NOISE AT WORK - PRINCIPLES OF RISK ASSESSMENT

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ABSTRACT

This paper presents the process of risk assessment resulting from exposure to noise. The process involves: (a) identification of noise hazards (noise exposure), (b) risk estimation by determining the likelihood of the occurrence of negative consequences of noise exposure (auditory and non-auditory effects of noise) and the degree of their severity, (c) risk reduction. Admissible values of noise determine the highest acceptable risk level.

It is becoming widely recognised that the economic and social costs of high noise levels in the workplace require significant action to reduce the workers' exposure to noise. Such costs include not only financial compensation or damages that must be paid and reduced enjoyment of everyday life for those with a hearing loss but also less quantifiable factors such as reduced productivity, increased stress and risk of accidents for a much larger number of workers.

According to Polish Central Statistical Office (GUS) almost 1 million workers in Poland are employed in adverse or outright harmful conditions, including approximately 330,000 workers exposed to noise exceeding 8-hour L_{Aeq} = 85 dB (see Fig. 1). Moreover, these statistics obviously underestimate the problem since they do not include either small enterprises employing fewer than 50 people or private farms. Annually, approximately 3,000–4,000 new cases of occupational hearing damage are recorded, accounting for about one-third of all occupational diseases (see Fig. 2).

The employer's general duty to assess and prevent occupational risk resulting from exposure to noise is established in European regulations (Directive 86/188/EEC, Proposal for Directive 94/C 230/03) and in Polish law (Labour Code) adapted to these regulations. The procedure of risk assessment involves:

- identification of noise hazards (measurement or prediction, comparison with admissible values),
- estimation of the risk by determining the likelihood (low - L, medium - M, high - H) of the occurrence of negative consequences of noise exposure (non-auditory effects of noise on health and human performance or hearing loss) and the degree of their severity,
- risk reduction - preparation of a risk control action plan (if necessary).

Usually, the risk level is estimated according to the following rule:

severity of negative consequences × likelihood = risk

In order to use this rule, it is necessary to estimate the severity of the consequences of noise exposure.

Occupational deafness - a permanent incurable disability - should be considered a consequence of high severity (H).

Partial hearing loss and some extra-auditory effects of noise resulting in temporary health deterioration, reduced productivity, decreased working efficiency and reduced general human performance may be considered consequences of medium severity (M).

Temporary threshold shift (TTS), decreased speech intelligibility and obstructed perception of auditory danger signals may be considered consequences of low severity (L).In some cases, difficulties in the perception of auditory warning signals may cause an accident at work with very serious consequences.

The risk may be low, medium (acceptable) or high (unacceptable).

Admissible values of noise (Threshold Limit Values - TLVs) determine the highest acceptable risk level.

Admissible values resulting from a hearing protection programme according to Polish regulations [9, 10] are as follows:

- noise exposure level standardised to a nominal 8-hour working day $L_{EX,\,8h} = 85$ dB and the corresponding daily A-weighted sound exposure $E_{A,\,d} = 3.64 \times 10^3$ Pa^2·s or, in the case of workplaces where noise exposure varies markedly from one working day to the next, noise exposure level standardised to a week $L_{EX,\,w} = 85$ dB and the corresponding weekly A-weighted sound exposure $E_{A,\,w} = 18.2 \times 10^3$ Pa^2·s,
- maximum A-weighted S-averaged sound level $L_{Amax,\,S} = 115$ dB or equivalent sound level over 1 s $L_{Aeq,\,1s} = 115$ dB,
- peak C-weighted sound level $L_{Cpeak} = 135$ dB.

The above-mentioned limits are presented in Fig. 3 as functions of noise exposure duration. These values apply to protected workstations when other regulations do not determine lower values (e.g. for young people - $L_{EX,\,8h} = 80$ dB, for pregnant women - $L_{EX,\,8h} = 65$ dB).

In the case of performing basic work tasks, the equivalent continuous A-weighted sound pressure level while an employee is at the workstation should not exceed values quoted in Table 1.

A proposal for the assessment of risk resulting from exposure to noise is presented in Table 2. It meets the requirements of the following European, international and Polish documents:

- Council Directive 86/188/EEC on the protection of workers from the risk related to exposure to noise at work [4],
- Commission proposal for a Council Directive on the minimum health and safety requirements regarding the exposure of workers to the risk arising from physical agents (94/C 230/03) [3],
- ISO 1999: Acoustics - Determination of occupational noise exposure and estimation of noise induced hearing impairment [6],
- ISO 9612: Acoustics - Guidelines for the measurement and assessment of exposure to noise in a working environment [7],
- Polish Labour Code [8],
- Regulation of the Ministry of Labour and Social Policy on TLVs of harmful agents in the working environment [10],
- Polish Standard PN-N-01307: Noise. Permissible values of noise in the workplace. Requirements relating to measurements [9].

Taking into account the admissible values of noise that ensure workers have proper conditions for the realisation of their basic tasks (see Table 1), a proposal for risk assessment is shown in Table 3.

Presented methods of assessing risk related to the exposure to noise apply to the assessment of existing workstations and workstations that are being built.

Risk analysis and risk assessment are the basic elements of a safety management system in an enterprise.

REFERENCES

1. Augustyńska D., Szeląg M., Noise limits in the workplace in Poland, Proceeding of INTER-NOISE 95, Newport Beach, CA, USA.
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4. Council Directive 89/188/EEC of 12 May 1986 on the protection of workers from the risk related to exposure to noise at work, OJ No. L137, 24 May 1986, p. 28.
5. Harms-Ringdahl L., Safety analysis. Principles and practice in occupational safety. Elsevier Science Publishers, UK, 1993.
6. ISO 1999: 1975 (first edition), 1990 (second edition), Acoustics - Determination of occupational noise exposure and estimation of noise-induced hearing impairment.
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10. Regulation of the Ministry of Labour and Social Policy of 23 December 1994 on TLVs of harmful agents in working environment.
11. Report by the International Institute of Noise Control Engineering Working Party on "Upper Limits on Noise in the Workplace", Noise/News International, Vol. 2, No 4, pp. 230–237 (December 1994).

Table 1. Equivalent continuous A-weighted sound pressure level over the whole period of noise exposure T_e ($T_e \leq 8$ h) (according to PN-N-01307: 1994) [9]

Workplace	Equivalent continuous A-weighted sound pressure level $L_{A\,eq,\,Te}$ (dB)
1. In operating cabins without telephone communication, laboratories with noise sources, workrooms with typewriters, teletypes and other rooms for similar use	75
2. In operating cabins with telephone communication, remote control cabins, rooms for precision work and other rooms for similar use	65
3. In administration areas, design offices, rooms for mental work, data handling and other rooms for similar use	55

- identification of noise hazards (measurement or prediction, comparison with admissible values),
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3. In administration areas, design offices, rooms for mental work, data handling and other rooms for similar use	55

Table 2. Proposal for the assessment of risk resulting from exposure to noise

Exposure to noise	Consequences	Severity of consequences	Likelihood	Risk	Risk control action plan
$L_{EX,\,8h}$<75 dB L_{Amax}<115 dB L_{Cpeak}<135 dB	a) Non-auditory effects of noise on health and human performance	L	L	L	a) Reducing noise exposure as far as reasonably practicable taking into account technical progress and availability of measures to control noise (at source, in particular)[1)] This requirement should be considered when designing, building and/or creating new enterprises or machinery, substantially extending or modifying existing enterprises or replacing machinery
$L_{EX,\,8h}$=76-80 dB L_{Amax}<115 dB L_{Cpeak}<135 dB	a) Non-auditory effects of noise on health and human performance	M	M	M	a) as above b) Periodic audiometric examination (at least every two years)
	b) Partial hearing loss	L	L	L	
$L_{EX,\,8h}$=81-85 dB L_{Amax}≤115 dB L_{Cpeak}≤135 dB	a) Non-auditory effects of noise on health and human performance	M	M	M	a) as above b) Periodical audiometric examination (once a year) c) Informing employees about potential risks d) Providing hearing protectors to employees who ask for them
	b) Occupational deafness	L	L	L	

[1)] This requirement was introduced in Council Directive No. 86/188/EEC [4] as the employer's general duty taking into account the fact that current research results on the influence of noise on health do not allow precise determination of safe noise levels.

Table 2. (continuation)

Exposure to noise	Consequences	Severity of consequences	Likelihood	Risk	Risk control action plan
$L_{EX, 8h}$=86-90 dB L_{Amax}>115 dB L_{Cpeak}>135 dB	a) Non-auditory effects of noise on health and human performance	H	H	H	a) as above b) Obligatory audiometric examination (constant supervision or - if not possible - examination at least every six months) c) as above d) Compulsory use of hearing protectors e) Drawing up and implementing a programme of technical and/or organisation measures to reduce noise (measures other than hearing protectors) f) Training on risk resulting from noise exposure and risk reduction (how to use hearing protectors and other protective equipment)
	b) Occupational deafness	H	H	H	
$L_{EX, 8h}$>90 dB L_{Amax}>115 dB L_{Cpeak}>135 dB	a) Non-auditory effects of noise on health and human performance	H	H	H	a), b), c), d), e), f) as above g) Marking hearing protection zones. These areas must be delimited and access to them must be restricted
	b) Occupational deafness	H	H	H	

Table 3. Proposal for the assessment of risk resulting from exposure to noise as a strenuous factor (for basic work tasks)

Exposure to noise	Consequences	Risk	Risk control action plan
$L_{Aeq,\,Te} \leq L_{dop}$ [2)] $L_{Amax} \leq 115$ dB $L_{Cpeak} \leq 135$ dB	Non-auditory effects of noise on health and human performance	acceptable	Reducing noise exposure as far as reasonably practicable taking into account technical progress and availability of measures to control noise[3)]
$L_{Aeq,\,Te} > L_{dop}$ [2)] $L_{Amax} > 115$ dB $L_{Cpeak} > 135$ dB	Non-auditory effects of noise on health and human performance	unacceptable	Reducing noise exposure with technical and organisation measures, with noise reduction at source a priority

[2)] Maximum permissible values of noise level (55, 65, 75 dB) are shown in Table 1.

[3)] See note [1)] in Table 2.

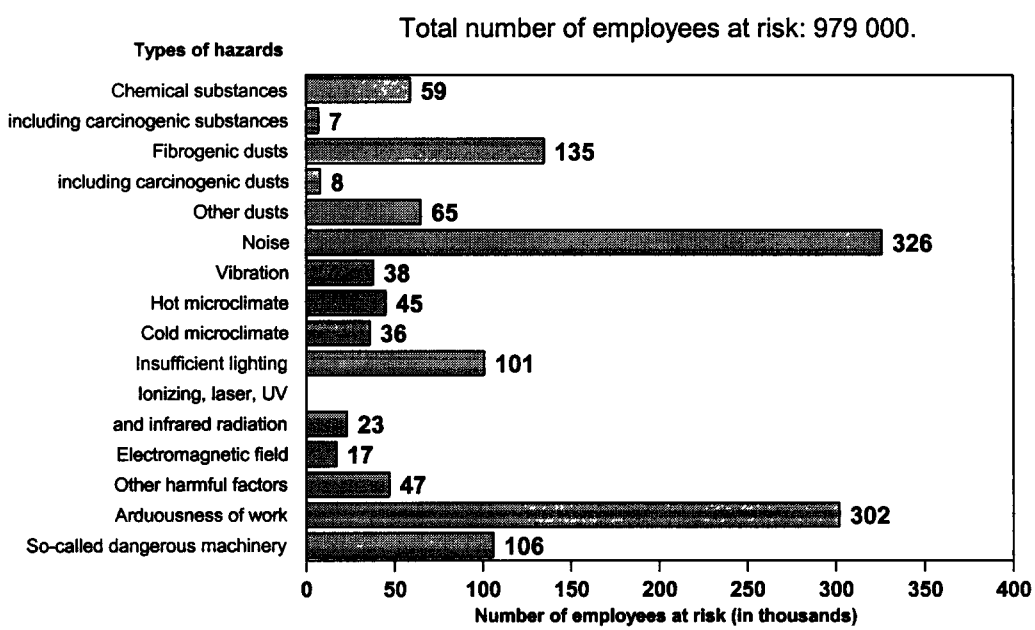

Figure 1. Employment in hazardous conditions in 1996

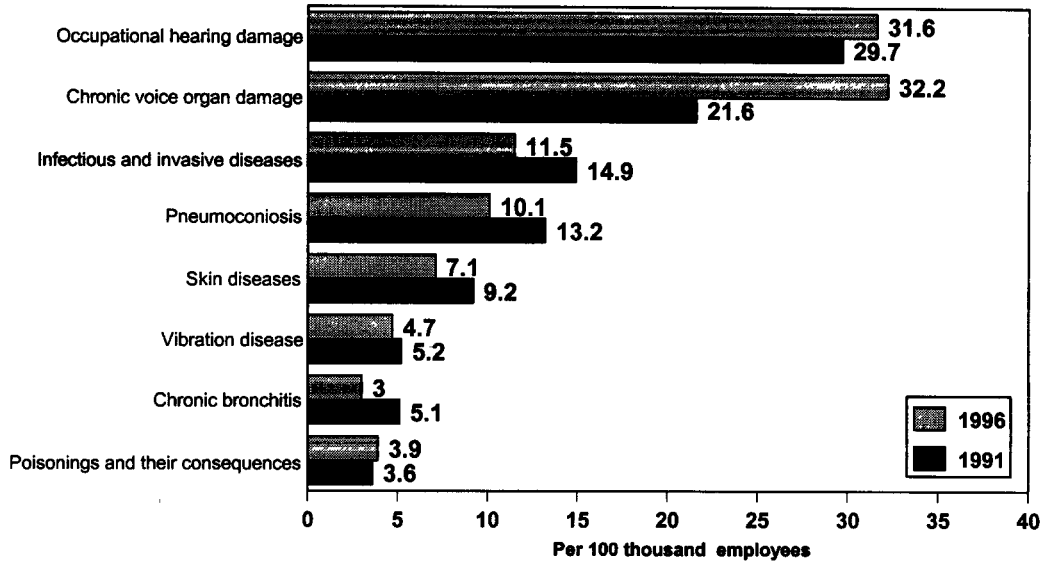

Figure 2. Occupational diseases with the highest sick rate in 1991 and 1996

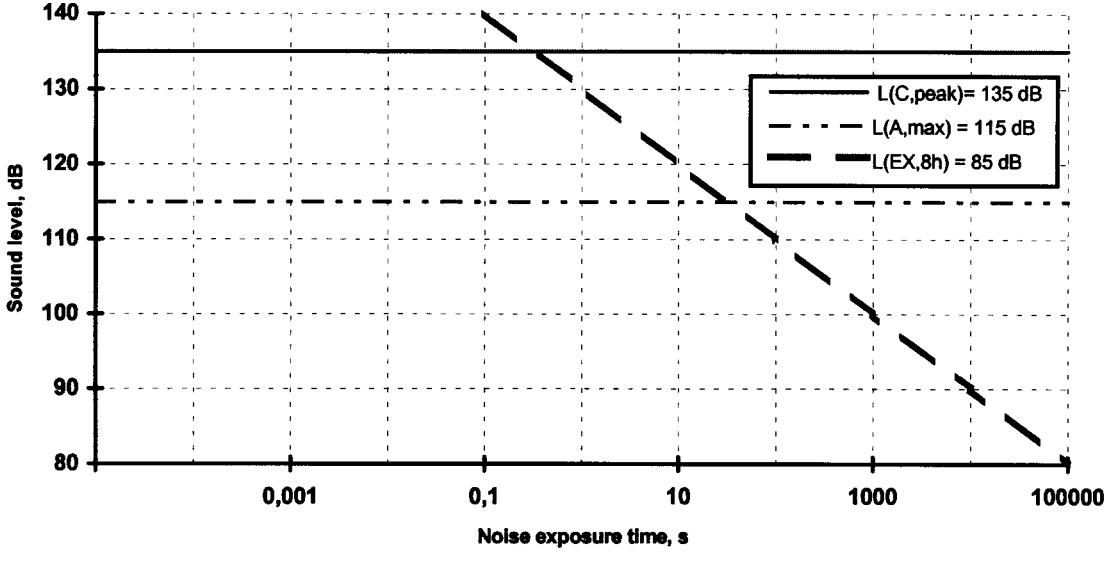

Figure 3. Noise limits as function of noise exposure