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PREVENTIVE MEASURES REDUCING THE RISK ARISING FROM DUST IN MINING WORKPLACES

1. Introduction

The dust is one of the most frequently observed harmful factors occurring in underground hard coal mines. Mine dust is formed during the mining of longwalls, drilling of dog headings, transport and grinding of output, as well as during the shifting of powered roof supports. Fighting dust should rely primarily on reducing the amount of dust produced in the place of its generation and on preventing the spread of dust in a circulating air current. It is assumed, that as a result of mining and transport, approximately 2–3% of output is transformed into the dust, both settled and airbone dust. Taking into consideration the coal extracted in 2011 in the coal mine "Jas-Mos", it gives the amount of about 38 376 tons. The harmful effects of dust on health of miners include: mechanical damage to the mucous membranes, skin irritation and sensitization, silicosis and cancer. In 2010, pneumoconiosis accounted for more than 80% of all occupational diseases detected in mining. However, it should be noted, that a large proportion of cases of pneumoconiosis (87%) was found in retired [1]. This is typical for pneumoconiosis, which might be revealed many years after exposure to dust. The harmfulness of dust is influenced by the concentration of a particular faction in the air (total or respirable), free silica content, size, shape and density of dust particles, as well as the time of the exposure.

2. The methodology of dust risk assessment

To assess the risk level, measurements by the Centralne Laboratorium Pomiarowo-Badawcze Sp. z o.o. in Jastrzębie Zdrój have been used. The measurements were carried

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out in areas of three longwalls exploited by "Jas-Mos" coal mine, being the part of JSW SA. Measurement of dust concentration in the working environment has been made in accordance with the following standards: PN-Z-04008-7:2002, PN-91/Z04030/06, PN-91/Z04030/05, PN-G-04035:2002, PN-91/Z-04018/04 [2–6].

During determination of the occupational risks associated with the occurrence of so-called measurable factors, relevant physical parameters posing a threat in the workplace are being measured. Then they are referred to the limit values contained in the relevant legislation in the form of NDS/NDN (occupational exposure limit). The assessment of worker's exposure to dust is based on the multiplicity of the standard for a given type of dust substance. Exceedance of the limit value is calculated with the following formula:

$$k = \frac{C_W}{NDS} \tag{1}$$

where:

C_W — mean weighted concentration of a particular type of dust for the entire work shift;

NDS — occupational exposure limit for certain types of dust.

The risk of exceeding the limit values for harmful factor at workplace is determined on the basis of the principle contained in Table 1 [7]. What is more, Table 1 presents estimation and occupational risk assessment method, as well as preventive measures recommended for the designated risk levels.

TABLE 1

Occupational risk assessment on the basis of exceedance of the limit values and preventive measures for the designated risk levels in a three-degree scale according to the standard-PN-N-18 002 [7]

Ordinal number	"*k*" parameter	Risk type	Risk level	Risk assessment	Preventive measures
1.	$k > 1$	3	high	unacceptable	If occupational risk is related to the work being done, actions aimed at risk reduction should be taken immediately. The work cannot be started before the reduction of occupational risk to acceptable levels.
2.	$0.5 < k < 1$	2	medium	acceptable	Measures aimed at reducing the occupational risk are recommended.
3.	$k < 0.5$	1	low		It is necessary to ensure that the occupational risk stays at least at the same level.

In case of hard coal dusts, occupational exposure limit values are listed in the list annexed to the Decree of the Minister of Labour and Social Policy of 29 November 2002 on maximum permissible concentrations and intensity of harmful factors in the working environment [8] (Tab. 2).

TABLE 2

Occupational exposure limits for hard coal and lignite dusts at selected workplaces [8]

Ordinal number	Hard coal and lignite dusts	Occupational exposure limit, mg/m^3
1.	containing free crystalline silica over 50%	
	total dust	1
	respirable dust	0.3
2.	containing free crystalline silica between 10% and 50%	
	total dust	2
	respirable dust	1
3.	containing free crystalline silica from 2% up to 10%	
	total dust	4
	respirable dust	2
4.	containing free crystalline silica below 2%	
	total dust	10
	respirable dust	–

3. Occupational risk assessment at selected job positions in "Jas-Mos" coal mine

Three job positions have been subjected to the assessment: shearer operator, section operator and conveyor belt operator. Performed operations, the measurements of dust and risk assessment for the aforementioned positions are given in the Tables 3–5.

TABLE 3

Measurements of dust and risk assessment for the job position of "section operator"

Description of activities at the workplace		Powered roof support service, repair and maintenance, manual material transport and conveyor belt transport, rerouting of armoured face conveyors, removing roof and side wall falls, securing roof and side walls, assembling and disassembling of the powered roof support unit, shortening and lengthening of armoured face conveyors and beam stage loaders.							
	Workplace localization	**Individual concentration of coal dust, mg/m^3**		**SiO_2 content, %**	**Exposure time, min**	**Mean weighted concentration for the entire work shift, mg/m^3**	**Exceedance of the limit value**	**Risk level without preventive measures**	**Preventive measures**	**Risk size after taking preventive measures**
"SECTION OPERATOR"	Oddz. G-1. Ściana 25 W-3 pokł. 505/2	total dust	20.69 31.28 17.36	2.6	450	21.93	5.48	high	1) use of dust respirators Class 2 or Class 3. 2) maintaining the full efficiency of spray equipment and adapting it to the amount of dust. 3) the use of "CABO" wetting agent with ongoing filling of the tank by the service.	low
		respirable dust	7.75			7.27	3.63			
	Oddz. G-2. Ściana 24 W-3 pokł. 505/2	total dust	20.13 32.14 22.32	1.8	450	23.31	2.33	high		low
		respirable dust	6.78			6.36	-			
	Oddz. G-3. Ściana 2 Z1Z2 pokł. 510/2	total dust	14.71 34.71 26.22	1.8	450	23.63	2.36	high		low
		respirable dust	6.99			6.55	–			

TABLE 4

Measurements of dust and risk assessment for the job position of "conveyor belt operator"

	Description of activities at the workplace	Conveyor belt service, replacement of damaged rollers and structural elements, constant supervision of the correct operation of the conveyor, maintaining order around the transfer points, leveling and adjusting the routes, shortening the route of the conveyor, conveyor belt replacement and repair.								
"CONVEYOR BELT OPERATOR"	**Workplace localization**	**Individual concentration of coal dust, mg/m^3**		**SiO_2 content, %**	**Exposure time, min**	**Mean weighted concentration for the entire work shift, mg/m^3**	**Exceedance of the limit value**	**Risk level without preventive measures**	**Preventive measures**	**Risk size after taking preventive measures**
	Oddz. G-1. Pochylnia transportowa 3 W-2 pokł. 505/2	total dust	7.87 6.03	3.3	450	6.56	1.64	high	1) use of dust respirators Class 2 or Class 3 2) maintaining the full efficiency of spray equipment. 3) the use of "CABO" wetting agent with ongoing filling of the tank by the service.	low
		respirable dust.	2.31			2.17	1.08			
	Oddz. G-2. Chodnik podścianowy 24 W3 pokł. 505/2	total dust	6.58 9.69 6.14	1.7	450	7.00	0.7	medium		low
		respirable dust	2.18			2.04	–			
	Pochylnia badawcza Z1 pokł. 510/2	total dust	6.84 10.58 7.96	1.9	450	7.93	0.79	medium		low
		respirable dust	2.46			2.31	–			

TABLE 5

Measurements of dust and risk assessment for the job position of "shearer operator"

Description of activities at the workplace		Mechanical winning of coal with use of shearer loaders, responsibility for proper technical condition of the shearer, methane measurements, securing the shearer in case of stops and damages, manual transport of materials and conveyor transport, removing roof and side wall falls.								
	Workplace localization	**Individual concentration of coal dust, mg/m³**		**SiO_2 content, %**	**Exposure time, min**	**Mean weighted concentration for the entire work shift, mg/m³**	**Exceedance of the limit value**	**Risk level without preventive measures**	**Preventive measures**	**Risk size after taking preventive measures**
"SHEARER OPERATOR"	Oddz. G-1. Ściana 25 W-3 pokł. 505/2	total dust	21.68 32.32 15.74	2.8	450	22.42	5.60	high	1) use of dust respirators – minimum of Class 2. 2) maintaining the full efficiency of spray equipment. 3) the use of "CABO" wetting agent with ongoing filling of the tank by the service.	low
		respirable dust	7.91			7.42	3.71			
	Oddz. G-2. Ściana 24 W-3 pokł. 505/2	total dust	20.69 31.87 22.85	1.5	450	23.57	2.36	high		low
		respirable dust	7.53			7.06	–			
	Oddz. G-3. Ściana 2 Z1Z2 pokł. 510/2	total dust	15.45 37.87 30.65	1.6	450	26.24	2.62	high		low
		respirable dust	7.75			7.27	–			

4. Preventive measures in "Jas-Mos" coal mine aimed to reduce the dust risk

Controlling dust and methane hazards in, "Jas-Mos" coal mine is based on the Plan Ruchu JSW SA, "Jas-Mos" coal mine for 2011–2013, as well as on the fourth edition of the "Document of Safety and Health of Workers" [9]. However, in order to reduce the size of the incidence of pneumoconiosis, "Company's Programme for Prevention of pneumoconiosis in 'Jas-Mos' Coal Mine" [10] has been developed and implemented.

The main actions aimed at reducing the risk of harmful effects associated with harmful dusts rely on replacing and upgrading of machinery and equipment, determination of the quantitative requirements for individual protective equipment and means of collective protection and prophylactic care. Preventive measures reducing the level of dust in "Jas-Mos" mine are implemented already at the stage of planning of exploitation. Those include minimizing of use of parallel ventilation in excavations, while exploitation and preparatory works are precisely planned and performed in advance in order to avoid accumulation of dusts associated with the concentration of work in the selected area. Very important role in the design phase plays proper location of ventilation pipe (in relation to sources of dust emissions). Technical plans for drilling and exploitation include the optimal scheme of work with the selection of appropriate technical and organizational solutions, taking into consideration geological disturbances and the position of the front of the works against the cleavage.

Suppressing the formation of dust in the place of its creation plays the key role in health protection of workers against dust risks. This could be achieved with the use of sectional sprinkler system, RAC system or water curtain. It also applies to preventive measures during coal transportation (eg. conveyor belt with tape covering). The use of modern irrigation systems and wetting agent (CABO, Zwilkop *Zw* — 10) does not always allow to reach the desired dust level (within acceptable limit values) and therefore optimal choice of individual protective equipment (dust respirators) is very important. At workplaces where the limit values of dust are exceeded, the use of respiratory protection equipment adequate for the threat is mandatory for the employees. The entire crew is equipped with individual protective equipment (minimum protection class of *P*2), regardless of the occupational risk. Employees working in the greatest threat to health resulting from harmful dusts are obliged to use respirators of class *P*3. This rules include, among others. such positions as shearer operator or section operator. In the last few years the whole crew is showing a significant increase of interest in protective equipment of class *P*3. This is due to increased health awareness from the staff and the mistaken belief that the protective equipment of higher class secures better. This situation led to increased demand for the class *P*3 dust respirators, whose initial price was very high because of small interest from the mines. Combined efforts of Mine Boards, Occupational Safety and Health services and the Company's Social Work Supervisor succeeded in (through increasing the number of purchased items and price negotiations) significant reduction of the price of *P*3–type respirators. Therefore, there is a better accessibility of protective equipment for the whole crew. A key role in pneumoconiosis prevention is played

by monitoring of employees' health and prevention, including annual chest X-ray for early detection of lesions in miners with the highest levels of dust exposure.

5. Summary

Dust measurements at the presented workplaces suggest, that the miners who work near the source of dust emission (shearer operator and section operator) or those who have contact with the contaminated air being discharged from these sources are the most vulnerable to the risks associated with the harmful effects of dust. The highest total dust has been observed at the job position of shearer operator, while it ranges from 15.45 up to 37.87 mg/m^3. Respirable dust for this position is between 7.53 and 7.91 mg/m^3. The lowest dust level has been reported close to conveyor belt — for total dust it ranged from 6.03 up to 10.58 mg/m^3, while for respirable dust it was between 2.18 to 2.46 mg/m^3. In most analyzed cases the risk level without preventive measures is defined as high, while after taking preventive measures it is reduced to low, which proves the effectiveness of the actions taken in the "Jas-Mos" coal mine.

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[3] PN-91/Z-04030/06 Ochrona czystości powietrza. Badania zawartości pyłu. Oznaczanie pyłu respirabilnego na stanowiskach pracy metodą filtracyjno-wagową.

[4] PN-91/Z-04030/05 Ochrona czystości powietrza. Badania zawartości pyłu. Oznaczanie pyłu całkowitego na stanowiskach pracy metodą filtracyjno-wagową.

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