MINERS` EXPOSURE TO GASEOUS CONTAMINATS CURENT SITUATION AND LEGISLATION

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ABSTRACT

In a light of ever increasing public sensitivity to professional illnesses and accidents, regulators start to strength TLV's for most of gaseous contaminants present especially in mining industry. This face new challenges for operators, now forced to implement better control, as much as to seek new tools and means in order to achieve the strengthened limits. This paper gives overview of current industry best practices and regulations, concerning workplace exposure limits to gaseous pollutants and also presents some experiences about current level of miner's exposure in some Macedonian mines. Also a brief description of exposure assessment and control techniques are given.

KEYWORDS

Exposure, Gaseous pollutants, Regulations, Control.

1. INTRODUCTION

Environment created by dynamic modern mining industry and due to an ever increasing intensity of production processes, including more powerful diesel equipment and increased blasting frequency and power, significantly increased risk of miners` exposure to potentially harmful gases such as CO, CO_2, NO and NO_2. Taking this into account, and the lack of specific data that would reflect the actual exposure of miners to these contaminants, determination of miner's exposure and better workplace control is a challenging task.

Diesel equipment and blasting are the most significant sources of gaseous contaminants in underground as well as surface mines. The type and quantity of gases evolved from mining are directly dependent of the type and amount of explosives that used, while the type, quantity and characteristics of exhaust gases and particulate matters from diesel equipment primarily depend on the fuel quality, oxygen content in working atmosphere, vehicles quality and equipment for filtration (catalysts).

The best method for dealing with gaseous contaminants in mines is a quality ventilation system that will provide enough oxygen and freshness, dilute gases and their removal from workplaces. The efficiency of underground ventilation system plays a significant role in miners` exposure to gaseous contaminants.

2. OCCUPATIONAL EXPOSURE LIMITS

Indicative Occupational Exposure Limit Values (IOELVs) are health-based limits set under the Chemical Agents Directive (98/24/EC). The Scientific Committee on Occupational Exposure Limits (SCOEL) advise the European Commission on limits. This committee evaluates the scientific information available on hazardous substances and makes recommendations for the establishment of an IOELV.

IOELVs are listed in Directives which Member States are obliged to implement by introducing national limits for the substances listed.

IOELV Directives require Member States to establish national occupational exposure limits for the chemical agents in question, taking into account the European values. In Republic of Macedonia as a candidate Member States on EU occupational exposure limits are identical, or very close to the IOELV.

Occupational exposure limits (OEL) are set in order to help protect the health of workers. OELs are concentrations of hazardous substances in the air, averaged over a specified period of time, referred to as a time-weighted average (TWA). Two time periods are used:

- Long-term exposure limit (8-hours TWA reference)
- Short-term exposure limit (STEL) (15 minutes)

Effects of exposure to substances hazardous to health vary considerably depending on the nature of the substance and the pattern of exposure. Some effects require prolonged or accumulated exposure.

The long-term (8-hour TWA) exposure limit is intended to control such effects by restricting the total intake by inhalation over one or more workshifts, depending on the length of the shift. Other effects may be seen after brief exposures.

Short-term exposure limits (usually 15 minutes) may be applied to control these effects. For those substances for which no short-term limit is specified, it is recommended that a figure of three times the long-term limit be used as a guideline for controlling short-term peaks in exposure. Some workplace activities give rise to frequent short (less than 15 minutes) periods of high exposure which, if averaged over time, do not exceed either an 8-hour TWA or a 15-minute TWA. Such exposures have the potential to cause harm and should be subject to reasonably practicable means of control unless a ‘suitable and sufficient’ risk assessment shows no risk to health from such exposures.

Short-term exposure limits (STELs) are set to help prevent effects such as eye irritation, which may occur following exposure for a few minutes.

Occupational exposure limits on gases commonly occur in underground mines such as CO_2, CO, NO_2, and NO according to Recommendations of the American Conference of Governmental Industrial Hygienists (ACGIH) and the US National Institute for Occupational Safety and Health (NIOSH), European (EOEL) and Macedonian occupational exposure limits (MOEL) are given in Table 1.

Table 1.OEL on mining gases according to Recommendations of the ACGIH and NIOSH, EOEL and MOEL

Substance	**Density at 20°C and 100 kPA [kg/m^3]**	**Relative density of dry air**	**Main sources in mines**	**Odor, color, taste**	**Hazards**	**Occupational exposure limits (ppm)**						**Methods of detection**
						ACGIH and NIOSH		**EOEL**		**MOEL**		
						TWA	STEL	TWA	STEL	TWA	STEL	
Carbon dioxide (CO_2)	1.805	1.519	Oxidation of carbon, fires, explosions, diesel engines, detonations	No	Rapid breathing	5000	30000	5000	15000	5000	/	Optical, infrared, colorimetric
Carbon monoxide (CO)	1.149	0.967	Fires, explosions, diesel engines, not complete combustion of explosives	No	Highly toxic, explosive	50	200	30	200	30	/	Electro chemical, catalytic oxidation, infrared, colorimetric
Nitrous monoxide (NO)	1.231	1.036	Diesel engines, blasting, welding	Acidic smell and taste	Rapidly oxidized to NO_2	25	/	/	/	25	/	Electro chemical, infrared, colorimetric
Nitrous dioxide (NO_2)	1.888	1.588	Diesel engines, blasting, welding	Reddish-brown, acidic smell and taste	Very toxic, lungs and throat irritation, lung infections	3	/	/	/	5	/	Electro chemical, colorimetric

3. METHODS OF PERSONAL EXPOSURE DETECTION

Due to the specific conditions that exist in underground mines determination of personal exposure to gaseous contaminants presents very complex procedure. One of the possible methods that proved as a relatively good and practical is colorimetric measurement with GASTEC dosimetric tubes because of following reasons:

- Ease of use;
- Resistant to mining environment impact (humidity, dust, temperature, etc.);
- No additional equipment for use (chargers, batteries, laboratory tests) is required;
- No calibration is required.

Colorimetric measurements with GASTEC dosimetric tubes, were used for determination of miners` exposure to CO and NO_2 in largest national mining companies as a joint effort of MMA - Macedonian Mining Association in collaboration with Mining Engineering Department at Faculty of Natural and Technical Sciences – University "Goce Delcev" in Stip. The measurement campaign includes two hard rock metallic mines, one underground operation (A) with 750.000 tons per year output and surface mine (B) with more than 8.000.000 tons per year total output. In mine A (underground operation with 6 active production areas) indicated group of exposed workers involved operators of diesel powered equipment, blasting specialist and production supervisors. Due to a difference of working conditions and suspected level of exposure two sub-groups where formed, workers from production areas under the general ventilation system and workers from development areas where auxiliary ventilation is usually applied. The group of workers from production areas included two 2 diesel loader drivers, 2 drill jumbo operators and 2 blasting specialists, while group of workers from underground construction areas was consisted of 1 diesel loader driver, 1 jumbo drill operator and 1 blasting specialist. Supervisor of each of the groups was also included in the assessment.
Compiled assessment data including 36 readings for each pollutant from Mine A, are given in the Table 2.

Table 2. 8 hour's TWA exposure in Mine A

	Shift I		Shift II		Shift III	
Working position	CO ppm	NO_2 ppm	CO ppm	NO_2 ppm	CO ppm	NO_2 ppm
Production Group						
LHD driver 1	11,85	1,325	15,5	1,425	13,25	1,55
LHD driver 2	9,75	1,075	12,25	1,05	11,53	0,95
Drilling operator 1	10,55	0,75	9,25	0,75	8,51	0,25
Drilling operator 2	7,50	0,25	8,50	0,50	6,52	0,25
Blasting operator 1	8,20	0,55	8,75	0,95	11,25	2,15

Blasting operator 2	4,50	0,25	7,325	0,75	9,75	1,85
Supervisor 1	10,25	0,87	7,85	0,25	7,85	0,50
Supervisor 2	9,25	0,55	5,25	0,25	5,55	0,25
Development group						
LHD driver	22,5	2,50	25,80	2,25	19,85	1,55
Drilling operator	16,37	1,85	14,75	2,15	12,25	1,25
Blasting operator	11,25	1,55	10,05	1,85	11,85	2,05
Supervisor	12,50	1,25	12,5	1,50	9,85	1,15

Average exposure of working positions in different groups are given in Table 3.

Table 3. Average exposure of working positions in different groups

	Average exposure (8 hour's TWA)			
	Production Group		Development Group	
Working position	CO ppm	NO_2 ppm	CO ppm	NO_2 ppm
LHD drivers	12,41	1,23	15,84	1,52
Drilling operator	8,47	0,46	10,47	0,89
Blasting operator	8,30	1,08	9,21	1,33
Supervisor	7,67	0,45	8,98	0,73

Average exposures of different working positions obtained in Macedonian study are generally higher, compared to data from the extensive study in German potash mines (Dahman, Monz, Sönksen 2007) as shown on Figure 1.

Although the results obtained are below the regulation limits and atmosphere could be regarded as safe, this data indicates that more effort on workplace atmosphere control should take place.

This study also concluded that efficiency of ventilation underground play a significant role in overall exposures, which is clearly indicated for all working positions in development group usually operating under local exhaust ventilation systems. Workers in development group are in average 10 to 48 % more exposed compared to corresponding positions in production group.

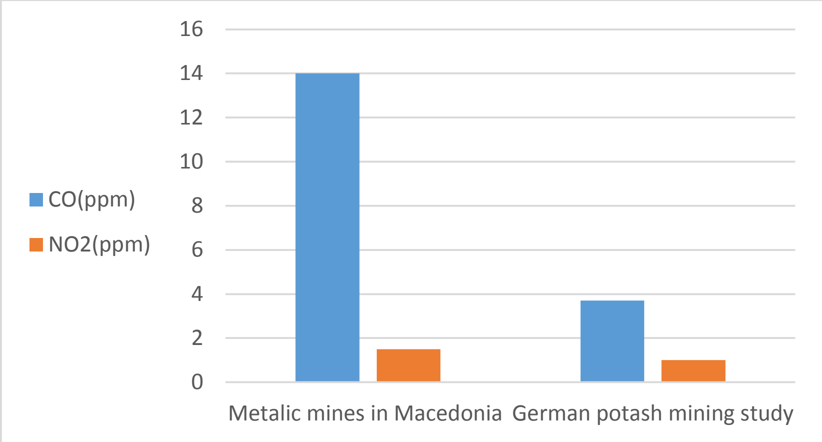

Figure 1: Average exposure of LHD drivers

4. CONCLUSION

The strengthened TLVs for most of gaseous contaminants present especially in mining industry, put a new challenges for operators, now forced to implement better control, as much as to seek new tools and means in order to achieve the strengthened limits. Control measures are focused to determine miner's exposure to gaseous contaminants, aiming to provide solid exposure data for risk assessment, as much as to develop efficient, cost efficient and easily applicable assessment programs and recommend additional protection/control measures as needed.

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