

Admissible values and methods of measurement of noise, ultrasonic noise and infrasonic noise at workplaces in Poland

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ABSTRACT

The adverse effects of noise, ultrasonic noise and infrasonic noise on human are associated mainly with the hearing organ. Nevertheless, non-auditory effects can be also observed in the entire human body. Therefore, the admissible values of noise and ultrasonic noise at workstations are specified in the Regulation of the Minister of Family, Labour and Social Policy. According to this Regulation, measurement methods should be specified in Polish Standards, and, consequently, the method for the measurement of noise at workplaces is defined in the Polish Standard PN-EN ISO 9612. In the case of ultrasonic noise the draft Polish Standard prPN-Z-01399 “Ultrasonic noise. Requirements for measurements in the work environment” was developed on the basis of the results of studies carried out in CIOP-PIB. Moreover, as regards the workplaces occupied by juveniles and pregnant women, the admissible values of noise, ultrasonic noise and infrasonic noise are defined in regulations issued by the Council of Ministers. In turn, values that constitute the criteria of annoyance of noise and infrasonic noise are defined in Polish Standards PN-N-01307 and PN-Z-01338. The discussion of the admissible values and the characterization of the draft Polish Standard prPN-Z-01339 are presented in the paper.

Keywords: Noise, Workplace, Measurement

1. INTRODUCTION

Chemical, biological and physical (including noise, ultrasonic noise, infrasonic noise, vibration, electromagnetic fields, optical radiation and microclimate) harmful factors are common in the working environment. According to the data of the Statistics Poland, in 2017, 262100 employed persons counted once in the group of predominant factor were exposed to work environment hazard (1). These data do not include enterprises employing less than 10 people, therefore it is estimated that the number of people employed in hazardous conditions can be twice as large.

As referenced in (1), in 2017, among hazardous factors related to work environment, noise was the most serious hazard affecting 187500 persons (58.0 % of persons employed in hazardous conditions). The number of persons exposed to noise was more than three times as large as those exposed to the second most frequent hazard in terms of frequency – industrial dusts which endangered 53400 persons (16.5% of persons employed in hazardous conditions). The most persons exposed to noise and industrial dusts were recorded in mining, first of all in mining of hard coal and lignite, and in manufacturing, primarily of metal products (1).

Working in such hazardous conditions may cause workers’ occupational diseases. In 2016, 2119 cases of occupational diseases were recorded in Poland, i.e. 14.3 cases per 100000 employed persons (2). According to the same reference (2), the incidence rate was mainly caused by pneumoconioses (28.5%), infectious or parasitic diseases (27.2%), chronic voice disorders (9.7%), chronic diseases of the peripheral nervous system (8.6%) and hearing loss (6.3%, i.e. 133 cases).

Based on the frequency range, noise is subdivided into:

- infrasonic noise, including frequencies from 1 to 20 Hz,
- audible noise (commonly known as “noise”), including frequencies from 16 (or 20) to 16000 (or 20000) Hz,

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- ultrasonic noise, including frequencies from 10000 to 40000 Hz.

The adverse effects of noise, ultrasonic noise and infrasonic noise on human are associated mainly with the hearing organ. Nevertheless, non-auditory effects can be also observed in the entire human body. Therefore, the admissible values of noise and ultrasonic noise at workstations are specified in the Regulation of the Minister of Family, Labour and Social Policy (3). According to this Regulation, measurement methods should be specified in Polish Standards. Evaluation of actual threats of noise and ultrasonic noise requires the employer's identification of the values of noise and ultrasonic noise exposures at workplaces. The purpose of this study was to present a discussion of the current admissible values of noise, ultrasonic noise and infrasonic noise at workplaces in Poland (including maximum admissible intensity and/or annoyance criteria) and of the measurement methods. Particular attention is paid to the ultrasonic noise measurement method.

2. NOISE

Noise (audible noise) is defined as all adverse, unpleasant, irritating, annoying or harmful sound that reaches the hearing organ and influences other senses and parts of the human body (4). The values of the maximum admissible intensities (MAI) of noise at workplaces are specified in the regulation of the Polish Minister of Family, Labour and Social Policy concerning the maximum admissible concentrations and intensities in the work environment for agents harmful to the health (3). According to this Regulation, occupational noise is characterized by:

- the A-weighted noise exposure level normalized to an 8 hour working day (daily noise exposure level), $L_{AEx,8h}$, (or normalized to a working week),
- the A-weighted maximum sound pressure level, L_{Amax} ,
- the C-weighted peak sound pressure level, L_{Cpeak} .

Table 1 specifies the values of MAI of noise.

Table 1 - The values of MAI of noise (3)

Parameter	Value of MAI
The A-weighted noise exposure level normalized to an 8 hour working day (daily noise exposure level), $L_{AEx,8h}$	85.0 dB
The A-weighted maximum sound pressure level, L_{Amax}	115.0 dB
The C-weighted peak sound pressure level, L_{Cpeak}	135.0 dB

In the case of workplaces occupied by pregnant women or by juveniles the values of MAI of noise are more rigorous (5, 6) – see Table 2.

Table 2 – The values of MAI of noise for pregnant women (5) and juveniles (6)

Parameter	Pregnant women	Juveniles
The A-weighted noise exposure level normalized to an 8 hour working day (daily noise exposure level), $L_{AEx,8h}$	65.0 dB	80.0 dB
The A-weighted maximum sound pressure level, L_{Amax}	110.0 dB	110.0 dB
The C-weighted peak sound pressure level, L_{Cpeak}	130.0 dB	130.0 dB

In addition to the above mentioned, obligatory values of MAI of noise, there are facultative admissible noise values according to the employee's possibility to fulfilling the basic tasks – the criterion of annoyance of noise (7). According to this criterion the equivalent A-weighted sound pressure level during the occupation of a workplace by an employee should not exceed the values given in Table 3.

Table 3 – The admissible values of the equivalent A-weighted sound pressure level (SPL) according to the employee’s possibility to fulfilling the basic tasks (7)

Workplace	A-weighted SPL, dB
In administrative rooms, design office room, theoretical study rooms, data processing rooms; in other rooms of similar designation	55
In dispatch, observation and remote control cabins equipped with telephone communication means used in the process of control; in rooms for performance of precision works; in other rooms of similar designation	65
In direct control cabins not equipped with telephone communication means; at laboratories with noise sources; in other rooms of similar designation	75

Methods for the measurement of noise at workplaces are specified in the Polish Standards PN-EN ISO 9612:2011 (8), PN-N-01307:1994 (7) and PN-ISO 1999:2000 (9).

3. ULTRASONIC NOISE

According to (4), ultrasonic noise contains components of high audible frequencies and low ultrasounds frequencies from 10 kHz to 40 kHz. Technological ultrasound devices are the main sources of ultrasonic noise in the working environment. Ultrasonic noise is a harmful factor in the working environment, and therefore this kind of noise is included in the Polish list of harmful factors. According to the above mentioned Regulation of the Minister of Family, Labour and Social Policy (3), ultrasonic noise at workplaces is characterised by the following quantities:

- equivalent continuous sound pressure levels in the third-octave bands of centre frequencies, f , 10 kHz, 12.5 kHz, 16 kHz, 20 kHz, 25 kHz, 31.5 kHz and 40 kHz, normalised to a nominal 8-hour working day, $L_{feq,8h}$, or to a working week, $L_{feq,w}$, (in the case of exposure to ultrasonic noise at an irregular manner over each day in a week or if a person works another number of days a week than 5 days),
- maximum sound pressure levels in the third-octave bands of centre frequencies, f , 10 kHz, 12.5 kHz, 16 kHz, 20 kHz, 25 kHz, 31.5 kHz and 40 kHz, L_{fmax} .

The values of the above-mentioned levels should not exceed the values of MAI of ultrasonic noise specified in the Regulation (3) and given in Table 4. Lower values of MAI of ultrasonic noise are in force to workplaces for pregnant women (5) and juveniles (6) – see Table 5 and Table 6.

Table 4 – The values of MAI of ultrasonic noise (3)

Frequency f , kHz	$L_{feq,8h}$ or $L_{feq,w}$, dB	L_{fmax} , dB
10, 12.5, 16	80	100
20	90	110
25	105	125
31.5, 40	110	130

Table 5 - The values of MAI of ultrasonic noise for pregnant women (5)

Frequency f , kHz	$L_{feq,8h}$ or $L_{feq,w}$, dB	L_{fmax} , dB
10; 12.5; 16	75	95
20	85	105
25	100	120
31.5; 40	105	125

Table 6 - The values of MAI of ultrasonic noise for juveniles (6)

Frequency f , kHz	$L_{feq,8h}$ or $L_{feq,w}$, dB	L_{fmax} , dB
10; 12.5; 16	75	100
20	85	110
25	100	125
31.5; 40	105	130

In 2018 the preliminary draft of the Polish Standard prPN-Z-01339 “Ultrasonic noise. Requirements for measurements in the work environment” was developed on the basis of the results of studies carried out in the Central Institute for Labour Protection – National Research Institute (CIOP-PIB). The measurement procedure (elaborated in CIOP-PIB, published in (10) and described in (11, 12, 13)) was implemented in the draft Standard prPN-Z-01339:2019 (14).

The current draft Standard prPN-Z-01339:2019 specifies both a method for measuring ultrasonic noise in the work environment and a method for determining of equivalent sound pressure levels of ultrasonic noise. The scope of the measurements includes sound pressure levels in the third-octave bands with the centre frequencies from 10 kHz to 40 kHz. The draft Standard prPN-Z-01339 also specifies a method for taking account of amendments related to the influence of the metrological characteristics of the measuring devices and the influence of a microphone protective grid on measurement results. The developed measurement process requires the observation and analysis of the ultrasonic noise exposure conditions in order to control the quality of measurements. Therefore, the draft Standard prPN-Z-01339 allows to estimate uncertainty measurements in order to determine the quality of the measurements. The main principles of measurements are the following (11, 12):

1. The ultrasonic noise measurements shall be carried out in the presence of the worker at the workplace. During measurement the microphone should be placed at a distance of approximately 10 cm from the external ear canal, on the side of the ear exposed to higher value of the sound pressure level.
2. The task based strategy (8) is recommended. For that reason the working time on the tested workplace should be divided into the duration of the individual tasks. The total duration of the tasks should encompass the full working shift.
3. At least three sound pressure measurements shall be performed for each task. The equivalent sound pressure level values for the m -th task shall be determined on the basis of Eq.(1):

$$L_{fi,eq,Tm} = 10 \log \left(\frac{1}{J} \sum_{j=1}^J 10^{0,1L_{fi,eq,Tm,j}} \right) \quad (1)$$

where:

$L_{fi,eq,Tm}$ – the equivalent sound pressure level in the i -th third-octave band for the m -th task, in dB,

$L_{fi,eq,Tm,j}$ – the equivalent sound pressure level in the i -th third-octave band, and for the j -th measurement for the m -th task, in dB,

J – the number of measurements for the m -th task.

4. The result of the equivalent sound pressure level measurement in the i -th third-octave band and

the result of the maximum sound pressure level measurement in the i -th third-octave band should be adjusted according to Eq. (2):

$$L_{fi} = L'_{fi} + K_{apfi} - K_{gfi} \quad (2)$$

where:

L'_{fi} – the meter/analyser reading in the i -th third-octave band, in dB,

K_{apfi} – the amendment related to metrological characteristics of measurement equipment, in dB (data from the certificate of calibration),

K_{gfi} – the amendment related to the influence of microphone protection grid, in dB.

5. The equivalent sound pressure levels in the i -th third-octave bands, normalized to a nominal 8-hour working day is given by Eq. (3):

$$L_{fi,eq,8h} = 10 \log \left[\sum_{m=1}^M \frac{T_m}{T_0} 10^{0,1L_{fi,eq,Tm}} \right] \quad (3)$$

where:

$L_{fi,eq,8h}$ – the equivalent sound pressure level in the i -th third-octave band, and for the m -th task, in dB,

T_m – the duration of the m -th task, in h,

T_0 – reference time interval, $T_0 = 8$ h,

m – the number of tasks,

M – the total number of tasks during the working shift.

Work is on-going to develop the final version of the Polish Standard PN-Z-01339 “Ultrasonic noise. Requirements for measurements in the work environment”.

4. INFRASONIC NOISE

Infrasonic noise is defined as the sound or noise of a spectrum within the frequency band of 1-20 Hz (4). The main sources of infrasonic noise in the working environment are among other low-speed turbomachines (e.g. compressors), power devices (e.g. mills) and air-conditioning systems. This noise is often the cause of employee complaints due to its annoyance.

Infrasonic noise at workplaces is characterised by the following, two quantities (15):

- the equivalent continuous G-weighted sound pressure level normalised to a nominal 8-hour working day, $L_{Geq,8h}$, (or normalised to a working week),
- the equivalent continuous G-weighted sound pressure level during occupation of the workplace (T_e) by the employee, $L_{Geq,Te}$.

Facultative values that form the criterion of annoyance of infrasonic noise are defined in the Polish Standard PN-Z-01338:2010 (15). This criterion is given in Table 7.

Table 7 – Criterion of annoyance of infrasonic noise – admissible values of the equivalent continuous G-weighted sound pressure level (SPL) (15)

Quantity	G-weighted SPL, dB
The equivalent continuous G-weighted sound pressure level normalised to a nominal 8-hour working day, $L_{Geq,8h}$, (or normalised to a working week), for all employees	102
The equivalent continuous G-weighted sound pressure level during occupation of the workplace designated for conceptual work, $L_{Geq,Te}$	86

In the case of pregnant women and juveniles there are the obligatory values of MAI of infrasonic noise defined in the regulations (5) (pregnant women) and (6) (juveniles). According to (5) and (6) the values of MAI of infrasonic noise at workplaces occupied by pregnant women and juveniles are the following: $L_{Geq,8h} = 86$ dB and $L_{Geq,Te} = 86$ dB.

Methods for the measurement of infrasonic noise at workplaces are described in the Polish

5. SUMMARY

According to data from Polish Statistics, noise is the most common hazardous factor related to working environment. The adverse effects of noise, ultrasonic noise and infrasonic noise on human are associated mainly with the hearing organ. Nevertheless, non-auditory effects can be also observed in the entire human body.

Working conditions are an important issue for both an employer and employee. Correct identification of hazards and their impact on employed persons creates a basis for undertaking preventive actions and maintaining an adequate policy in order to improve occupational safety and health (OSH).

Methods of measurements and assessments of noise, ultrasonic noise and infrasonic noise are used to determine respectively noise and/or ultrasonic noise and/or infrasonic noise exposure. In general, the measurement results are used to compare the existing acoustic working conditions with:

- the requirements specified in applicable OSH regulations (i.e. regulations containing both the obligatory values of MAI of noise and ultrasonic noise for all employee and the obligatory values of MAI of noise, ultrasonic noise and infrasonic noise for pregnant women and juveniles),
- the requirements specified in applicable Polish Standards (i.e. standards containing the criteria of annoyance of noise and infrasonic noise).

Methods for the measurements of noise and infrasonic noise at workplaces are specified in Polish Standards. An exception to this, is ultrasonic noise - work is on-going to develop the final version of the Polish Standard relating ultrasonic noise measurements at workplaces.

ACKNOWLEDGEMENTS

This publication has been based on the results of the fourth stage of the program “Safety and working conditions improvement”, co-funded in the years 2017 – 2019 within the capacity of the governmental services by the Ministry of Family, Labour and Social Policy. The main coordinator: Central Institute for Labour Protection – National Research Institute.

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