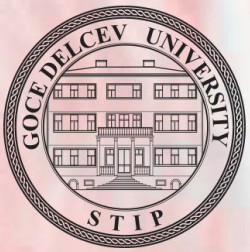

UNIVERSITY GOCE DELCEV - STIP
FACULTY OF NATURAL AND
TECHNICAL SCIENCES

ISSN:1857-6966

Natural resources and technology

No. 1 Volume XVI June 2022

UNIVERSITY "GOCE DELCEV" – STIP
FACULTY OF NATURAL AND TECHNICAL SCIENCES

Natural resources and technologies

JUNE 2022

VOLUME XVI

NO. 1

ISSN 1857-6966

NATURAL RESOURCES AND TECHNOLOGIES

Editorial Board:
Prof. Blazo Boev, Ph. D, Goce Delcev University, Faculty of Natural and Technical Sciences, Stip, Republic of North Macedonia;
Prof. Zoran Despodov, Ph. D, Goce Delcev University, Faculty of Natural and Technical Sciences, Stip, Republic of North Macedonia;
Prof. Zoran Panov, Ph. D, Goce Delcev University, Faculty of Natural and Technical Sciences, Stip, Republic of North Macedonia;
Prof. Mirjana Golomeova, Ph. D, Goce Delcev University, Faculty of Natural and Technical Sciences, Stip, Republic of North Macedonia;
Prof. Dejan Mirakovski, Ph. D, Goce Delcev University, Faculty of Natural and Technical Sciences, Stip, Republic of North Macedonia;
Prof. Ivajlo Koprev, Ph. D, University of Mining and Geology "St. Ivan Rilski", Sofia, Bulgaria;
Prof. Nikola Lilic, Ph. D, University of Belgrade, Faculty of Mining and Geology, Belgrade, Serbia;
Prof. Jože Kortnik, Ph. D, University of Ljubljana, Faculty of Natural Sciences and Engineering, Department of geotechnology, mining and environment, Ljubljana, Slovenia;
Prof. Daniela Marasova, Ph. D, Technical University of Kosice, Institute of Industrial Logistics and Transport, Kosice, Slovakia;
Prof. Lucyna Samek, Ph.D, AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Krakow, Poland;
Prof. Václav Zubíček, Ph. D, VSB - Technical University of Ostrava, Czech Republic;
Prof. Evica Stojiljkovic, Ph. D, University of Nis, Faculty of Occupational Safety in Nis, Serbia;
Prof. Ivica Ristovic, Ph. D, University of Belgrade, Faculty of Mining and Geology, Belgrade, Serbia;
Prof. Kemajl Zeqiri, Ph. D, Isa Boletini University, Faculty of Geosciences, Department of Mining, Mitrovice, Kosovo;
Prof. Aleksandar Nikoloski, Ph. D, Murdoch University, Collage of Science, Health, Engineering and Education, Department of Chemical and Metallurgical Engineering and Chemistry, Perth, Australia;
Ömer Faruk EFE, Professor, Bursa Technical University, Faculty of Engineering and Natural Sciences, Department of Industrial Engineering, Bursa, Turkey.

Editor in Chief:
Prof. Afrodita Zendelska, Ph. D, Goce Delcev University, Faculty of Natural and Technical Sciences, Stip, Republic of North Macedonia

Editors:
Prof. Blagica Doneva, Ph. D, Goce Delcev University, Faculty of Natural and Technical Sciences, Stip, Republic of North Macedonia;
Ass. Prof. Vancho Adjiski, Ph. D, Goce Delcev University, Faculty of Natural and Technical Sciences, Stip, Republic of North Macedonia;

Language Editor:
Prof. Snezana Kirova, Ph. D, Goce Delcev University, Faculty of Educational Sciences, Stip, Republic of North Macedonia;

Technical Editing:
Kire Zafirov, Goce Delcev University, Stip, Republic of North Macedonia;

Editorial Office
Goce Delcev University - Stip
Faculty of Natural and Technical Sciences

Contents

Manuscript received: 01.04.2022
Accepted: 26.04.2022

Natural Resources and Technology
Vol 16, No. 1, pp. 77 - 81 (2022)
ISSN 1857-6966
UDC: 622.23.05-057:613.644.027
DOI: https://doi.org/10.46763/NRT22161077an
Original research paper

PERSONAL NOISE EXPOSURE ON UNDERGROUND MINING WORKERS

Saska Arsova Nesevski[1], Marija Hadzi-Nikolova[2], Dejan Mirakovski [2], Nikolinka Doneva[2], Afrodita Zendelska[2]
[1]SASA Mine, Ltd Makedonska Kamenica
[2]Faculty of Natural and Technical Sciences, Goce Delcev University, Stip, Macedonia
**Corresponding author: s.arsova@sasa.com.mk*

Abstract

As result of improvements in technology through higher labor productivity, continuous production methods and operating flexibility, mechanization has also advanced rapidly in open pits and underground mines, as well as in mineral processing plants. Parallel to this improvement, occupational noise level in the mining industry has shown a noticeable increase. The development of modern mechanized operations in mining industry has been considerably decreasing the physical burden of work, but the most undesired and unavoidable by-product of these operations is the higher noise levels.

This paper presents the results of personal noise exposure of workers in mineral processing plants in underground mines.

Key words: *mineral processing, crushing, grinding, hearing loss*

INTRODUCTION

The rapid development of technology, which also contributes to increasing productivity in the mining industry, indicated the need for using more powerful mining machinery. Powerful mining machinery, on the other hand, results in increased noise levels, both in surface and underground mines as well as in mineral processing plants [1]. In underground mines, confined and enclosed space further increases the problem of high noise exposure [2]. The main noise source in underground mines is drilling machinery and LHD equipment, while in the mineral processing plant the main noise sources are crushers and mills.

Noise is often considered an inconvenience rather than an occupational hazard. However, prolonged noise exposure can cause permanent damage to the auditory nerve and/or its sensory components, known as noise induced hearing loss (NIHL). In 1996, NIOSH reported that occupational hearing loss was the most common occupational disease in the United States, with 30 million workers exposed to excessive noise levels [NIOSH, 1996]. The problem is particularly pronounced in the mining industry, where studies show that 70% to 90% of miners have noise induced hearing loss (NIHL) [3].

Prolonged exposure to noise causes short and long-term effects on workers. Short term effects of noise exposure are temporary hearing loss, stress, annoyance, difficulty in verbal communication and safety hazards [4]. The main long-term effect on workers' health from noise exposure is noise-induced hearing loss (NIHL) which cannot be remedied by medical treatment [5].

Numerous studies show that occupational noise is an important risk factor for hearing loss in older workers, i.e., 7% to 21% (average 16%) of hearing loss in adults is due to exposure to high noise levels on the workplace [6]. The National Institute for Occupational Safety and Health (NIOSH) has recognized noise-induced hearing loss (NIHL) as one of the top ten occupational diseases in the United States and it emphasizes its importance as one of the critical areas on the National Research Agenda in the field of occupational safety and health [7].

In the Republic of Macedonia, in order to determine the minimum requirements for workers` protection from risks to their health and safety that arise or for which there is a possibility of arising from noise exposure, especially from the risk of hearing loss, the Ministry of Labor and Social Policy adopted the

Rulebook on safety and health at work of the workers at noise risk (Official Gazette of RM, no. 21/08), in accordance with Directive 2003/10/EC of the European Parliament and of the Council concerning the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise). Article 4 of the Rulebook defines the exposure limit values and the exposure action values in relation to the daily noise exposure levels and the maximum sound pressure level (Table 1).

Table 1. Exposure limit and exposure action values

Exposure level	$L_{EX,8h}$ (dB)	$L_{p,\,Cpeak}$ (dB)	p_{Cpeak} (Pa)
Exposure limit values	87	140	200
Upper exposure action values	85	137	140
Lower exposure action values	80	135	112

MATERIAL AND METHODS

The basic measuring strategies for noise level in the working environment and the guidelines for the correct choice of measuring strategy are given in the international standard MKS EN ISO 9612: 2010 Acoustics - Determination of noise exposure in the working environment - Engineering method [8].

The following measuring equipment was used to measure the personal noise exposure of workers:

– instrument for measuring personal noise exposure (noise dosimeters) which satisfies the requirements according to IEC 61252 and in accordance with the requirements of IEC 61762-1: 2002 instrument class 1.

Noise dosimeters are used when taking long-term measurements of moving workers performing complex or unpredictable work tasks or performing a large number of discrete work tasks.

When using noise dosimeters, the microphone is placed on top of the workers` shoulder at a distance of about 0.1 m from the entrance of the external ear canal on the side of the most exposed ear (Figure 1). The microphone and the cord should be secured in such a way that mechanical impact or cover with clothing is disabled which may lead to incorrect results. When placing the microphone, care should be taken not to disturb the normal and safe performance of work tasks.

Figure 1. Microphone location during personal noise exposure measurement

Workers fitted with a noise dosimeter must be informed of the purpose of measurement and advised not to remove the measuring instrument during the entire measurement period and to perform their work tasks normally.

Noise dosimeter, which measures the noise level for several hours, calculates the cumulative noise level expressed as the application of a noise dose for a certain time in percentage.

The measurements of personal noise exposure of the workers in the mineral processing plant were performed with a set of dosimeters for personal noise exposure (doseBadge) of the manufacturer Cirrus Research plc, and the data were processed with specialized software dBlink3, as well as CASELLA Dbadge2.

The recommended limit values according to NIOSH were used for comparison of the results from measurement of the personal noise exposure of mining workers, because, according to the Rulebook on safety and health at work of the workers exposed to noise risk (Official Gazette of RM, No. 21/08), 85 dB(A) is above action value for 8 hours of noise exposure.

As a result of the measurement, values for the equivalent noise level exposure for the examined period in dB (A), as well as value of the applied dose in % have been obtained.

The methodology for noise exposure measurement in the working environment according to the above-mentioned standard includes the following 4 steps:

– Analysis of the work process;
– Choice of measurement strategy;
– Measurement;
– Error assessment and measurement uncertainty.

Strategy according to the workplace has been applied as a measurement strategy for noise exposure level on workers in a mineral processing plant.

RESULTS AND DISCUSSION

The main noise sources in the mineral processing plant are crushers, mills, presses, and flotation machines.

The measured values of the noise exposure level on the workers in the mineral processing plant are normalized to an 8 hours working day and the daily noise exposure level is obtained, $L_{EX,8h}$, according to the ISO 9612-2009: Acoustics - Determination of occupational noise exposure - Engineering method, according to the following formula:

$$L_{EX,\,8h} = L_{Aeq,\,Te} + 10 \log 10\ T_e/T_0\ \text{dB (A)}$$

where:

$L_{Aeq,\,Te}$ - measured equivalent noise level in dB (A) during Te

Te - daily duration of the workers' exposure

T_0 - 8 hours reference time

The results obtained from the personal noise exposure measurement on the workers in a mineral processing plant are given in Table 2.

Table 2. Personal Noise Exposure on workers in a mineral processing plant

Workplace	Min [dB(A)]	Max [dB(A)]	$L_{EX,\,8h}$ dB(A)	Dose (%)
Worker in flotation process	83,2	85,5	84,7	95
Grinding worker	83,6	87,6	86,3	143
Worker on filter press	73,7	82,2	80,4	34
Pump worker	83,2	82,6	81,1	46
Shift Engineer	72,3	71,5	70,6	4
Sampler	71,0	76,3	74,5	10
Crushing worker	85,7	88,7	87,2	173
Desk worker	80,6	84,2	82,9	65
Worker in the reagent department	72,6	75,8	74,9	10

The results of the personal noise exposure measurements on the workers in the mineral processing plant (Table 2) show that the workers in the crushing and grinding department are exposed to a quite high noise level, which significantly exceeds the upper exposure action value, as well as the allowable dose, which means that for these jobs it is mandatory to use personal protective equipment, in accordance with

EN 352-1 with a noise reduction level (NRR - Noise Reduction Rating) of 20 - 25 dB. Workers in the flotation plant are exposed to the noise level which is very close to the upper exposure action value and the allowable dose, which means that in this workplace it is mandatory to use personal protective equipment in accordance with EN 352-1 with the level of Noise Reduction Rating (NRR) of 15 - 20 dB. For other respondents (worker on press, pump worker, shift engineer, sampler, desk worker and worker in reagent department), the daily noise exposure level, $L_{EX, 8h}$, is within permissible exposure limit value, i.e., the upper exposure action value of 85 dB (A) in accordance with the Rulebook for safety and health at work of workers at risk of noise ("Official Gazette of the Republic of Macedonia" No. 21/08), but given the fact that in some workplaces it is still higher than the lower action value, these workers are obliged to wear personal protective equipment in accordance with EN 352-2 with a noise reduction level (NRR - Noise Reduction Rating) of 10-15 dB.

CONCLUSION

The results obtained from the personal noise exposure measurements on workers in the mineral processing plant, as well as numerous other studies in this area clearly indicate the fact that mining workers are exposed to quite high noise levels that often exceed the permissible limit values and thus represent an important risk factor for hearing loss. Hearing loss caused by occupational exposure to noise has multiple negative consequences both at the individual and at society level [9]. Although there are a number of factors that contribute to noise induced hearing loss (NIHL), the lack of prevention can be said to play a large role in this phenomenon. Therefore, it is necessary to adopt programs to strengthen preventive measures for reducing occupational noise exposure, through usage of engineering controls and reducing the noise level at the source itself [10]. Adoption and continuous improvement of programs for the prevention of hearing loss, which include noise level assessment, noise control, audiometric monitoring of workers' hearing, proper use of PPE for hearing, continuous education of workers and evaluation of the program are necessary to effectively reduce the global burden of noise induced hearing loss.

REFERENCES

1. Sensogut, S., (2007), Occupational Noise in Mines and Its Control – A Case Study, Polish J. of Environ. Stud. Vol. 16, No. 6 939-942
2. Kepeski, A., Mirakovski, D., Hadzi-Nikolova, M., Doneva, N., (2016) Personal noise exposure on mining workers. Natural Resources and Technologies, 10 (10). pp. 49-61. ISSN 185-6966
3. Bauer, R. Eric., Babich, R. Daniel, R. Vipperman, R. Jeffrey, (2006), Equipment Noise and Worker Exposure in the Coal Mining Industry, National Institute for Occupational Safety and Health Pittsburgh Research Laboratory Pittsburgh, PA,
4. M.J. Crocker, (2007), "General introduction to noise and vibration effects on people and hearing conservation", in Handbook of Noise and Vibration Control, edited by M.J. Crocker, John Wiley & Sons, New York
5. J.M. John, (2000), "Occupational hearing loss", American Journal of Industrial Medicine, 37, 112–120
6. Nelson, D et all., (2005), The Global Burden of Occupational Noise-induced Hearing Loss, American Journal of Industrial Medicine
7. Kovalchik, G. Peter, Matetic, J. Rudy, Smith, K. Adam, Bealko, B. Susan, (2008), Application of Prevention through Design for Hearing Loss in the Mining Industry, Journal of Safety Research 39 pp. 251–254.
8. Hadzi-Nikolova, M., Mirakovski, D., Doneva, N. (2014) Noise Measurement Strategies on workplace and determination of personal noise exposure. In: VII Expert counseling with international participation Podex-Povex '14, 14-15 Radovis, Macedonia
9. Landen, D., Wilkins, S., Stephenson, M., McWilliams, L., (2004) Noise Exposure and Hearing Loss Among Sand and Gravel Miners, Journal of Occupational and Environmental Hygiene, 1: 532–541.
10. Hadzi-Nikolova, M., Mirakovski, D., Doneva, N., (2012) Legislation on assessing and controlling the occupational noise. In: Underground mining technology, Macedonia

ПЕРСОНАЛНА ИЗЛОЖЕНОСТ НА БУЧАВА НА РАБОТНИЦИТЕ ВО РУДНИЦИТЕ СО ПОДЗЕМНА ЕКСПЛОАТАЦИЈА

Сашка Арсова Нешевски[1], Марија Хаџи-Николова[2], Дејан Мираковски[2], Николинка Донева[2], Афродита Зенделска[2]
[1]Рудник Саса ДООЕЛ, Македонска Каменица
[2]Факултет за природни и технички науки, Универзитет „Гоце Делчев“, Штип
*Контакт автор: s.arsova@sasa.com.mk

Резиме

Како резултат на брзиот развој на технологијата, зголемена работна сила, продуктивност, континуирани методи на производство и оперативната флексибилност, развојот на механизацијата исто така брзо напредува, како во рудниците со површинска и подземна експлоатација, така и во погоните за преработка на минерални суровини. Паралелно со овој развој на рударската механизација, нивото на бучава во рударската индустрија бележи значително зголемување. Развојот на модерната рударска механизација значително го намалува физичкиот напор, но придонесува за зголемување на нивото на бучава.

Во трудот се прикажани резултатите од персонална изложеност на бучава на работниците во погонот за преработка на минерални суровини во рудниците со подземна експлоатација.

Клучни зборови: *преработка на минерални суровини, дробење, мелење, загуба на слух*