COMPARATIVE STUDY OF NOISE MEASUREMENT IN WORK ENVIRONMENT WITH FREQUENCY WEIGHTINGS

Doc. Ing. Michaela Balážiková, PhD.[1], Ing. Martina Dulebová[2]
Faculty of Mechanical Engineering – Technical University of Kosice, Department of Safety and Quality of Production, Slovak Republic[1,2]

michaela.balazikova@tuke.sk, martina.dulebova@tuke.sk

Abstract: *The paper deals with the impact of noise (low frequency noise on threshold point) on human health and safety in the workplace. The first part of the article describes the main impacts of noise on human health - specific and systemic. Part of the paper is also the process of risk assessment according to the valid directive of the European Parliament and Council Directive 2003/10 / EC.*

The paper deals with frequency weightings of low frequency noise. Authors describe frequency weightings A and Z and its difference in low frequency noise measurement and also the main goal of its usage. Part of article is experimental measurement of this noise in work environment.

Keywords: RISK ON WORKPLACE, LOW FREQUENCY NOISE, NOISE MEASUREMENT

1. Introduction

Noise is unwanted sound that can cause impairments or damage to health. The employee is surrounded at the workplace by various noises. Some are necessary, because they have meaning as signals, enable him to orientate in space and influence his behaviour and communication with other people; others are undesired, because they have a disruptive or even damaging effect. [1]

The risk of damage (changes) to the hearing of employees occurs after long-term exposure to noise with a level over 80 dB. The effects of noise can be divided into two basic groups, namely specific and systemic (non-auditory) – Fig.1. The specific effects of noise on a person are those influences whose final effect is directly dependent on damage and changes to the auditory organs. The systemic effects of noise on a person are those influences that in a crucial way change the functioning of part of the central nervous system other than the auditory organs. These are then mediated by special structures of the nervous system. [1] [2]

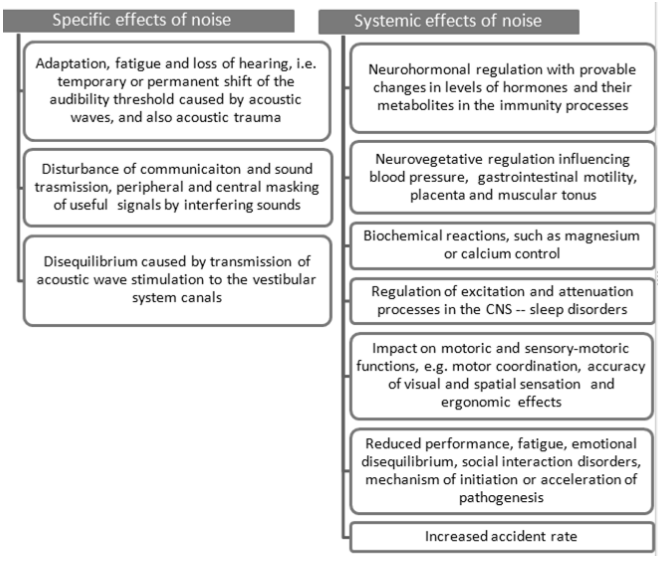

Fig. 1: *Specific and systematic effects of noise*

2. Low frequency noise

Low frequency noise is one of the most harmful factors occurring in human working and living environment. Low frequency noise components from 20 to 250 Hz are often the cause of employee complaints. [3]

In recent years, some European countries have adopted national criteria for low frequency noise, including Sweden ((Socialstyrelsen¬Sweden, 1996)), Denmark (Jakobsen, 2001) Netherlands ((N S G, 1999) Germany (DIN: 45680, 1997), Poland (Mirowska, 2002). Some of these methods assume a threshold curve for limitation of annoyance, based approximately on the ISO226 threshold, or a curve parallel to this threshold, but extended to frequencies below 20Hz. [4]

Human hearing has in general different sensitivity with different vibrations. During the perception of noise distortion occurs, and for this reason weight filters A, B, C, D, G and Z are introduced which are used for the conversion of the actual measured values of noise level to other levels. These filters are inverse to the curves of the equal noise volume at levels of 40 dB, 80 dB and 120 dB, and their frequency sensitivity is similar to the frequency sensitivity of the human ear.

2.1 Sources of low frequency noise

Low-frequency mechanical vibrations generated by machines and machine systems evoke disruptive dynamic forces, which are most often caused by imbalanced rotating material or material with reverse movement, abaxial connection of rotational components, disproportional shaking of mutually moving components, a mechanical release, seismic excitement and technological process. [5]

One of the most important sources of low-frequency noise is the flowing of a fluid in machine systems, ventilation and air-conditioning systems, combined units, transport vehicles, combustion turbines, compressors, entertainment businesses and festivals as well as household appliances. Low-frequency wavelengths can also have a natural character, such as, for example, the atmospheric flowing of air. [4][5]

2.2 Effects of low frequency noise

The adverse health effects of community noise include subjective annoyance, interference with speech communication, disturbance of rest and sleep, impaired psychological function, and negative behavioural effect. Besides the psychosocial effects of community noise, there is also concern about the impact of noise on the cardiovascular system. [4]

Studies have found that low frequency noise can be annoying and can create potential health hazards for people exposed to them, especially for highly sensitive subjects. [6]

From experience, it can be concluded that working and resting in such an environment can lead to headaches, and unpleasant feelings which, in turn, can lead to a reduction of working or relaxing efficiency. In general, it has been found that if people are exposed to very low frequencies of sound and infrasound, they may experience difficulties in performing mental work, as well as a general sense of discomfort. As the intensity increases or exposurecontinues for longer periods of time, dizziness, nervousness, fatigue, irritation, nausea, and headaches may occur. [6] [7]

3. Measurement of low-frequency noise on workplace

Measurements are essential for assessing the negative effects of noise and for setting permissible values (criteria) which influence health, comfort and performance in a negative way. Measuring the exposure of employees to noise during work is among the quantitative measurements, and it is done for the purpose of assessing the health-risk of noise exposure and the assigning of a job to a category. An important part of any management of acoustic risks is introducing appropriate criteria for determining a favourable solution to the problems of noise. The required minimizing subsequently determines the resources for making alternative proposals for reducing noise and in the end the resources for estimating costs when meeting the required criteria. [8]

The measuring and setting of noise exposure ran at a workplace where automobile parts are machined using a CNC cutting machine. (Fig.2)

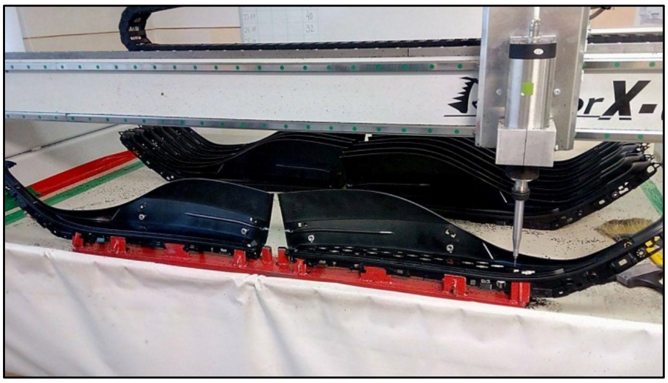

Fig. 2: *Noise source – CNC cutting machine*

The application range of the CNC milling machine Raptor X- SL is extremely wide due to the adjustable work surface height. The Z axis stability is excellent, allowing you to work as accurately on large 3D objects as one can on flat sheet materials. Chosen technical data of this CNC milling machine shows Table 1.

Table 1: *Technical Data of CNC cutting machine [9]*

Technical data Raptor X-SL 1200/S20	
Clamping Area	X -1500 x Y-2200 mm
X-axis Travel	1200 mm
Y-axis Travel	2010 mm
Z-axis Travel	300 mm Standard, optional up to 600mm available
Positioning speed X+Y / Z	40.000 mm/min max. (in Verb. mit WIN PCNC USB)
Working speed	20.000 mm/min max./ 3D-travel up to 10.000 mm/min
Step width X	0,0213 mm
Step width Y + Z	0,0113 mm
Repeat accuracy	approx. 10 µm
Positioning error	can be calibrated
Drive X / Y / Z	Stepper motor 9,4 Ampere / 930 Ncm holding torque!
Drive type X / Y / Z	Low backlash precision planetary gears with 11000 Ncm output torque
Power supply 3-channel controller	380 Volt / 50 Hz
Full version Software CAD/CAM	ConstruCAM-3D
Total weight	approx. 820 kg incl 3-channel controller
Construction and surface	Massive steel construction, fully powder coated, light grey

The measuring of the noise was performed at the workplace of the equipment operator during operation; noise was measured using a 2250 noise analyser from the company Brüel & Kjær (Fig.3), which serves for performing broadband measurements of noise exposure in the field. The B&K 2250 host a number of software modules, including frequency analysis, logging (profiling) and recording of the measured signal. [10]

Key features of hand-held Analyzer Type 2250:

- General-purpose Class 1 sound measurements to the latest national and international standards
- Occupational noise assessment
- Environmental noise assessment and logging
- Product development and quality control
- FFT analysis of sound and vibration
- Building acoustics, loudness and noise rating measurements
- Tone assessment using 1/3-octave and FFT methods
- Low-frequency building vibration according to ISO 8041:2005 and DIN 45669 – 1:2010 – 09
- Infrasound (G-weighting) measurements according to ISO 7196:1995 and ANSI S1.42 – 2001 (R2011)

Fig. 3: *Hand- held Analyzer Type 2250, module for frequency analysis and time module*

During the measurement of noise only a CNC cutting machine was active at the workplace. The axis of the microphone was set for the CNC cutting machine, and the noise meter was placed at a height of 1.5 m above the floor. The results were stored in the memory of the measuring device and subsequently processed using the relevant computer software. Operator of technical device is not using hearing protectors and during milling he is right next to the CNC milling machine (Fig.4).

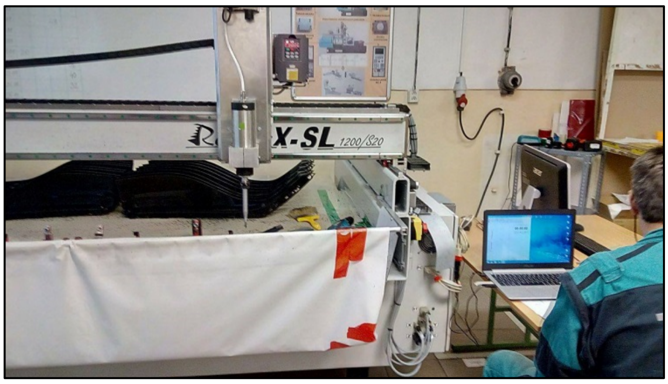

Fig. 4: *Workplace of measurement of low frequency noise from machine*

During the experimental measuring the equivalent level A of acoustic pressure L_{Aeq} and the equivalent level Z of acoustic pressure L_{Zeq} were measured over time during the performance of the machining work. The main reason and aim of this measurement was to point out the different levels of acoustic pressure using the A-scale filter and the Z-scale filter at low frequency 80 Hz and at frequency 500 Hz. Records from measurements at various frequencies and weightings are shown in Fig.5 - Fig. 8.

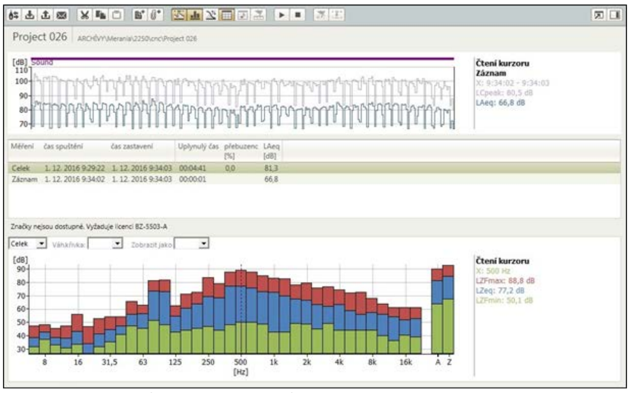

***Fig. 5:** Record of measurement of noise level A exposure at 500 Hz*

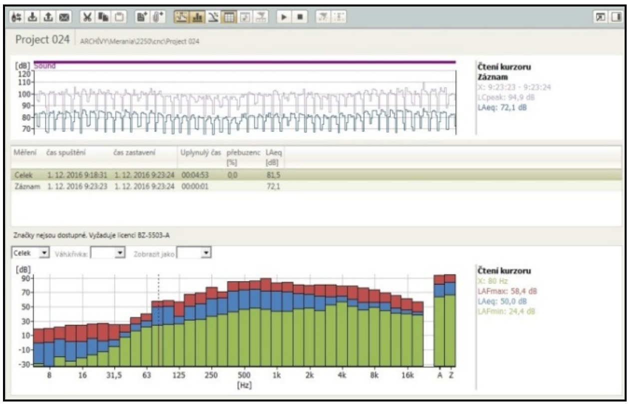

***Fig. 6:** Record of measurement of noise level A exposure at 80 Hz*

***Fig. 7:** Record of measurement of noise level A exposure at 500 Hz*

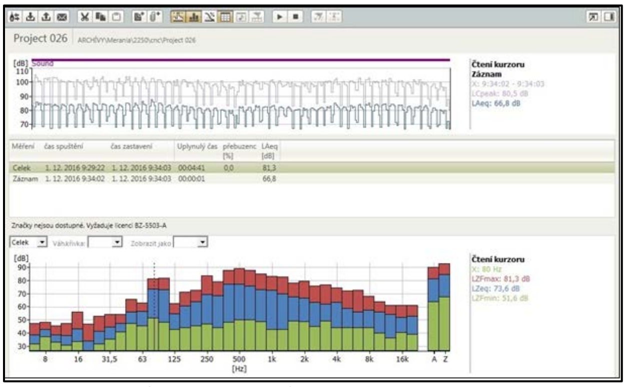

***Fig. 8:** Record of measurement of noise level Z exposure at 80 Hz*

Summary of measured values are in Tab.2.

***Table 2**: Summary of measured data*

Weight filter A	
L_{Aeq} value (500 Hz)	73,7 dB
L_{Aeq} value (80 Hz)	**50 dB**
Weight filter Z	
L_{Zeq} value (500 Hz)	77,2 dB
L_{Zeq} value (80 Hz)	**73,6 dB**

4. Evaluation of the experimental measurement

The measuring of the noise load during machining points to the fact that acoustic wavelengths of low frequency (specifically at 80 Hz) have a higher value with weighted Z than with the weighted A, with the difference in values of 23.6 dB. Such low frequencies are able to influence the cardiovascular system, the neuropsychic system and the sensory-motor functions of a person.

Fig. 9 describes the process of risk assessment of noise on selected workplace during the low frequency noise measurement with A - weighting and Z- weighting at frequencies 80 Hz as well as the comparison at 500 Hz.

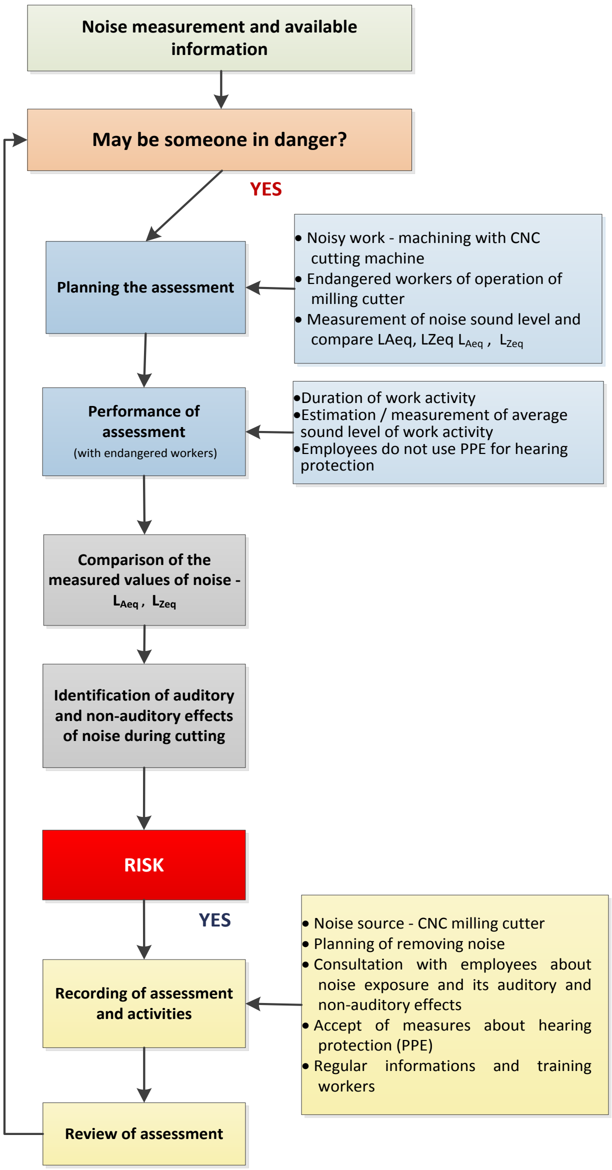

***Fig. 9:** Process of risk assessment of noise on selected workplace*

The Z-weighting represents the real influence of acoustic energy on a person and the environment, and the A-weighting represents the sensory expression of the acoustic energy, which is mainly lower and does not correspond to the real state. [7]

It is impossible from the viewpoint of the working of energy to correctly evaluate the acoustic wavelengths at low frequencies of the A-weighting; therefore, it is more appropriate to use the Z-weighting, or even the C. A small sensitive portion of the population can feel discomfort of very low frequencies (infrasound) even from levels of 65 dB, if the relevant combination of frequency and length of working occur. [7]

5. Conclusion

The mutual working of noise and other factors of the work environment increase the risks that employees are exposed to during their work activities. Employers have the legal obligation to ensure that the level of safety and protection of health is such that risks arising at the workplace with individual work activities are acceptable. On the basis of exceeded values the employer is obligated to immediately take measures following from general principles of prevention, to take the relevant measures (so long as this is possible) for removal of the source of noise, or reducing it at the given workplace, and provide workers with appropriate and adequate personal protective equipment (PPE).

At present, when one of the most significant problems is becoming the securing of reliable operation of newly proposed mechanical systems, questions on studying the origin, spread and isolation of low-frequency wavelengths from machines and their parts are very topical. It is possible to ensure the required reduction of the unwanted effects of low-frequency noise on a person and the surrounding environment using vibrodiagnostics and vibroisolation.

Measures for noise reduction can significantly change the surrounding machine-person environment. Therefore, it is recommended that all interested parties make use of each proposed measure and actively take part in its preparation. Representatives who perform a variety of functions can or should take part.

Because low-frequency noise is a major component of many occupational and community noises the effects of such noises may be viewed as, in part, the effects of low frequency noise. Regularity authorities must accept that annoyance by low frequency noise presents a real problem which is not fully described by the commonly used assessment methods. There is an increasing acceptance that low frequency noise needs to be specifically attended to, but only a few countries have adopted specific guidelines for low frequency noise.

The investigations show that these limits are not sufficient from viewpoint of human health in the generation of specific low frequency noise. Therefore, it is needed to define the limit values and procedures describing the circumstances under which compliance with the regulations can be verified. These procedures can be based either on calculations from sound prediction models or on measurements. [6]

This contribution is the result of the project implementation:

"APVV 15-0351 Development and application of risk management models in terms of technological systems in line with the industry (Industry) 4.0".

"VEGA 1/0150/15 Development of methods of implementation and verification of integrated systems for safe machines, machine systems and industrial technologies".

"*University Science Park Technicom for Innovation Application Supported by Knowledge Technology, ITMS: 313011D232*".

6. Literature

[1] BALÁŽIKOVÁ M., SINAY, J.: Implementation of auditory and non-auditory effects of noise in the risk assessment process in mechanical engineering. In: Procedia Engineering. 2012, No. 48, p. 621-628. ISSN 1877-7058S

[2] BABISCH W., BASNER M., DAVIS A., et al. Auditory and non-auditory effects of noise on health. In: Lancet. 2014;383 (9925):1325-1332

[3] SHEHAP M.A., SHAWKY H.A, EL-BASHEER, T. M.: Study and Assessment of Low Frequency Noise in Occupational Settings. In: Archivec of acoustics. 2016. roč. 41, č. 1, s. 151–160.

[4] BERGLUND, B., HASTEN, P., JOBR, F,.: Sources and effects of low-frequency noise. In: J. Acoust. Soc. Am. roč.99, č. 5, 1996, s. 2985–3002.

[5] ŽIARAN, S.: Nízkofrekvenčný hluk a kmitanie. Bratislava: STU, 2016. 316 s. ISBN 978-80-227-4536-9.

[6] ŽIARAN S. The assessment and evaluation of low-frequency noise near the region of infrasound. Noise Health -2014;16:10-7

[7] PAWLACZYK- ŁUDZCZYNSKAM, MALGORZATA A KOL.: The impact of low frequency noise on human mental performance. In: International Journal of Occupational Medicine and Environmental Health. roč. 18, 2005, č. 2, s. 185 - 198.

[8] BALÁŽIKOVÁ, M.: Riadenie akustických rizík: Habilitačná práca. Košice: TU,2014.111 s.

[9] Operating Instructions Raptor X-SL-Series. 2010. 102 p. https://www.cnc-step.de/wp-content/uploads/2014-12-17-Operating-Instructions-RaptorX-SL-Series-1.pdf [cit. 2017-30-03]

[10] Product Data Hand-held Analyzer Types 2250 and 2270. 20p. http://www.bruel.hu/pdf/bp2025types225070G4.pdf [cit. 2017-30-03]