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# ULTRASONIC NOISE AT SELECTED WORKSTATIONS

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**Abstract**
Ultrasonic noise at workstations in Poland is defined as the broadband noise containing high audible and low ultrasonic frequencies. The assessment of ultrasonic noise exposure is based on (equivalent and maximum) sound pressure level in the 1/3 octave band (the central frequencies are from 10 kHz to 40 kHz). The main sources of ultrasonic noise in the working environment are the so-called low frequency ultrasonic technological devices, including washers, welders, ultrasonic drills, soldering tools and galvanizing pots. Ultrasonic noise is also generated by pneumatic tools and high-speed machinery such as planers, millers, grinders, circular saws and some textile machinery. This article presents a method of assessment ultrasonic noise at workstations used in Poland and the results of assessing occupational exposure to ultrasonic noise at selected workstations.

## 1. INTRODUCTION

Technological ultrasonic devices of low ultrasonic frequencies, in which the ultrasonic vibrations are produced in order to carry out or improve complex technological processes, constitute the main source of ultrasonic noise in work process. Nominal frequency of their work ranges from 16 kHz to 40 kHz. Ultrasonic washers (2/3 of all technological ultrasonic devices) constitute the most numerous group of ultrasonic noise sources. Ultrasonic vibrations emitted by the washers at workstations cause the noise of 110-135 dB sound pressure level (in the dominating 1/3 octave band). Ultrasonic welders (plastic, metal and hardly weldable materials) constitute the second group as regards the number of ultrasonic noise sources. Sound pressure level at the workstations of ultrasonic welders amounts to 110-135 dB (in the dominating 1/3 octave band). Other groups of technological ultrasonic devices are: ultrasonic drills, soldering tools and plating tanks. Ultrasonic noise occurs also during

the work of dental devices used for tartar removing – scalers. Apart from the above-mentioned technological devices, in which the ultrasonic vibrations constitute the working factor, ultrasonic noise arises also as an unintentional result of the work of many machines and devices. The existence of ultrasonic components of significant sound pressure levels has been found in the work of devices where phenomena of aerodynamic (flow or outflow of compressed gas) or mechanical character (big rotational speed of machines elements) occur. It refers to compressors, blowpipes, valves, pneumatic tools and high-speed machinery (planers, millers, circular saws and some textile machinery).
The paper presents the results of ultrasonic noise assessment at workstations carried out by the Central Institute for Labour Protection – National Research Institute. Ultrasonic noise has been examined at workstations of 27 technological ultrasonic devices: ultrasonic washers, welders, grinders, stamping presses and scalers.

## 2. ADMISSIBLE VALUES OF ULTRASONIC NOISE IN POLAND

The analysis of unfavourable changes in the human organism which are the effects of the exposure to ultrasonic noise constitutes the basis for hygienic standards set in Poland in the 70's. The maximum admissible intensity of ultrasonic noise was defined in 1986 in the Polish standard PN-N-01321: 1986 "*Ultrasonic noise. Admissible values of sound pressure level at workstations and general provisions for measurements.* The methods of ultrasonic noise measurement at workstations as well as maximum admissible values (MAI) for ultrasonic noise have been defined in the standard, taking into account the requirements for health protection.
The provisions of the European Directive 2003/10/CE refer among other things to assuring the safety and health protection of workers in all aspects related to work, carrying out the obligatory occupational risk assessment resulting from the exposure to harmful agents and limiting the risk to the lowest possible level. Therefore the provisions create the necessity of carrying out occupational risk assessment related to the exposure to noise that, in general terms, can also refer to ultrasonic noise in the working environment.
In the majority of countries the assessment of ultrasonic noise is carried out on the basis of the measurement of the equivalent sound pressure level in 1/3 octave bands from 10 kHz to 50 kHz (in some until 100 kHz), referred to 8-hour exposure to noise.
The following admissible values of ultrasonic noise for workers' health protection (MAI values) are in force in Poland (apart from the groups at particular risk: pregnant women and juveniles):

- the equivalent sound pressure level in 1/3 octave band with the central frequency *f* from 10 kHz to 40 kHz, referred to 8-hour working day, $L_{f,eq,8h}$ in dB or working week $L_{f,eq,w}$ (the reference to working week is exceptionally used in case of the irregular ultrasonic noise influence on human organism in given days of week or when an employee works different number of days in a week than 5),
- maximum sound pressure levels in 1/3 octave band with the central frequency *f* from 10 kHz to 40 kHz, $L_{f,max,}$ in dB.

*Table 1. Admissible equivalent sound pressure levels at workstation referred to 8-hour working day and maximum sound pressure levels in 1/3 octave bands.*

| Centre frequency of 1/3 octave bands f, kHz | Admissible equivalent sound pressure levels $L_{f,eq,8h,dop}$, dB | Maximum admissible sound pressure levels $L_{f,max,dop}$, dB |
|---|---|---|
| 10; 12,5; 16 | 80 (77*)(75^) | 100 |
| 20 | 90 (87*)(85^) | 110 |
| 25 | 105 (102*) (100^) | 125 |
| 31,5; 40; | 110 (107*)(105^) | 130 |

*Admissible values (MAI) of equivalent ultrasonic noise sound pressure levels for pregnant women.

^ Admissible values (MAI) of equivalent ultrasonic noise sound pressure levels for juveniles.

## 3. THE METHOD OF THE ASSESSMENT OF ULTRASONIC NOISE AT WORKSTATION

The method of the assessment of ultrasonic noise at workstation is based on the determination of the admissible values (MAI) excess rate for ultrasonic noise (for K > 1 the excess of the admissible values (MAI) occurs). MAI rate is determined for the equivalent and maximum sound pressure levels in each 1/3 octave band using the formula 1 and 2. MAI rate of the equivalent sound pressure levels in 1/3 octave band is determined using the formula:

$$K_{Lf,eq,8h} = 10^{\frac{L_{f,eq,8h} - L_{f,eq,8h,dop}}{10}} \quad (1)$$

where: $L_{f,eq,8h}$ – the equivalent sound pressure levels in 1/3 octave bands, with the central frequency *f* from 10kHz to 40kHz, referred to 8-hour working day.

$L_{f,eq,8h,dop}$ – the admissible equivalent sound pressure levels in 1/3 octave bands, with the central frequency *f* from 10kHz to 40kHz, referred to 8-hour working day.

MAI rate of maximum sound pressure levels in 1/3 octave bands of noise exposure is determined using the formula:

$$K_{Lf,max} = 10^{\frac{L_{f,max} - L_{f,max,dop}}{20}} \quad (2)$$

where: $L_{f,max}$ – maximum sound pressure levels in 1/3 octave bands with the central frequency *f* from 10 kHz to 40kHz

$L_{f,max,dop}$ – maximum admissible sound pressure levels in 1/3 octave bands with the central frequency *f* from 10kHz to 40kHz

MAI rate of for ultrasonic noise for a given workstation is the highest for both assessments from all 1/3 octave bands.

## 4. THE RESULTS OF MEASUREMENTS AND ASSESSMENT OF ULTRASONIC NOISE AT SELECTED WORKSTATIONS

The equivalent sound pressure level in 1/3 octave bands with the central frequency *f* from 10 kHz to 40 kHz $L_{f,eq,8h}$ and maximum sound pressure levels level in 1/3 octave bands with the central frequency *f* from 10 kHz to 40 kHz $L_{f,\,max}$ have been measured at selected workstations. Calculations results of the admissible values (MAI) excess rate for ultrasonic noise characteristic quantities of machines and devices with the largest emission of ultrasonic noise are presented in the tables below.

**Ultrasonic washers**

The excess rate of admissible equivalent 8-hour sound pressure level in 1/3 octave bands of ultrasonic noise frequencies - $K_{Lf,eq,8h}$ at washers workstations is presented in table 2. The largest MAI rates occur in 1/3 octave bands with the central frequencies: 16 kHz, 20 kHz and 40 kHz, (in one cases also in 20 kHz and 31,5 kHz) and excess the value 4.

*Table 2. MAI rate (equivalent 8 hour sound pressure level in 1/3 octave bands) for ultrasonic noise at washers workstations.*

| No. | Name of the device | MAI value excess rate $K_{Lf,eq,8h}$ in 1/3 octave bands with the central frequencies | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 10 kHz | 12,5 kHz | 16 kHz | 20 kHz | 25 kHz | 31,5 kHz | 40 kHz |
| 1. | washer Sonic 5 | 0,04 | 0,07 | 0,58 | 1,78 | 0,01 | 0,04 | 3,63 |
| 2. | washer Sonic 5p | 0,01 | 0,01 | 0,04 | 0,05 | 0,01 | 0,05 | 3,09 |
| 3. | washer Sonic 6 | 0,19 | 0,33 | 2,88 | 0,89 | 0,03 | 1,32 | 4,17 |
| 4. | washer Sonic 10 | 0,02 | 0,09 | 2,24 | 0,17 | 0,01 | 0,55 | 1,2 |
| 5. | washer Sonic 14 | 0,03 | 0,01 | 0,09 | 0,12 | 0,00 | 0,01 | 1,23 |
| 6. | washer Sonic 33 | 0,02 | 0,04 | 0,33 | 0,39 | 0,00 | 0,03 | 0,78 |
| 7. | washer Via Bianka Di Savoia 2 | 0,03 | 0,13 | 0,13 | 0,02 | 0,00 | 0,00 | 0,00 |
| 8. | washer Sonic 120 | 0,00 | 0,04 | 0,01 | 0,14 | 0,19 | 0,00 | 0,00 |
| 9. | washer Sonic 170 | 0,00 | 0,01 | 0,15 | 1,26 | 1,12 | 0,00 | 0,00 |
| 10. | washer Sonic 364 | 0,00 | 0,01 | 0,08 | 0,02 | 0,00 | 0,00 | 0,02 |
| 11. | washerUltrasonic–Cleaner | 0,1 | 1 | 0,60 | 0,05 | 0,28 | 0,08 | 0,00 |
| 12. | washer U-1000 | 0,09 | 0,39 | 0,14 | 0,23 | 0,33 | 0,02 | 0,02 |

The results of MAI value excess rate (of maximum sound pressure level in 1/3 octave bands) for ultrasonic noise - $K_{Lf,max,}$ at washers workstations are presented in table 3 and do not excess the admissible levels.

*Table 3. MAI rate (of maximum sound pressure level in 1/3 octave bands) for ultrasonic noise at washers workstations.*

| No. | Name of the device | MAI value excess rate $K_{Lf,max,}$ in 1/3 octave bands with the central frequencies | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 10 kHz | 12,5 kHz | 16 kHz | 20 kHz | 25 kHz | 31,5 kHz | 40 kHz |
| 1. | washer Sonic 33 | 0,06 | 0,08 | 0,22 | 0,24 | 0,01 | 0,07 | 0,37 |
| 2. | washer Sonic 120 | 0,04 | 0,13 | 0,03 | 0,22 | 0,27 | 0,01 | 0,00 |
| 3. | washer Sonic 364 | 0,04 | 0,04 | 0,09 | 0,06 | 0,00 | 0,02 | 0,09 |
| 4. | washer U-1000 | 0,03 | 0,58 | 0,07 | 0,22 | 0,43 | 0,00 | 0,00 |

**Ultrasonic welders**

The results of MAI values excess rate (of the admissible equivalent 8-hour sound pressure level in 1/3 octave band) - $K_{Lf,eq,8h}$ for ultrasonic noise at welders workstations are presented in table 4. The largest rates occur in 1/3 octave bands with the central frequencies: 10 kHz, 16 kHz and 20 kHz (in one case also in 12,5 kHz and 40 kHz band) and significantly excess the value 100.

*Table 4. MAI rate (of equivalent 8 hour sound pressure level in 1/3 octave bands) for ultrasonic noise at welders workstations.*

| No. | Name of the device | MAI value excess rate $K_{Lf,eq,8h}$ in 1/3 octave bands with the central frequencies | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 10 kHz | 12,5 kHz | 16 kHz | 20 kHz | 25 kHz | 31,5 kHz | 40 kHz |
| 1. | welder WPM- 22 | 10 | 0,06 | 0,20 | 2,82 | 0,00 | 0,00 | 0,00 |
| 2. | welder MECASONIC -1100 | 0,10 | 0,40 | 50 | 398 | 0,16 | 0,00 | 0,63 |
| 3. | welder MP 201 | 0,10 | 0,10 | 2,00 | 31,60 | 0,02 | 0,00 | 0,00 |
| 4. | welder MECASONIC OMEGA | 0,16 | 0,40 | 50,12 | 199,53 | 0,04 | 0,01 | 0,40 |
| 5. | welder Branson 8700 | 50,12 | 3,31 | 120,2 | 1318 | 0,56 | 0,10 | 5,62 |
| 6. | welder COBRA | 0,14 | 0,07 | 0,45 | 3,98 | 0 | 0 | 0,01 |

The results of MAI values excess rate (of the maximum admissible sound pressure level in 1/3 octave band) for ultrasonic noise - $K_{Lf,max,}$ at welders workstations are presented in table 5. The largest rates occur in 1/3 octave bands with the central frequencies: 20 kHz (in one cases also in 10 kHz and16 kHz band) and excess the value 7.

*Table 5. MAI rate (of maximum sound pressure level in 1/3 octave bands) for ultrasonic noise at welders workstations.*

| No. | Name of the device | MAI value excess rate $K_{Lf,max,}$ in 1/3 octave bands with the central frequencies | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 10 kHz | 12,5 kHz | 16 kHz | 20 kHz | 25 kHz | 31,5 kHz | 40 kHz |
| 1. | welder Branson 8700 | 2,00 | 0,40 | 2,51 | 7,94 | 0,19 | 0,07 | 0,63 |
| 2. | welder COBRA | 0,28 | 0,20 | 0,79 | 2,51 | 0,05 | 0,01 | 0,06 |

**Grinders**

The results of MAI values excess rate (of the admissible equivalent 8-hour sound pressure level in 1/3 octave band) for ultrasonic noise - $K_{Lf,eq,8h}$ at grinders workstations are presented in table 6. The largest rates occur in 1/3 octave bands with the central frequency 20 kHz and excess the value 11.

*Table 6. MAI rate (of equivalent 8 hour sound pressure level in 1/3 octave bands) for ultrasonic noise at grinders workstations.*

| No. | Name of the device | MAI value excess rate $K_{Lf,eq,8h}$ in 1/3 octave bands with the central frequencies | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 10 kHz | 12,5 kHz | 16 kHz | 20 kHz | 25 kHz | 31,5 kHz | 40 kHz |
| 1. | grinder USTZ - 100 | 0,01 | 0,02 | 0,01 | 0,00 | 0,00 | 0,00 | 0,00 |
| 2. | grinder USTZ - 300 | 0,01 | 0,00 | 0,03 | 0,03 | 0,00 | 0,00 | 0,00 |
| 3. | grinder BDWD (415-165-10 | 0,00 | 0,00 | 0,01 | 0,06 | 0,00 | 0,00 | 0,00 |
| 4. | grinder BDWD (415-166-10) | 0,01 | 0,00 | 0,02 | 0,25 | 0,00 | 0,00 | 0,00 |
| 5. | grinder BDWD (415-167-10) | 0,01 | 0,03 | 1,0 | 11,22 | 0,00 | 0,00 | 0,00 |
| 6. | grinder BDWD (415-168-10) | 0,00 | 0,00 | 0,13 | 1,26 | 0,00 | 0,00 | 0,00 |

**Stamping presses and scaler**

The results of MAI values rates (of the equivalent 8-hour sound pressure level in 1/3 octave band) for ultrasonic noise - $K_{Lf,eq,8h}$ at stamping presses and scaler workstations are presented in table 7. The results of MAI values rates (of maximum sound pressure level in 1/3 octave band) for ultrasonic noise - $K_{Lf,max,}$ at the above-mentioned workstations in 1/3 octave band are presented in table 8. The largest MAI value rates - $K_{Lf,eq,8h}$ and $K_{Lf,max,}$ (of both the equivalent 8-hour sound pressure level and maximum sound pressure level in 1/3octave band) for ultrasonic noise at grinders workstations occur in 1/3 octave band with the central frequency of 20 kHz (in one case for maximum sound pressure level in 10 kHz band), but they do not exceed the value 0,6.

*Table 7 MAI rate (equivalent 8 hour sound pressure level in 1/3 octave bands) for ultrasonic noise at and scaler workstations.*

| No. | Name of the device | MAI value excess rate $K_{Lf,eq,8h}$ in 1/3 octave bands with the central frequencies | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 10 kHz | 12,5 kHz | 16 kHz | 20 kHz | 25 kHz | 31,5 kHz | 40 kHz |
| 1 | stamping press MGID1(001) | 0,00 | 0,00 | 0,04 | 0,28 | 0,00 | 0,00 | 0,00 |
| 2 | stamping press MGID1(002) | 0,00 | 0,00 | 0,07 | 0,55 | 0,00 | 0,00 | 0,00 |
| 3 | Scaler ADEC 2040 | 0,01 | 0,01 | 0,01 | 0,00 | 0,00 | 0,00 | 0,00 |

*Table 8. MAI rate (of maximum sound pressure level in 1/3 octave bands) for ultrasonic noise at stamping press and scaler workstations.*

| No. | Name of the device | MAI value excess rate $K_{Lf,max,}$ in 1/3 octave bands with the central frequencies | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 10 kHz | 12,5 kHz | 16 kHz | 20 kHz | 25 kHz | 31,5 kHz | 40 kHz |
| 1. | stamping press MGID1(001) | 0,01 | 0,01 | 0,05 | 0,13 | 0,00 | 0,00 | 0,00 |
| 2. | stamping press MGID1(002) | 0,01 | 0,01 | 0,09 | 0,26 | 0,07 | 0,00 | 0,00 |
| 3. | Scaler ADEC 2040 | 0,28 | 0,30 | 0,15 | 0,13 | 0,10 | 0,03 | 0,02 |

## 5. SUMMARY OF MEASUREMENTS RESULTS

For 12 examined ultrasonic washers workstations MAI value excess rates for ultrasonic noise $K_{Lf,eq,8h}$ occur in 6 types of washers (50%) and range from 1,12 to 4,17. The results of ultrasonic noise measurements and assessment for 6 welders workstations have shown that MAI value excess rates for ultrasonic noise $K_{Lf,eq,8h}$ occur at all workstations of the examined welders (100%) and amount from 2,5 to 1318. MAI value excess rates for ultrasonic noise $K_{Lf,max}$ occur in 2 types of welders (33%). In case of ultrasonic grinders MAI value excess rates for ultrasonic noise $K_{Lf,eq,8h}$ occur at 2 workstations from 6 examined of 3 types of grinders (33%), and amount from 2,8 to 12.

MAI value excess rates (of equivalent 8-hour sound pressure level - $K_{Lf,eq,8h}$ and maximum sound pressure level $K_{Lf,max}$) for ultrasonic noise do not occur at stamping presses and scaler (for tartar removing) workstations. The value rates ($K_{Lf,eq,8h}$ and $K_{Lf,max}$) amount from 0,13 to 0,55 in the dominating 1/3 octave band. For ultrasonic noise at the dental unit workstation – scaler – the results have shown that the low supersonic frequencies dominate (1/3 octave band with the central frequency 10 kHz and 12,5 kHz).

## 6. CONCLUSIONS

For 27 ultrasonic devices workstations, the excess of MAI values for ultrasonic noise (of equivalent 8-hour sound pressure level) - $K_{Lf,eq,8h}$ and (maximum sound pressure level) - $K_{Lf,max}$ occur at 17 workstations, which constitutes 60% of the total number of the examined workstations. In most cases the excess of MAI values for ultrasonic noise occurs for the equivalent 8-hour sound pressure levels.
On the basis of the obtained results it was stated that in some cases (ultrasonic washers) the highest values of sound pressure occur in the 1/3 octave band with the central frequency of 40 kHz. It is an alarming fact, because it is the last 1/3 octave which is, according to the current requirements, taken into account while assessing the hazard due to the ultrasonic noise. From the point of view of health protection and workers safety at least next 1/3 octave, i.e. 50 kHz should be controlled (maximum sound energy may occur for this and higher 1/3 octave bands).

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## REFERENCES

[1] Augustyńska D., Koton J., Pawlaczyk-Łuczyńska M.: *Hałas ultradźwiękowy – Procedura pomiarowa*. PIMOŚP nr 2 (28), 2001.

[2] Mikulski W., Smagowska B.: at all. 05.7 *Ocena ryzyka zawodowego związanego z narażeniem na hałas ultradźwiękowy.* CIOP-PIB Warsaw 2005.

[3] Mikulski W., Smagowska B.: *Hałas ultradźwiękowy na wybranych stanowiskach pracy*. Proceeding XXXIV Zimowej Szkoły Zwalczania Zagrożeń Wibroakustycznych, Gliwice-Ustroń, 27.02-03.03.2006r.

[4] Śliwiński A.: *Ultradźwięki i ich zastosowania*. WNT. Warsaw 2001.

[5] PN-N-01321:1986 (PN-86/N-01321) *Hałas ultradźwiękowy. Dopuszczalne wartości poziomu ciśnienia akustycznego na stanowiskach pracy i ogólne wymagania dotyczące wykonywania pomiarów*.

[6] ISO 1999: 2000 *Acoustics-Determination of occupational noise exposure and estimation of noise-indused hearing impairment*.

[7] Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise).