TECHNICALUNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 61, Issue I, March, 2018

HEARING IMPAIRMENT OF HUMAN OPERATOR UNDER THE ACTION OF NOISE POLLUTION ON THE WORKING SPACE

Mariana ARGHIR, Arabela-Adriana LUPAŞ (married LUNGU)

Abstract: *The paper presents aspects of generated sound pollution what influences human operator, at workplace. It is believed that hearing damage is not dependent on age, but only professional exposure to noise. It will take into account the different ages for the industrial workers who are exposed to pollution soundtrack.*
Key words: noise pollution, hearing impairment, human operator, working space.

1. INTRODUCTION

The study done in this paper, is the resulting of a need for estimation the human damage to the operator's hearing, which operates in the industrial environment with is exposured to noise in the workplace professional.

Hearing damage estimation is applied through the use of international standardization in the field, who bring some improvements, because this study is looking at the effects of low frequencies, which are strongly felt in hearing for the human operator.

This paper brings their contribution to predicting hearing damage subjected to noise, for low frequencies, dangerous enough, they have not been sufficiently analyzed so far.

2. THEORETICAL CONSIDERATIONS

The level of the threshold of audibility of a population exposed to the sound pollution are considered that has two distinct components.

It notes with "H" level of audibility threshold associated with age, measured in dB, and it is the abbreviate from international standardization labeled "HTLA". This threshold represents the lower limit of the acoustic pressure level A, from which the subject can receive sounds or noises. This damage to hearing is considered as is determined only by the human operator age and not by the least exposure to sound pollution.

Another component of hearing damage is designated with "N" (short notation for NIPTS) and represents the diplacement of the noise level produced bysound pollution, actual or potential, which is expressed in dB.

Thus, the level of the threshold of audibility [dB] associated with age and with noise, denoted "H' - noted in a short form of HTLAN", for a population exposed to noise is calculated with a relationship regarded as empirical, but that has been proven experimentally in many circumstances. Relationhas a formand content:

$$H' = H + N - \frac{HN}{120} \qquad (1)$$

The relationship can be applied only to the corresponding quantils of variables: H', H and N, in accordance with international standardization.

Observations:

1. The term "HN/120" begins to alter significantly the result if the „H + N "is greater than 40dB;
2. The relationship of the two assembly size "H" and "N" is an approximation of the biological characteristics of human body;

3. Approximation at the point two is considered quite accurate, although it is empirically established;
4. The last part of the relation (1) through N-HN/120 is called NIPTS, because it brings the corrections over the first two sizes.

3. AUDIBILITY THRESHOLD VARIATION PREDICTION

In order to predict the effects of noise on the hearing threshold, it is necessary to establish two databases:

- A database, which is noted A from healthy persons (otologic normal), who shows no signs or symptoms of disease of the inner ear and who were not exposed to noise;
- A database labeled B, from Romania, and which represents the control population, which was not exposed to noise.

3.1. Database noted A

Hearing depending on the age of a population unexposed to noise depends on some adventitious selected factors which can be identified, but they have not professionally noise as the origin.

The database is completely provided and expressing themselves through the empirical formula (2), where **a** is a coefficient, which is identified according to the frequency and is differentiated by gender.

$$H_{0,50} = a(Y - 18)^2 + H_{0,50;18} \qquad (2)$$

Hearing threshold level **N** according to age **Y** (years) to quantill 0.50 as it deems the two sexes divided equally on the job, depends on the audibility of a person with 18 years of age. For practical purposes $H_{0,50;18}$ the median value of the threshold of audibility for normal otologic persons same sex, aged 18 years, shall be treated as
zero.

The actual values of the threshold of audibility [dB] in the **A** database are reproduced in table 1.

Table 1.
The threshold of audibility in the **A** database

Frequency [Hz]	Audibility level [dB]			
	Age [years]			
	20	25	30	35
	Quantill			
Men	0.5	0.5	0.5	0.5
125	0.012	0.147	0.432	0.867
250	0.012	0.147	0.432	0.867
500	0.014	0.172	0.504	1.012
1000	0.016	0.196	0.776	1.156
2000	0.028	0.343	1.008	2.023
3000	0.046	0.564	1.656	3.324
4000	0.064	0.784	2.304	4.624
Women				
125	0.012	0.147	0.432	0.867
250	0.012	0.147	0.432	0.867
500	0.014	0.172	0.504	1.012
1000	0.016	0.196	0.576	1.156
2000	0.024	0.294	0.864	1.734
3000	0.030	0.372	1.094	2.168
4000	0.036	0.441	1.296	2.601

3.2. Database named B

The database called **B** is the characteristic of Romania, and it can be assumed that the component as it shows in table 2.

Table 2.
The threshold of audibility in the **B** database

Frequency [Hz]	Audibility level [dB]			
	Age [years]			
	20	25	30	35
	Quantill			
Men	0.5	0.5	0.5	0.5
125	2	2	3	4
250	3	5	4	7
500	4	6	7	8
1000	2	5	0	3
2000	0	3	2	4
3000	6	7	9	13
4000	9	7	10	17
Women				
125	1	2	3	4
250	3	3	4	6
500	3	5	6	7
1000	0	0	1	2
2000	2	4	0	2
3000	2	3	4	6
4000	4	2	4	6

In table 2 the values of the threshold of audibility are much higher than those shown in table 1, because they are not a reference for the population.

3.3. Risk of hearing damage with age

The risk of damage to hearing is established after the rule used in the database **A** when the population is adults for whom cuantila is 0.50 (meaning that each sex be represented by 50%), and for determining the actual values of the threshold of hearing, is dependent on the age of 50 years.

The results of the risk evaluation of hearing damage are centralized in table 3 for both sexes, noted HTLA.

Table 3.

HTLA for 50 years

Age 50 years Quantill 0,50	Frequency [Hz]						
	125	250	500	1000	2000	3000	4000
Men	3.072	3.072	3.584	4.096	7.168	11.776	16.384
Women	3.072	3.072	3.584	4.096	6.144	7.680	9.216

4. CALCULATION OF THE THRESHOLD OF PERMANENT HEARING

The threshold of permanently audibility associated with the age depends on the period in which the human body is subjected to the industrial pollution, and on the sound pressure limit dependent on frequency.

The estimating formula for the threshold of audibility is empirical and is dependent on some constants obtained through experiments. The estimated values can be found in table 4. Some of these are given by the authors.

The symbol for the permanent displacement of the threshold of hearing due to exposure to street noise is NIPTS.

Table 4.

Constants values of the NIPTS determination

Frequency [Hz]	u	v	L_0 [dB]
125	-0.042	0.210	101
250	-0.025	0.160	97
500	-0.033	0.110	93
1000	-0.020	0.070	89
2000	-0.045	0.066	80
3000	+0.012	0.037	77
4000	+0.025	0.025	75

The values of threshold hearing produced by the noise, noted **N** (short form of his NIPTS) is based on sound frequency, on exposure time and the level of exposure to noise on a normed work normal 8h mediated on $L_{EX,8h}$ exposure time θ.

For shutter speeds between 10 and 40 years NIPTS potentials median values $N_{0,50}$ [dB] are given for both sexes by the relation:

$$N_{0,50} = (u + v\log(\theta/\theta_0)) \cdot \left(L_{EX,8h} - L_0\right)^2 \quad (3)$$

In this relationship notations are:

- L_0 – is the limit level of acoustic pressure defined according to the frequency in table 4;
- θ – is the exposure time in years;
- θ_0 – is the time of an year;
- u and v – are the given coefficients depending of the frequencies, and they are in the tabel 4.

4.1.The permanent displacement of the hearing threshold caused by noise

It is believed that exposing the body to professional noise at work unfolds a number known for years. The centralized form of tabular movement of audibility threshold produced by noise, if the exposure takes place for 15, 20, 25 and 30 years, at the professional noise level equal with 82 dB, 85dB, 90dB, 95dB and 100dB.

Table 5.

Permanent displacement of threshold caused by noise, N [dB]

Time of Noise Exposure [Years]	The noise level on a standardised working day, 8h $L_{EX,8h}$ [dB]	Frequency [Hz]						
		125	250	500	1000	2000	3000	4000
30 years	82	0.	0.	0.	0.	0.15	1.67	3.03
	85	0.	0.	0.	0.	0.94	4.27	6.19
	90	0.	0.	0.	0.08	3.77	11.26	13.93
	95	0.	0.	0.52	3.00	8.48	21.60	24.77
	100	0.	1.90	6.34	10.09	15.09	35.26	38.71
25 years	82	0.	0.	0.	0.	0.13	1.59	2.94
	85	0.	0.	0.	0.	0.85	4.08	6.00
	90	0.	0.	0.	0.08	3.40	10.77	13.49
	95	0.	0.	0.48	2.80	7.65	20.65	23.95
	100	0.	1.79	5.92	9.42	13.59	33.70	37.46
20 years	82	0.	0.	0.	0.	0.11	1.50	2.82
	85	0.	0.	0.	0.	0.70	3.85	5.76
	90	0.	0.	0.	0.07	2.79	10.43	12.95
	95	0.	0.	0.44	2.56	6.28	19.50	23.10
	100	0.	1.65	5.40	8.60	11.17	31.83	35.97
15 years	82	0.	0.	0.	0.	0.08	1.39	2.67
	85	0.	0.	0.	0.	0.52	3.55	5.44
	90	0.	0.	0.	0.06	2.09	9.38	12.24
	95	0.	0.	0.38	2.24	4.69	17.99	21.76
	100	0.	1.47	4.71	7.54	8.10	29.37	33.76

5. HEARING THRESHOLD LEVEL OF A POPULATION EXPOSED TO NOISE

The threshold of audibility of men is higher than the threshold of audibility of the women, who work under the same conditions of exposure to industrial noise.

This finding is very important, that is why the study will continue to determine the threshold of audibility for men only.

It is considered a 0.5 quantill for a male population subjected to the industrial noise. It is known:

- Level of hearing threshold at the age of 20 years, 25 years, 30 years and 35 years, are presented in table 1;
- Forecast threshold of audibility for 50 years due to the age (tablelul 3);
- Level of the audibility threshold for men undergoing the industrial noise in a time of 30 years, 25 years, 20 years and 15 years, which are centralized in table 5;
- Exposure to professionally noise is done until the age of 50 years, regardless of the starting age;
- The level of exposure to industrial noise is considered as accepted by the standardized value, 82dB, but surpasses it, reason for which they have considered and exposure to 85 dB, 90 dB, 95 dB, and 100 dB.

The study is performed in an industrial Hall, in which is found a printed sheet for prepackaged food products and which require a sufficient tightness. Food will be stored at a temperature lower than the ambient. Results of the study are centralized in table 6.

Table 6.

The level of the audibility threshold of a population subject to industrial noise, H' [dB]

Time of noise exposure [Years]	Age range for men	The noise level on a standardised working day, 8h $L_{EX,8h}$ [dB]	Frequency [Hz]						
			125	250	500	1000	2000	3000	4000
30 years	20 years To 50 years	82	3.072	3.072	3.584	4.096	7.318	13.446	19.414
		85	3.072	3.072	3.584	4.096	8.108	16.046	22.774
		90	3.072	3.072	3.584	4.176	10.938	23.036	30.314
		95	3.072	3.072	4.104	7.096	15.648	33.376	37.772
		100	3.072	4.972	9.924	14.186	22.258	43.576	49.744
25 years	25 years To 50 years	82	3.072	3.072	3.584	4.096	7.298	13.366	19.324
		85	3.072	3.072	3.584	4.096	8.018	15.856	22.384
		90	3.072	3.072	3.584	1.176	10.568	22.546	29.874
		95	3.072	3.072	4.064	6.896	14.818	32.426	36.991
		100	3.072	4.862	9.504	13.516	20.758	42.169	48.729
20 years	30 years To 50 years	82	3.072	3.072	3.584	4.096	7.278	13.276	19.234
		85	3.072	3.072	3.584	4.096	7.868	15.626	22.144
		90	3.072	3.072	3.584	4.166	9.958	22.206	29.334
		95	3.072	3.072	4.024	6.656	13.448	31.276	39.684
		100	3.072	4.722	8.984	12.696	18.338	40.482	47.443
15 years	35 years To 50 years	82	3.072	3.072	3.584	4.096	7.248	13.166	19.054
		85	3.072	3.072	3.584	4.096	7.688	15.326	21.824
		90	3.072	3.072	3.584	4.156	9.258	21.156	28.624
		95	3.072	3.072	3.964	6.336	11.858	29.766	38.144
		100	3.072	4.542	8.294	11.636	15.268	38.264	45.537

5.1. Interpretation of results

5.1.1. Exposure to noise with 82 dB

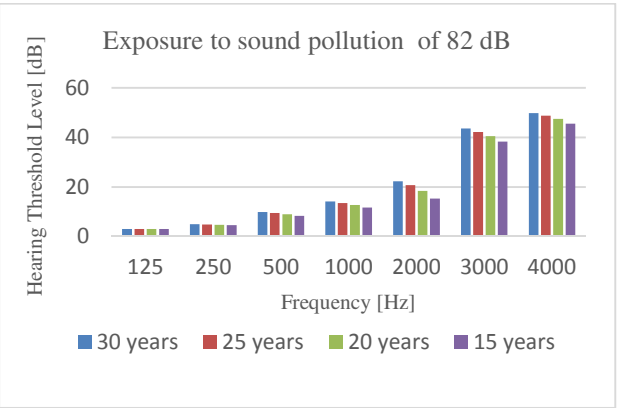

Fig. 1. Forecast for audibility threshold exposure to pollution soundtrack of 82 dB

From the summarizing data table will individually analyze the effect of exposure to industrial noise on different age periods.

5.1.2. Exposure to noise with 85 dB

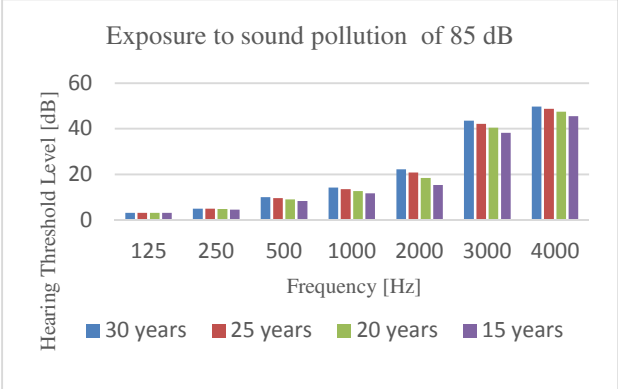

Fig. 2. Forecast for audibility threshold exposure to pollution soundtrack of 85 dB

5.1.3. Exposure to noise with 90 dB

Sound pollution exposure of 90 dB is especially difficult for the human operator, requiring excessive auditory organ.

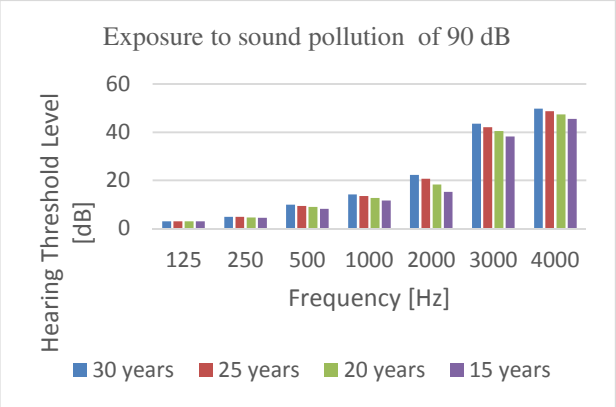

Fig. 3. Forecast for audibility threshold exposure to pollution soundtrack of 90 dB

5.1.4. Exposure to noise with 95 dB

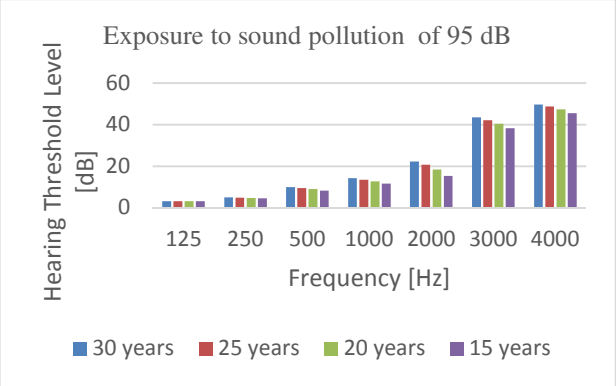

Fig. 4. Forecast for audibility threshold exposure to pollution soundtrack of 95 dB

5.1.5. Exposure to noise with 100 dB

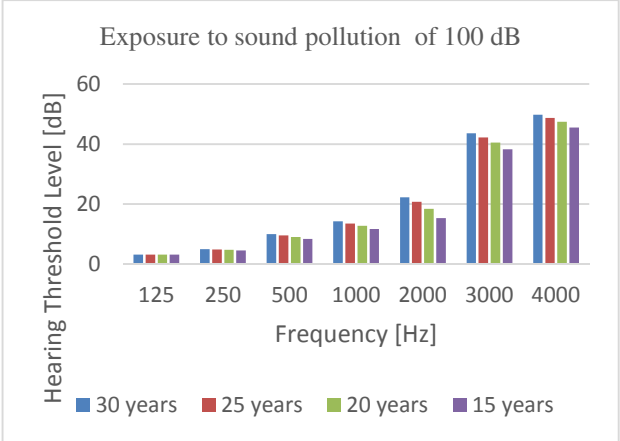

Fig. 5. Forecast for audibility threshold exposure to pollution soundtrack of 100 dB

6. CONCLUSIONS

This study estimate of damage to hearing from exposure to professional noise. It is an alarm signal for the industry, to bring out the fact that after 20 years of work hearing organ had an irreversible deteriorates, and the human operator is unrecoverable.

The sound pollution greather that at 71dB produce injury to the human opperator any time. Looking at the figures between 1 and 5 at 30 years exposure to the noise diminish the hear activity with 40 dB, and the operator can identify the sound greater this sound preassure.

7. BIBLIOGRAPHY

[1] SR ISO 1999: 2003, Determinarea expunerii la zgomot professional si estimarea deteriorarii auzului

Deteriorarea auzului operatorului uman supus la polusre sonoră la locul de muncă

Rezumat: *Lucrarea prezinta aspectele generate de poluarea sonora ce actioneaza asupra operatorului uman, la locul de munca. Deteriorarea auzului se considera ca nu este dependenta de varsta, ci numai de expunerea profesionala la zgomot. Se vor lua in considerare diferite varste pentru lucratorii din mediul industrial, care sunt supusi la poluare sonora.*

Mariana ARGHIR, Prof. Dr. Eng., Department of Engineering Mechanical Systems, UTCN, E-mail: Mariana.Arghir@mep.utcluj.ro, marianaarghir@yahoo.com, Office Phone 0264.401.657, Cluj-Napoca, ROMANIA.

Arabela LUPAŞ (married LUNGU), DrD. Eng., Department of Engineering Mechanical Systems, UTCN, E-mail: arabela.lungu@yahoo.com, Mobil 0724.268.078, Cluj-Napoca, ROMANIA.