6th International Symposium

MINING AND ENVIRONMENTAL PROTECTION

21 - 24 June 2017., Vrdnik, Serbia

MINING AND ENVIRONMENTAL PROTECTION

PROCEEDINGS

Editor
Prof. dr Ivica Ristovic

Vrdnik
21 - 24. June 2017.

FOREWORD

After the consultations with business entities in the field of mining and environmental protection, faculties and scientific institutes, an initiative for organizing a scientific meeting on mining and environmental protection was taken in 1996. The Faculty of Mining and Geology in Belgrade, CENTER FOR ENVIRONMENTAL ENGINEERING, have organized the First Yugoslav Conference with International participants held from 25 to 27 April 1996 in Belgrade, Serbia. 2nd International Symposium was held in Belgrade from 25 to 27 1998. 3th Symposium was held in Vrdnik from 21 to 23 May 2001, 4th International Symposium was held in Vrdnik from 23 to 25 June 2003, and 5th International Symposium was held in Vrdnik from 10 to 13 June 2015.

Due to the large number of subjective and objective reasons organization of the symposium was discontinued in 2003. On the basis of the conclusions made at the 5th Symposium MEP 2015, and great interest of domestic and foreign scientific and professional public, the Faculty of Mining and Geology in Belgrade, in cooperation with co-organizers (National University of Science and Technology "MISIS", Moscow, Russia Berg Faculty TU Košice, Slovakia, University of Ljubljana, Faculty of Natural Sciences and Engineering, Slovenia, Goce Delcev University in Stip, Macedonia and University in Banja Luka, Faculty of Mining, Prijedor, Republic of Srpska, Bosnia and Herzegovina), shall organize the 6th International Symposium Mining and Environmental protection.

Previous Symposium, were very successful and scientist and companies from many countries gathered to exchange information and research results. The objective of this Conference is to bring together engineers, scientists and managers working in mining industry, research organizations and government organizations, on development and application of best practice in mining industry in the respect of environment protection.

At the Book of Proceedings of 6th International Symposium on Mining and Environmental protection are 59 Papers. One third is from abroad, or their authors is from different countries. At least 150 authors and co-authors took part in the preparation of these papers. The papers were reviewed by Reviewers and Scientific Committee. Only high-quality papers were selected, from two side, one from the scientific basis and the second from point of view of applicability in resolving problems at the development of mining.

We are very grateful to the authors of the papers, who contributed to a great extent to the success of this meeting by having sent enough number of high quality papers, and thereby made the work of the reviewers a pleasant one in respect of selecting the best quality papers. Also we would like to thank all of the participants in the Symposium, as well as the sponsors who helped and enabled us to hold such a great meeting.

Editor

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6th International Symposium **MINING AND ENVIRONMENTAL PROTECTION**

Editor: prof. dr Ivica Ristovic, Faculty of Mining and Geology, Belgrade

Publisher: University of Belgrade, Faculty of Mining and Geology, Belgrade, Serbia

For publisher: Prof. dr Dušan Polomčić, Dean

Technical desing: M.Sc. Milena Lekić

Printed by*:* SaTCIP, Vrnjacka Banja, 2017

Copies: 150

ISBN 978-86-7352-298-2

The publication of this Proceedings approved by the Council of Faculty of Mining and Geology, University of Belgrade

All Papers in Proceedings are reviewed

This Proceedings was published with the financial assistance of the Ministry of Education, Science and Technological Development of Republic of Serbia

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6th International Symposium
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MINERS PERSONAL NOISE EXPOSURE IN METAL AND NON-METAL MINES IN MACEDONIA

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Abstract: *Miners in all types of mining (surface and underground) are usually exposed to high noise levels, resulting mostly from heavy and noisy machinery, while in underground mines limited and closed space further increases the problem of exposure to high noise levels. Excessive exposure to high noise levels poses a serious danger to the miners` health which can lead to poor verbal communication and reduce their ability to recognize warning signals. Excessive noise is also a global occupational health hazard with considerable social and physiological impacts, including noise-induced hearing loss (NIHL). Numerous researches and studies conducted, worldwide, indicate that exposure to high noise levels at mining workers poses a serious risks factor for hearing loss. This paper presents measured noise profiles of main sources in some mines and quarries in Macedonia, as well as personal noise exposure of workers involved.*

Key words: *Noise, Hearing loss, Mining, Exposure.*

1. INTRODUCTION

Noise exposure has been recognized as a causal factor in hearing loss for many hundreds of years [1]. Prolonged noise exposure over a period of years generally causes permanent damage to the auditory nerve and/or its sensory components [2]. Excessive noise is a global occupational health hazard with considerable social and physiological impacts, including noise-induced hearing loss (NIHL) [3]. NIHL is an irreversible sensorineural hearing impairment caused by prolonged exposure to noise. NIHL causes communication interference that can substantially affect social integration, self-image, and the quality of life (National Institutes of Health [4]. NIHL ranks among the most significant occupational health problems in many countries [5-10]. Workers suffering from NIHL are denied the ability to converse normally with others and are endangered in the work environment, as their ability to perceive audible warnings is seriously compromised [11]. Occupational noise exposure data for coal, metal, and nonmetal mining reported from different governmental or research organizations indicate high levels of noise exposure through the industry. The MSHA coal report showed that operators from seven different types of machines: auger miners, bulldozers, continuous mining machines, front end loaders, roof bolters, shuttle cars (electric), and trucks exceeded 100% noise dosage (US Department of Labor, Mine Safety and Health Administration, 2000–200514). Also, continuous mining machines were the number one machine among all the equipment whose operators exceed 100% dosage.

Results from Study of Personal Noise Exposure that have been conducted among Sand and Gravel miners shows that Miners' noise exposures exceeded the Recommended Exposure Limit (REL) of the National Institute for Occupational Safety and Health (NIOSH) for 69% of workers, and exceeded the Mine Safety and Health Administration's action level for enrollment in a hearing conservation program for 41% of workers [16].

In addition, a large number of scientific studies [3, 5, 8, 12, 20, 22, 23] also indicate that miners are very likely to experience overexposure to noise and proper noise control and protection measures are of up most importance in the efforts of providing safe workplace environment.

Having in mind magnitude of the problems associated, UGD - AMBICON lab has initiated several research campaigns in collaboration with national mining industry, aimed in identification of main sources in some mines and quarries in Macedonia, as well as personal noise exposure of workers involved.

2. METHODS AND MATERIALS

In order to determine main noise sources within mining operations as well as personal noise exposure levels of workers involved, measurement campaign involving few of the largest metal and non-metal mines in Macedonia was initiated in last few years (largest metal and non-metal open pits and one underground metal mine).

For all noise sources identified within the mineral extraction processes, a 15 minutes' noise levels measurement in one-third octave band were performed and source specific noise profiles were created. Noise measurements were performed at 1,5 m height nearby noise sources in one-third frequency octave band according to ISO 1996 2:2010 Acoustics - Description, measurement and assessment of environmental noise - Part 2: Determination of environmental noise levels, using a Sound Level Meter type CR: 171C, an instrument Class 1 according to IEC 61762. Frequency analysis provide additional information about the noise source as well as about prevalence of certain frequencies, whether they are in humans hearing range.

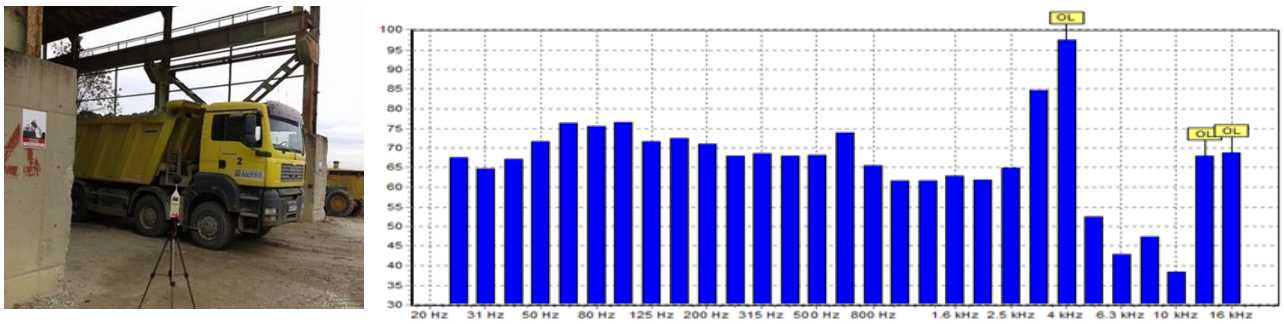

Figure 1. *Noise levels measurement and source specific profiles*

Personal Noise Exposure levels for homogenous exposure groups (HEG's) of workers were determined in accordance with EN ISO 9612:2010 Acoustics – Determination of occupational noise exposure – Engineering method and Directive 2003/10/EC of the European Parliament and of the Council on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise).

Measurements were performed using personal noise dosimeters (doseBadge - Cirrus Research plc) that measure sound levels over entire shift (8 hours) and provide calculation of cumulative noise level expressed as noise dose using proprietary software dBlink3. Dosimeters were placed at the employees` shoulder, at a distance of 0.2 to 0,4 m from the entrance of the external auditory canal.

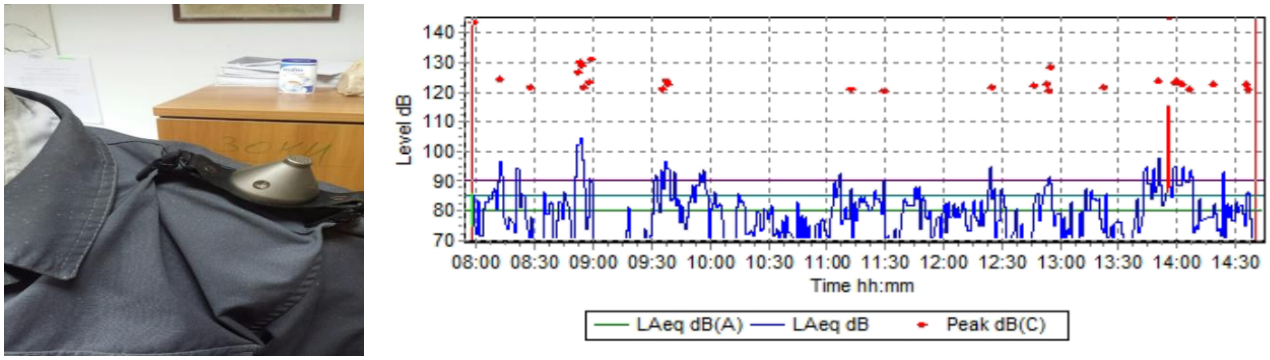

Figure 2. *Personal noise dosimetry*

Following parameters were directly determined through the measurements:

- L (p, A, eqT_e) – as A - weighted equivalent continuous sound pressure level for the effective duration of the shift;
- T_e - effective duration of the shift, in hours
- T_0 – reference shift duration (T_0 = 8 hours)
- $L_{EX,8h}$ – as A - weighted noise exposure level normalized to a nominal 8 hours shift;
- $L_{p, Cpeak}$ – as C - weighted peak sound pressure level
- Dose of daily noise exposure level [%].

Exposure values determined were compared against Exposure limit values and exposure action values as defined in Article 3 of the Directive 2003/10/EC where daily noise exposure levels and maximum sound pressure level are defined as follow:

- Exposure limit values: $L_{EX,8h}$ = 87 dB(A) and $L_{p, Cpeak}$ = 140 dB(C);
- Upper exposure action values: $L_{EX,8h}$ = 85 dB(A) and $L_{p, Cpeak}$ = 137 dB(C);
- Lower exposure action values: $L_{EX,8h}$ = 80 dB(A) and $L_{p, Cpeak}$ = 135 dB(C);

As required in above mentioned regulations, workplace description and data about personal hearing protection usage were also collected and accounted in subsequent risk assessment processes.

3. RESULTS AND DISCUSION

As expected, main noise sources within the mineral extraction zones, involves mostly heavy mining machinery like bulldozers, excavators, truck-tippers, crushers and conveyor belts [17,18,19]. Noise levels for main sources within quarry range between minimal 64.5 dB for trucks and 98.6 dB for bulldozers (Table 1).

Table 1. *Measured Noise Level at main mining noise sources*

Noise Source	Measured $L_{eq,15min}$ [dB(A)]
Bulldozers	95,8 - 98,6
Excavators	78,8 - 81,2
Truck-Tippers	64,5 – 69,7
Primary Crusher	83,4 – 86,3
Transport Conveyor	77,3 – 78,6

Personal exposure data of heavy equipment operators are mostly in line with noise levels of the respective noise sources, with exclusion of truck drivers where higher level of exposure are explained with effects from noise sources like bulldozers and crushers nearby trucks spent significant amount of their operating time during the shift.

Equivalent noise exposure level normalized to a nominal 8 hours shift, are highest for bulldozer (94,9 - 98,6 dB) and crusher (83,2 - 89,2 dB) operators and lowest for truck drivers (80,2 - 84,5 dB) and excavator operators (77,2 - 83,9 dB).
Results obtained with direct measurement of homogenous exposure groups (HEG's) of workers are given in table below (Table 2).

Table 2. *Personal Noise Exposure of heavy equipment operators*

Workplace	Min dB(A)	Max dB(A)	$L_{EX, 8h}$ dB(A)	Dose (%)
Bulldozer operators	96,5	101,1	94.9 - 98,6	1000 - 2600
Excavator operators	77,8	84,5	77,2 – 83,9	18 - 84
Truck drivers	80,6	85,1	80,2 - 84,5	33 - 92
Conveyer operators	83,2	85,8	82,7 - 84,3	64 - 85
Crusher operators	85,3	89,3	83,2 - 89,2	66 - 265

Results obtained clearly indicate that bulldozers and crusher operators are most exposed workers groups and in most cases the levels measured are significantly above the recommended exposure levels. For bulldozer operator's exposure levels in all cases are significantly above the threshold values (1000 to 2600% of recommended daily doses are measured). Exposure levels for other workers groups are below

the recommended exposure levels, but in all cases lower exposure action values are reached and exposure above 80% of recommended daily doses were measured.

Although the number of workers included in the measurements is rather limited, results clearly indicate magnitude of the problem, which is in most cases underestimated as such, even from the workers involved itself.
Data collected shows that more that 80 % of the workers didn't use the hearing protection equipment even when adequately provided, although 42 % of the report some hearing problems and more than 64 % reported associated health effects like high blood pressure.

5. CONCLUSION

It is clear that intensive mining operations and heavy equipment usage create noisy environment and significant noise exposures for workers involved are very likely. Long-term exposures of high noise levels could induce permanent auditory damage to the auditory nerve and/or its sensory components[2]. Excessive noise is a global occupational health hazard with considerable social and physiological impacts, including noise-induced hearing loss (NIHL)[1]. High levels of exposure are also indicated throughout the mining industry in Macedonia as shown with the results presented above. Unfortunately, this problem is neglected from all stakeholders involved, and although 42 % of the workers included in the audit reported some hearing problems, more than 80% didn't use protective equipment even adequately provided.

Therefore, it is of ultimate importance to initiate risk awareness campaigns and educate the workers and engineers about the consequences and protection measures available. Noise exposure could be effectively reduced through a systematic approach and implementation of engineering controls and hearing loss prevention programs.
This programs and control measures may involve significant resources, but positive examples throughout the industry proof their effectiveness and if properly implemented they could lead to immediate reduction of noise induced hearing loss problems. Proper selection and usage of hearing protection equipment is also one of readily available tools and ear muffs with NRR (Noise Reduction Rating) of 20 to 25 dB according to EN 352-1 should be mandatory used in all cases where significant exposure levels are determined. Also, in all cases where lower exposure action values are reached, usage of earplugs with NRR of 10 to 15 dB according to EN 352-2 should be mandatory.

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