

NOISE AT POLISH MEDICAL UNITS – EXEPLARY OF RESULTS AT WORKSTATIONS

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Abstract

Inadequate acoustic conditions in hospital premises are the result of noise coming from outside of the room, noise from any apparatus or tools used and reverberation noise, resulting from room characteristics. Acoustic factors could have some negative effects on an employee, causing i.e. irritation, decreased attention or fatigue. The paper contains the results of noise study at chosen workstations in hospital (eq. stomatology units, ultrasound scanners, magnetic resonance scanners). The results of the noise measurements showed a wide range of SPL values depending on the type of the equipment and kind of the test.

Introduction

Acoustic conditions in hospital premises are the result of noise coming from outside of the room, noise from any apparatus or tools used and reverberation noise, resulting from room characteristics. In addition, acoustic conditions found in hospital premises that depend on, i.e., the quality of these premises and the equipment they house, affect the acoustic quality of the rooms [1, 2, 3]. The World Health Organization (WHO) recommends the equivalent A-weighted sound pressure level (SPL) in hospital premises not to exceed 30 dB with a C-weighted peak sound pressure level (C-weighted SPL) of 40 dB. At the same time, the organization concludes that exposure to occupational noise levels above 55 dB results in sleep disorders and heart disease [4]. According to literature, the results of acoustic background in operating rooms are 60 dB according to Luzzie [12] and 70 dB to Holzer [13]. In Australian hospitals (according to Elliott) in IOM units, the A-weighted sound pressure level (SPL) of the acoustic background exceeds 50 dB [14]. Marius's study found that the average SPL in emergency departments was 52.9 dB, while the highest recorded SPL was within the range of 94-117 dB [15]. Lawson's results on intensive therapy showed that nighttime SPL was 50 dB and peak was 80-86 dB [16]. Luzzi and Pai received the same results in different areas of daytime operating rooms where the highest SPL were recorded in the range 80-90 dB [12, 17].

The effects of noise on the hearing organ occur when worker is exposed to noise levels of 80-90 dB, while other effects (other than hearing impairment) occur at noise levels of 45-55 dB [5, 6,7]. Exposure to noise with levels exceeding 80 dB results in permanent or temporary shifts of hearing threshold [8]. Effects other than hearing impairment are visible in the endocrine and autonomic systems [5, 8]. In this sense, the assessment of the non-auditory impact of occupational noise in hospitals is important for both staff and patients [1,2, 9, 10, 11]. Also the annoyance should be taken into account in assessing the exposure to noise in the medical work environment. It results from the specificity of the work on workstations. Acoustic factors could cause some negative effects on an employee, causing i.e. irritation, decreased attention or fatigue a general reaction, expressing dissatisfaction and resistance to work environment.

Test method

The noise test method at workstations consists of determining the SPL values based on measurements in order to assess objective acoustic conditions in a given work environment. The noise exposure assessment is carried out by comparing the measured values of the hazardous factor with the limit values. Noise measurements are carried out using an indirect method in accordance with the requirements of standards: PN-N-01307: 1994, PN-EN ISO 9612: 2011 and PN-N-01338: 2010 [10, 18, 19] and with the research procedure developed by the Central Institute for Labour Protection - National Research Institute (CIOP-PIB) [20].

For the purpose of assessing the exposure to noise of an employee at a given workstation, noise measurements are carried out at typical locations where the worker is present; taking into account the standard operating conditions of the tool or device that is the source of the noise. Prior to measuring the noise, the sources of the noise and, depending on the type of machinery and equipment, the work stations, as well as the type of work and activities involved, the appropriate measurement strategy and the measuring equipment should be determined. According to the requirements contained in the PN-EN ISO 9612 standard, there are three measurement strategies to choose from: measurements by activity, workstation measurements, full-day measurements (dosimetry).

The following values are measured:

- equivalent G-weighted SPL for infrasound noise,
- equivalent A-weighted SPL normalized to a nominal 8-hours working day, maximum A-weighted SPL and a C-weighted peak SPL in the audible frequency range,
- equivalent SPL and maximum SPL in 1/3 octave frequency bands with the center frequencies from 10 kHz to 40 kHz normalized to 8-hours using (or equivalent SPL in the one-third octave frequency bands with the center frequencies from 10 kHz to 40 kHz normalized to week) within the ultrasonic noise.

The noise limits (the Maximum Admissible Intensities - MAI) for the protection of health (in audible and ultrasonic frequencies ranges) for all employees, applicable in Poland, are set out in the Ordinance of the Minister of Labour and Social Policy of 6 June 2014 [21]. The values (for audible frequencies) listed below in Table 1 refer to all employees excluding pregnant women and young workers. For pregnant women and young workers the lower limit values are contained in the other document [22]. The limit values of ultrasonic noise at workplaces for all employees, pregnant women and young workers are presented in Table 2.

Table 1 – The limit values of noise at workplaces for all employees.

The quantities of noise	Limit values of noise (dB)
Noise exposure level ($L_{EX,8h}$)	85
Maximum A-weighted SPL, L_{Amax}	115
Peak C-weighted SPL L_{Cpeak}	135

Table 2 – The limit values of ultrasonic noise at workplaces for all employees.

The center frequencies of 1/3 octave frequency bands [kHz]	Equivalent SPL	Maximum SPL
	$L_{\text{freq,8h}}$ or $L_{\text{freq,w}}$ [dB]	L_{fmax} or $L_{\text{fmax,w}}$ (dB)
10; 12,5; 16	80 (75 [*])	100
20	90 (85 [*])	110
25	105 (100 [*])	125
31,5; 40;	110 (105 [*])	130

¹Limit value of equivalent SPL of ultrasonic noise for women and young workers

Noise limits (within the audible frequency range), due to the ability of employees to perform basic tasks on selected types of positions, are determined by the Polish Standard PN-N-01307: 1994 [10]. Table 3 lists acceptable noise levels at workstations that define the annoyance criterion. The Polish Standard PN-N-01338: 2010 "Acoustics- Measurement and evaluation of infrasound noise at workstations" applies for the annoyance criterion of infrasonic noise [19]. According to this document, acceptable noise levels of infrasonic noise at workplaces are contained in Table 4.

Table 3 – Acceptable SPLs depended on activity of workers at workstations

Workstation	Equivalent A-weighted SPL (dB)
In direct control cabins not equipped with telephone communication means; at laboratories with noise sources; in rooms with machines and counting devices, typing machines, or tele printers; in other rooms of similar designation.	75
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 administrative rooms, design office rooms, theoretical study rooms, data processing rooms and other rooms of similar designation.	55

Table 4 – Acceptable SPLs for the infrasonic noise

Workstation	Equivalent G-weighted SPL (dB)
The equivalent continuous G-weighted SPL, normalized to a nominal 8-hour working day or the 40-hour average weekly working time as specified by the labour code for all employees	102
The equivalent continuous G-weighted SPL during occupation of a workstation designated for conceptual work	86

The results of measurements of the noise at workstations

The measurements of noise quantities within the range of audible and ultrasonic frequencies, were performed at the workstations of magnetic resonance scanners [23], ultrasound diagnostic apparatuses, dental units and cleaning workstations (air compress and ultrasonic washers). Measurements were performed with Svantek's Svan 979 and Svan 948 sound analyzers and microphones (with a diameter of 1/2" for audible frequency and 1/4" for ultrasonic frequency). Measurement points were located in places where employees stay at workstations at distances from 0.5 (washer) to 2 m (scanner) from the machines. Noise measurements at the scanner workstations were performed during the operation of these magnetic resonance devices with a magnetic field strength of 1.5 T [23]. This kind of equipment is a widely used in medical diagnostics. The results of the measurements of the noise quantities within the range of audible frequencies performed at the workstations of magnetic resonance scanners are shown in Table 5. On the basis of the results of noise measurements at the workstations of magnetic resonance

scanners, it should be stated that at the test workstations the equivalent A-weighted SPLs are within the range of 69.8 dB to 96.3 dB. The measured maximum A-weighted SPLs range from 81.4 dB to 106.8 dB while the C-weighted peak SPLs are between 98 dB and 116.7 dB. Limit values of the maximum A-weighted SPL and the C-weighted peak SPL are not exceeded. Having regard to the limit values of noise exposure level for measured noise having the equivalent A-weighted SPL of 96.3 dB, daily exposure time should not exceed 35 minutes.

Table 5 – The results of SPL measurements at magnetic resonance scanners [23]

No of scanner	Test	L _{Aeq} (dB)	L _{Amax} (dB)	L _{Cpeak} (dB)
1	head	84.7	93.8	108,1
	heart	69.8	81.4	102.1
2	spine - the lumbar region	88.1	93.9	106.1
	head	94.7	106.8	116.7
3	head	96.3	104.0	115
	head			

Table 6 contains the results of SPL measurements at the workstations of ultrasound diagnostic apparatus. At these workstations the equivalent A-weighted SPLs are in the range of 61.9 dB to 73.5 dB. The limit values of equivalent A-weighted SPL for the annoyance (65 dB, see Table 3) is exceeded for two workstations of ultrasound diagnostic apparatus. The measured maximum A-weighted SPLs are in the range from 79.4 dB to 90.8 dB while the peak C-weighted SPLs are in the ranges from 98.4 dB to 108.5 dB. Limit values of SPLs at these workstations for hearing protection are not exceeded.

Table 6 – The results of SPL measurements at ultrasound diagnostic apparatuses.

apparatus	L _{Aeq} (dB)	L _{Amax} (dB)	L _{Cpeak} (dB)
ATL HDI 5000	73.5	90.8	108.5
Siemens Elegra	72.0	84.2	99.4
Voluson 730	61.9	79.4	98.4

Table 7 shows the results of noise measurements at dentists' workstations. At these workstations, the equivalent A-weighted SPLs are in the range of 71.7 dB to 75.7 dB. The measured maximum A-weighted SPLs are in the range from 77.3 dB to 85.2 while peak C-weighted SPLs are between 95.7 dB and 108.2 dB. Limit values of SPLs at these workstations for hearing protection are not exceeded but the limit values of noise annoyance (65 dB) is exceeded for all workstations.

Table 7 – The results of SPL measurements at dentists' workstations

No of workstation	L _{Aeq} (dB)	L _{Amax} (dB)	L _{Cpeak} (dB)
1	75.7	79.0	97.9
2	73.8	83.8	108.2
3	74.9	77.3	95.7
4	71.7	85.2	98.4

The results of measurements of SPLs at cleaning workstations (by air compress) are in the Table 8. The equivalent A-weighted SPLs are within the range of 96.7 dB to 104.3 dB and exceed limit values of hearing protection. Daily the exposure time should not exceed 6 minutes for workstation No 2. The measured maximum A-weighted SPLs are in the range from 103.1 dB to 106.0 dB and the peak C-weighted SPLs are in the ranges from 116 dB to 117.9 dB. Limit values of the maximum A-weighted SPL and the C-weighted peak SPL specified for hearing protection are not exceeded. On this workstations big influence of the values of SPL has distance from worker head to nozzle of device.

Table 8 – The results of measurements of SPL at cleaning workstations

No of workstation	L _{Aeq} (dB)	L _{Amax} (dB)	L _{Cpeak} (dB)
1	96.7	103.1	117.5
2	99.9	104.2	116.0
4	104.3	106.0	117.9

Ultrasonic washers are another group of devices used in medical units for ultrasonic cleaning of parts. The ultrasonic noise measurements for these devices were carried out during the washing of medical devices. Ultrasonic noise measurements (in the 10kHz to 40kHz frequency range) were performed at 8 ultrasonic cleaning workstations. Table 9 contains measurement results of equivalent SPL in 1/3 octave bands with center frequency from 10kHz to 40kHz.

Table 9 – The results of measurements of equivalent SPL in 1/3 octave bands with center frequency from 10kHz to 40kHz at ultrasonic cleaning workstations.

No of washers	Equivalent SPL $L_{f,eq,8h}$ in 1/3 octave bands with center frequency						
	10 kHz	12.5 kHz	16 kHz	20 kHz	25 kHz	31.5 kHz	40 kHz
1	65.8	68.7	77.6	92.5	84.6	95.5	115.6
2	59.0	59.0	66.5	77.4	79.6	97.2	114.9
3	72.9	75.2	84.6	89.5	89.5	111.2	116.2
4	63.7	69.5	83.5	82.2	83.4	107.4	110.8
5	64.7	60.8	69.4	80.6	75.8	90.9	110.9
6	63.8	66.5	75.2	85.9	76.0	94.4	108.9
7	70.0	80.0	77.8	77.0	99.5	99	79.3
8	74.3	85.2	75.4	74.6	100.4	81.8	68.1

For ultrasonic cleaning workstations (except for washer No 6), the limit values of equivalent SPL in 1/3 octave bands normalized to nominal 8h working day of ultrasonic noise are exceeded. The biggest difference between the limit SPL in the 1/3 octave band with center frequency of 40 kHz (110 dB) and a measured equivalent A-weighted SPL (116.2 dB) is 6.2 dB, for the washer No 3. In this case daily exposure time should be no longer than 115 minutes.

Summary

In conclusion, it should be noted that the performed measurements have shown a wide range of SPL values depending on the type of device and kind of the test (magnetic resonance scanner) or operation of the device (air compress and washer). Based on the conducted occupational noise measurements (in audible and ultrasonic frequencies ranges) at the selected workstations in the hospital it is concluded that:

- measured equivalent A-weighted SPLs are exceed 85 dB at workstations of magnetic resonance scanners and cleaning workstations. In this case it is necessary to determine maximum of daily exposure time.
- maximum A-weighted SPL and a C-weighted peak SPL are below the limit values for all workstations.
- in the ultrasonic frequencies, measured equivalent SPL in 1/3 octave bands with center frequency from 10kHz to 40kHz exceed the limit values for this frequency range at cleaning workstations.

The information presented in the paper confirms the harmfulness and annoyance of noise at workstations in hospitals. In order to limit the noise exposure of workers at workstations, certain technical and organizational prevention measures must be taken. If limit values (MAI) are exceeded, one of the ways to reduce the exposure to staff noise is to use a shortened exposure time.

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