inclined drift C31, seam 415/1.

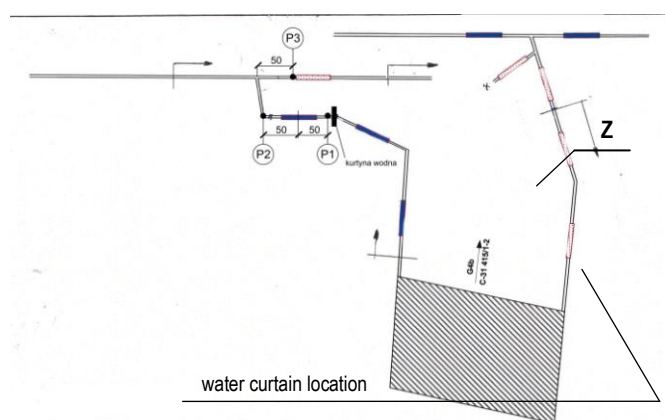


Fig. 1. Layout of measurement points and direction of ventilated air flow in inclined drift C31, seam 415/1: → – air flow direction, P1, P2, P3 – measurement point, Z – loading of materials and employees

Parameters of the heading in inclined drift C31, seam 415/1, where the measurements were carried out are as follows:

- heading height – 3.6 m
- heading width – 5.5 m
- heading section (F) – 15.8 m²
- average speed of air flowing through the heading – 1.0 m/s (up to max 1.6 m/s)
- air flow capacity to $V_{nom. av} = 15.17 \text{ m}^3/\text{s}$

The TELESTO mist system device was installed at the heading roof in the place indicated in Fig. 1.

The TELESTO mist system device installed during the tests had the following features:

- capacity of 1 nozzle – 1 dm³/min.

- number of nozzles installed – 11 pcs
- water capacity/curtain – 1 dm³/min.
- pressure of water supplied to the curtain – 0.4–0.6 MPa.

3.2. Testing procedure

The tests were performed at three selected reference points:

- reference point no. 1 – 50 m from the TELESTO mist system device
- reference point no. 2 – 100 m from the TELESTO mist system device
- reference point no. 3 – 20 m from gallery exit

The testing reference points were selected taking the following into account:

- the time that the mining teams spent at the given point
- mine air parameters and composition at the given point being inferior compared to others in inclined drift C31 subject to testing in seam 415/1-2

The tests were performed for the optimum concentration values in the aqueous solution of the ZWILKOP ZW-10 preparation, i.e. 15% and 20%, as well as entailing optimum time of the mining personnel work on negative parameters and the composition of the mine air at the given reference points.

The reference points were chosen with the Mining Facility Ventilation and Operation Safety Services.

Mine air was sampled at the selected reference points in accordance with the applicable standards in force (PN-Z-04008-7-2002, PN-EN 482:2002, PN-EN 689:2002) during normal work performed by mining employees.

The determination of the hazardous substances 2-(2-butoxyethoxy)ethanol and 2-ethylhexan-1-ol, constituting ingredients of the preparation was performed by means of gas chromatography with flame ionization detector (GC-FID) in accordance with the analytical procedure PA-16: “Testing of volatile organic compounds, VOC-mixture 3, in workplace atmospheres and waste gases using the gas chromatography method. Sampling based on activated carbon, sample desorption with 2% methanol solution in carbon disulphide” (4th edition, 01 March 2012).

The tested air stream was sent through absorbing tubes filled with activated carbon, with a volume flow of up to 30 litres/hour.

3.3. Test results

The results of tests concerning the concentration of hazardous substances 2-(2-butoxyethoxy)ethanol and 2-ethylhexan-1-ol present in the mine’s atmosphere are shown in Table 1, 2 and 3.

Table 1. Results obtained at measurement point P1 in inclined drift C31, seam 415/1-2

Measurement point	Ventilated air parameters	ZWILKOP ZW-10 preparation concentration ‰	Concentration, mg/m ³		Allowable concentration according to the Ordinance of the Minister of Labour and Social Policy of 29 November 2002 on the maximum allowable concentrations and maximum allowable intensity of agents harmful to health in the workplace (Journal of Laws Dz. U. 02.217.1833, as amended)			
			2-(2-butoxyethoxy) ethanol	2-ethylhexan-1-ol	2-(2-butoxyethoxy) ethanol		2-ethylhexan-1-ol	
					NDS	NDSch	NDS	NDSch
P1 – 50 m from water curtain	$V = 0.8\text{--}1 \text{ m/s}$ $t = 27.7^\circ\text{C}$ $p = 1073 \text{ hPa}$	15	BQL	0.0110	67	100	160	320
		20	BQL	0.0153	67	100	160	320

Table 2. Results obtained at measurement point P2 in inclined drift C31, seam 415/1-2

Measurement point	Ventilated air parameters	ZWILKOP ZW-10 preparation concentration ‰	Concentration, mg/m ³		Allowable concentration according to the Ordinance of the Minister of Labour and Social Policy of 29 November 2002 on the maximum allowable concentrations and maximum allowable intensity of agents harmful to health in the workplace (Journal of Laws Dz. U. 02.217.1833, as amended)			
			2-(2-butoxyethoxy) ethanol	2-ethylhexan-1-ol	2-(2-butoxyethoxy) ethanol		2-ethylhexan-1-ol	
					NDS	NDSCh	NDS	NDSCh
P2 – 100 m from water curtain	V = 0.9–1 m/s t = 28.7°C p = 1073 hPa	20	0.0043	0.0137	67	100	160	320
P3 – 20 m from gallery exit	V = 1.4–1.5 m/s t = 26.1°C p = 1073 hPa	20	0.0040	0.0140	67	100	160	320

Table 3. Results obtained at measurement point P3 in inclined drift C31, seam 415/1-2

Measurement point	Ventilated air parameters	ZWILKOP ZW-10 preparation concentration ‰	Concentration, mg/m ³		Allowable concentration according to the Ordinance of the Minister of Labour and Social Policy of 29 November 2002 on the maximum allowable concentrations and maximum allowable intensity of agents harmful to health in the workplace (Journal of Laws Dz. U. 02.217.1833, as amended)			
			2-(2-butoxyethoxy) ethanol	2-ethylhexan-1-ol	2-(2-butoxyethoxy) ethanol		2-ethylhexan-1-ol	
					NDS	NDSCh	NDS	NDSCh
P3 – 20 m from gallery exit	V = 1.4–1.5 m/s t = 26.1°C p = 1073 hPa	20	0.0040	0.0140	67	100	160	320

Description of the symbols used in Table 1, 2 and 3:

- V – air flow rate in gallery
- t – air temperature in gallery
- t – air pressure in gallery
- P1, P2, P3 – reference measurement points
- BQL – below the limit of quantification
- NDS – maximum allowable concentration – the weighted average concentration whose impact on employees over an 8-hour working day and an average weekly working time as defined in the Polish Labour Code, throughout the period of their occupational activity, should not cause adverse changes to their health or to the health of their descendants.
- NDSCh – maximum allowable momentary concentration – the average concentration which should not cause adverse changes to the employee's health, if it occurs in the workplace for no longer than 15 minutes and not more than twice per shift, at intervals of at least 1 hour.

The results shown in Table 1, 2 and 3 of tests of concentration, in mine atmosphere, of the hazardous substances 2-(2-butoxyethoxy)ethanol and 2-ethylhexan-1-ol, constituting ingredients of the preparation, carried out in inclined drift C31, seam 415/1-2 at the “Borynia-Zofiówka-Jastrzębie” Hard Coal Mine, do not demonstrate exceeded NDS (maximum allowable concentration) or NDSCh (maximum allowable momentary concentration) values.

The composition of the ZWILKOP-ZW 10 preparation includes no other hazardous components, hence the mining personnel was not subject to any other tests for exposure by inhalation with regards to other hazardous substances.

The concentration values obtained during the tests performed are 1,000 times lower than the allowable values (Ordinance... 2002).

4. CONCLUSION

- Using aqueous solutions with the preparation with a concentration of 15 and 20‰ does not cause the allowable concentration in mine atmospheres (Ordinance... 2002) of the hazardous substances 2-(2-butoxyethoxy)ethanol and 2-ethylhexan-1-ol, constituting ingredients of the ZWILKOP ZW-10, to be exceeded.
- The preparation was assessed positively in terms of toxicity and harmfulness by the Silesian Medical University, Chair and Department of Environmental Medicine and Epidemiology. Work performed using the preparation does not constitute a hazard to the health or life of employees and does not have a significant impact on the natural environment. The assessment was issued on the basis of the documents submitted and the results of tests carried out (Orszulik 2013).
- The preparation obtained a safety mark certificate (Certificate 2013) and may be used in mining plants. The certificate was issued on the basis of the test results submitted (Orszulik 2013).

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