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REVIEW ON THE PERSONAL NOISE EXPOSURE LEVEL IN A MANUFACTURING PLANT

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Abstract: The continuous growth of the technology allows the companies to purchase manufacturing equipment according to their needs and standards. While designing the production system the focus should be not only on the productivity but also on the ergonomic design of the workplace. One of the crucial factors for designing an ergonomic workplace is the noise. The noise in a manufacturing plant is generated from different sources depending on the industry, mainly from the machines and equipment. In this paper the level of personal noise exposure at 4 different departments in a manufacturing plant will be presented. The noise measurements were performed with dosimeters in three series. The results were downloaded and analyzed using a noise monitoring tool. According to the results presented in this paper the noise exposure level in a manufacturing plant varies depending on the noise sources located near the measurement point.
Keywords: manufacturing, noise measurements, exposure level

1. INTRODUCTION

Occupational noise is considered as one of the most common widespread risk factors, with a strong evidence base linking it to an important health outcome (hearing loss) [1]. It was reported that about 600 million workers worldwide were exposed to occupational noise each year [2]. Adverse effects of noise include stress, incomplete or complete hearing loss, increased risk of accidents, it may affect the cardiovascular system leading to the release of adrenaline associated with stress and increased blood pressure, and less intense noise can pose a danger to workers` safety, as it may interfere with verbal communication and affect working [3]. The noise level and the duration of a worker's exposure to the noise level present the most important factors regarding the noise hazards that can cause occupational diseases and they pose a serious risk to the health of occupationally exposed workers [4].

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 [5]. Prolonged exposure to noise at high intensity is associated with damage to the sensory hear cells of the inner ear and development of permanent hearing threshold shift, as well as poor speech in noise intelligibility [6]. There is also evidence that noise exposure frequently leads to tinnitus which might be due to alterations in the central auditory function [5]. In the adult population it may significantly influence quality of life and constitute a major limitation in relation to hearing–critical jobs, decreasing the potential worker's opportunities of employment.

The noise in the manufacturing industry is generated by the machines and tooling used in the manufacturing process. The worker operating on a specific machine is exposure to noise of the machine, but this affects also the workers operating in the same area or within the plant. The diverse nature of equipment used by the manufacturing sector results in varying noise levels due to the age of the used equipment, and the operational speed of the machines. A large percentage of the labor force employed in a manufacturing plant is exposed to noise. According to literature research, a huge part of the production plants create noise that exceeds the permitted limits, and on average ranges between 70–118 dB.

In order to determine the minimum requirements for workers` protection from risks to their health and safety in the Republic of North Macedonia there is a 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).

The Rulebook covers the risk that arise or for which there is a possibility of arising from noise exposure, especially the risk of hearing loss. 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) [8]. The manufacturing companies have to adopt the recommendations and maintain noise exposure level under the limit values in accordance with the Rulebook.

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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

To be able to act in accordance with the Rulebook the industry need to perform regular noise measurements, track the noise exposure level and implement measures to mitigate the adverse effects. The goal of noise management is to maintain low noise exposures, such that human health and wellbeing are protected. Eliminating or reducing excessive noise at workplace is not simply a legal responsibility for employers but it is also in an organization's commercial interest. As much as safe and healthier the working environment is, the probability of cost due to absenteeism, accidents and under performance is decreasing. Noise can be a serious problem in many industry workplaces, but whatever the workplace, there are three key steps that should be followed to prevent noise adverse effects to workers:

- assess the risks of noise exposure;
- when the assessment is completed, take actions to prevent or control the risks;
- regularly monitor and review the effectiveness of the measures in place. [7]

The assessment means that all relevant noise sources need to be identified and regularly monitored. Depending on the results of the assessment preventive and corrective measures will be adopt if required. To ensure effective noise control program, the industry need to regularly review the implemented action plan. The aim of this paper is to determine the personal noise exposure level in each department of a manufacturing plant and if they are exceeding the limit values according to the Rulebook on safety and health at work of the workers at noise risk. Depending on the results additional action will be proposed. Regular measurement and monitoring of personal noise exposure is necessary in order to ensure and maintain the noise level in the working environment within the limit values, to protect workers` health, reduce risk of adverse effects, improve working conditions, increase productivity and product quality.

2. RESEARCH MATERIALS AND METHODS

The aim of the research is determination of the personal noise exposure level in a manufacturing plant and for this purpose noise level measurements were performed. The basic measuring strategies for noise level in the working environment and the guidelines for the correct choice of measuring process are described in the international standard MKS EN ISO 9612: 2010 Acoustics – Determination of noise exposure in the working environment – Engineering method [9]. The methodology for noise exposure measurement includes the following 4 steps:

- analysis of the work process;
- choice of measurement strategy;
- measurement;
- error assessment and measurement uncertainty.

The manufacturing plant has four different organizational units and due to that the research team has chosen 4 departments and 2 measurement point by department in the plant. The measurements were performed in three series in a period of one month. The equipment used to measure the personal noise exposure of the workers in a manufacturing plant is the following: 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 [10] and software tool for data management. Dosimeters are small devices that contain a microphone to capture the level of personal noise exposure. The dosimeters used for the measurements is a set of dosimeters for personal noise exposure (doseBadge) of the manufacturer CASELLA Dbadge2. The software tool for noise data management used in the research is Noise safe.

When using noise dosimeters, the microphone is placed on top of the workers` shoulder at about 0.1–0.4 m from the entrance of the external ear canal on the side of the most exposed ear as presented in Figure 1. We need to be sure that the microphone is not covered with clothing or other material that can be a cause for not accurate data. The criterion for selecting the workers is that they must be at their workplace for 8 hours including regular breaks. Before the dosimeters are distributed, the workers who participate in the research will receive instructions on how to use the dosimeters and what is the purpose of this measurement equipment. All the participants voluntarily accepted to be part of the research and to act properly by the guideline given by the research team.

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3. RESULTS AND DISCUSSION

Having the measurements completed the data recorded with dosimeters were downloaded using a software tool. The measured levels of noise exposure in a manufacturing plant have been normalized to 8 hours working day and the daily noise exposure level, LEX,8h, has been obtained according to the ISO 9612–2009: Acoustics – Determination of occupational noise exposure – Engineering method. In addition, the formula (1) used for the calculations:

$$LEX, 8h = LAeq, Te + 10 \log_{10} Te/To \text{ dB (A)} \quad (1)$$

where:

LAeq, Te – measured equivalent noise level in dB (A) during Te

Te – daily duration of the employee's exposure

To – 8 hours reference time.

Figure 1 – Dosimeter position during personal noise exposure measurement

The main noise source in the manufacturing plant are machines and equipment used in the production process. In addition, the results obtained for all the departments included in the research will be presented. Table 2 shows the noise exposure levels in Department 1. The measured noise levels do not exceed the limit values according to the Rulebook on safety and health at work of the workers at noise risk in North Macedonia. The daily tasks in Department 1 require exposure to noise generated from the machines and equipment but not constantly.

Table 2. Personal noise exposure level at a manufacturing plant – Department 1

Measurement point	Min [dB(A)]	Max [dB(A)]	Lex,8h [dB(A)]
Department 1 A	65.4	72.9	67.9
Department 1 B	50.2	75.2	68.6

Table 3 presents the noise exposure levels in Department 2. The measured noise levels do not exceed the limit values according to the Rulebook on safety and health at work of the workers at noise risk in North Macedonia. Lower noise exposure level than those in Department 1 were obtained. The daily tasks in Department 2 do not require exposure to noise generated from the machines but from some equipment.

Table 3. Personal noise exposure level at a manufacturing plant – Department 2

Measurement point	Min [dB(A)]	Max [dB(A)]	Lex,8h [dB(A)]
Department 2 A	60.8	67.6	61.9
Department 2 B	56.1	72.4	66.6

Table 4 presents the noise exposure levels in Department 3. The measured noise levels do not exceed the limit values according to the Rulebook on safety and health at work of the workers at noise risk in North Macedonia. Higher noise exposure level than those in Department 1 and 2 were obtained. The daily tasks in Department 3 require exposure to noise generated from the machines and equipment.

Table 4. Personal noise exposure level at a manufacturing plant – Department 3

Measurement point	Min [dB(A)]	Max [dB(A)]	Lex,8h [dB(A)]
Department 3 A	67.4	75.7	70.3
Department 3 B	66	74.9	70.1

Table 5 presents the noise exposure levels in Department 4. The measured noise levels do not exceed the limit values according to the Rulebook on safety and health at work of the workers at noise risk in North Macedonia. Higher noise exposure level than those in Department 1,2 and 3 were obtained. The daily tasks in Department 4 require exposure to noise generated from the machines and equipment.

Table 5. Personal noise exposure level at a manufacturing plant – Department 4

Measurement point	Min [dB(A)]	Max [dB(A)]	Lex,8h [dB(A)]
Department 4 A	80.4	83.1	79.6
Department 4 B	77.9	80.3	76.8

According to the literature research, a huge part of the manufacturing plants create noise that exceeds the permitted limits, and on average ranges between 70–118 dB. The results presented in this paper vary between 62–80 dB. Comparing to the underground mining industry, where noise exposure level varies in the range of 70–90 dB, the workforce in the manufacturing plant is exposure to lower noise levels [10].

The industry needs to adopt a control plan for noise exposure and monitor the exposure levels. In this way will keep adequate workplace for everyone. Machinery, equipment, and work practices are typically the sources of excessive noise in the workplace [11]. During the phase of purchasing new equipment the

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industry should take in consideration the effect of the noise caused by the equipment as one of the sourcing criteria. The implementation of noise control program and other aspects of noise regulations place a financial and compliance burdens on employers. However, this should not discourage employers from implementing feasible engineering noise controls [12].

4. CONCLUSIONS

The results from the performed measurements of personal noise exposure of the workers in a manufacturing plant present different noise exposure level in the monitored departments. The noise level varies depending on the machines and tools located around the measurement point and their operational time. The measured values do not exceed the limit exposure value according to the Rulebook on safety and health at work of the workers at noise risk (Official Gazette of RM, no. 21/08) applicable in North Macedonia.

However, the exposure levels are high at some of the measurement points, near the limit value of 85dB, and this requires regular control measurements as there can be a risk factor for that may cause adverse effects to the health and safety of the workers. Performing regular measurements and risk assessment on the personal noise exposure level will keep the workplace safe and healthy.

Establishing and maintaining hearing loss prevention program, including trainings and education on the risks, preventive and corrective measures, and personal protective equipment, is not a benefit only for the workers but also for the employer. The social and economic costs arising from harmful effects of occupational noise are a cause for concern in all industries. Minimizing the occupational health and safety risks and hazards will result in increased productivity and high–quality products.

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