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EVALUATION OF HERAING LOSS OF HUMAN IN WORKING CONDITION USING AUDIOMETRICAL MEASUREMENTS

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Abstract
Noise must also be considered as another risk of working environment belonging to the most spread working risks. Noise has become an important hygienic factor having an influence on human health, mainly on auditory apparatus.
It is difficult to treat damage of hearing caused by noise, that's why successful protection of workers consists of consequent technical and medical prevention check-ups. Technical prevention is also based on utilization of audiometric measurement and determination of total hearing loss, on this basis it is possible to carry out arrangements against deteriorating of the auditory apparatus.
The research based on medical check-ups can document how the hearing loss of the workers in noisy environment can be worsened. When applying the data from research it is possible to predict dynamics of progress of hearing loss on the basis of audiometric measurements by means of their evaluation and using suitable diagrams and formulas.
Key: noise, working environment, audiometric measurement, hearing apparatus

1. INTRODUCTION – SPECIFICATION OF THE RESEARCH'S SUBJECT

Medical controls of the workers exposed to higher degree of risks of noise are a part of measurements to protect health of the workers. The employer is obliged to provide medical prevention examinations for the people exposed to noise excising upper level values of the exposure.

Basic prevention examinations in relation to work are the following:

- Entry medical examination
- Regular medical examination
- Final medical examination

Medical examination is a basic element of the prevention as noise is considered to be risk that gradually impairs health of the exposed workers. In case when the exposure exceeds action values it is compulsory to provide control of the individuals aimed at providing medical examinations and early diagnostics of any loss of hearing induced by noise.

2. MATERIAL AND METHODOLOGY

The object of the investigation was the employees who took part in medical prevention examinations including the workers who had hearing problems.

The aim of the prevention examination of the workers exposed to excessive noise was an early diagnostics of changes of hearing induced by noise and protection of hearing. Every examination consisted of examination of otoscopic examination combined with audiometric examination including hearing threshold tone level and audiometric air conduction.

The investigation was carried out in the years 2001 up to 2009 at the workplace that was equipped with audiometer MAICO MA 52 and with audiometric booth Sibelmed S-40.

3. EXPERIMENTAL METHODS

An assessment of the dynamics of the hearing loss development of a randomly selected worker. The randomly selected worker (32 years old blacksmith) has been working in a noisy environment

prevailingly in the type of work 43 totally for about 10 years. The dynamics of the hearing loss development of the mentioned worker has been assessed by means of the medical examinations in the years 2001 up to years 2009.

The programs Microsoft Excel and Microsoft Word have been applied for selection of the tables and suitable graphs including selection of the equations for concrete measured and assessed results from audiometric measurements of the individual workers (.....). On the basis of the mentioned programs suitable types of lines for depicting trends, regression, regression equations and reliability R2 have been selected.

Table 1. The measured data from the audiogram (dB) and calculated hearing loss (%) of the evaluated worker in medical examinations, AC (air conduction), BC (bone conduction), LE – (left ear), RE (right ear)

Frequency (Hz)	500	1000	2000	4000	6000	Hearing Loss (%)	Total Hearing Loss (%)
AC (dB)-LE-2009	10	10	20	25	35	5.1	4.95
BC (dB)-LE-2009	10	10	20	30			
AC (dB)-RE-2009	10	15	20	20	40	4.9	
BC (dB)-RE-2009	10	15	20	20			
AC (dB)-LE-2008	15	15	15	15	20	3.0	3.55
BC (dB)-LE-2008	10	10	15	15			
AC (dB)-RE-2008	15	15	20	20	25	5.2	
BC (dB)-RE-2008	10	15	15	25			
AC (dB)-LE-2007	10	15	10	30	30	4.2	3.0
BC (dB)-LE-2007	10	15	10	25			
AC (dB)-RE-2007	10	10	10	25	30	2.6	
BC (dB)-RE-2007	10	10	10	20			
AC (dB)-LE-2005	10	10	15	20	40	2.7	3.05
BC (dB)-LE-2005	10	10	15	20			
AC (dB)-RE-2005	10	15	15	25	35	4.1	
BC (dB)-RE-2005	10	15	15	20			
AC (dB)-LE-2003	15	15	15	10	10	2.8	2.12
BC (dB)-LE-2003	15	15	15	10			
AC (dB)-RE2003	15	15	10	10	35	1.9	
BC (dB)-RE2003	15	15	10	10			
AC (dB)-LE-2001	15	15	15	10	15	2.8	2.27
BC (dB)-LE-2001	15	15	15	15			
AC (dB)-RE-2001	10	10	15	15	30	2.1	
BC (dB)-RE-2001	10	10	15	15			

The results in Table 1 were acquired during the audiometric examinations of hearing threshold by air and bone conductions by means of MA 52. The results were evaluated and they were processed into graphs of the hearing loss of the left and right ears on the basis of Excel program in the framework of medical examinations carried out in the years 2001 up to 2009 years (Figure 1, 2)

Hearing loss of the right ear (RE) (%) of the evaluated worker in the individual years on the basis of the medical examination.

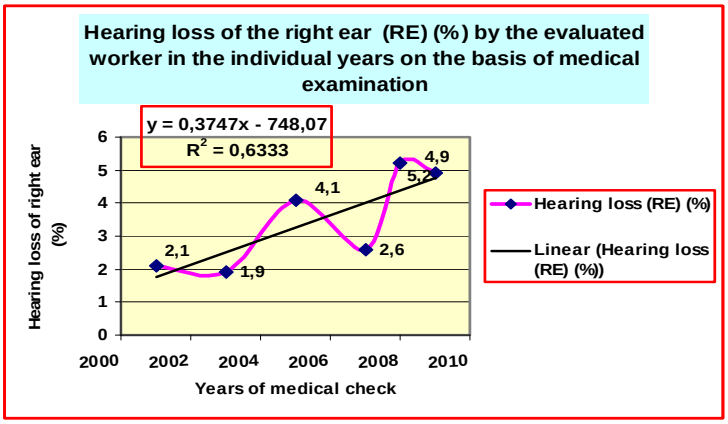

Figure 1. Hearing loss of the right ear of the evaluated worker on the basis of the medical examinations in the years 2001-2009

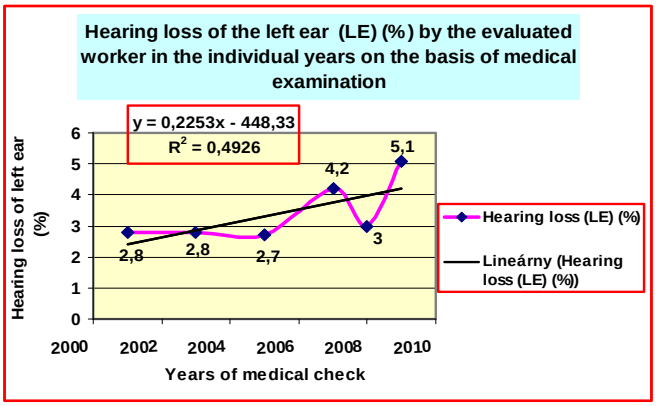

Figure 2 Total hearing loss (THL) of the evaluated worker in the individual years on the basis of medical examinations

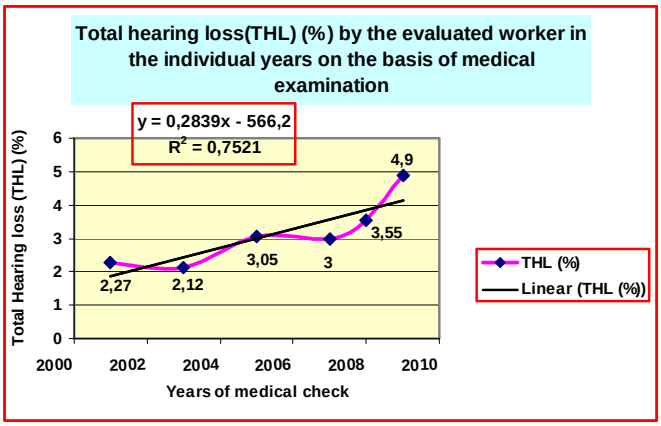

Figure 3 Total hearing loss (THL) of the evaluated worker on the basis of the medical examinations in the years 2001- 2009

Range of hearing loss in practice is being assessed mainly in by means of the percentage of the hearing loss calculated on the basis of Fowler's equation

$$F = L + \frac{H - L}{4}[\%] \qquad (1)$$

where:

F - stands for total hearing loss

L - loss of hearing measured and calculated for the better ear from the audiogram according to Fowler's (%) equation

H - hearing loss measured and calculated for the worse ear on the basis of Fowler´s equation

Hearing loss is being calculated for each ear separately, a then for both ears simultaneously to define bineural (total) hearing loss.

$$F = L + \frac{H - L}{4}\ \% = 4.9 + \frac{5.1 - 4.9}{4} = 4.95\ \%$$

The basis of calculations of percentage of hearing loss is threshold values of air conduction for pure tones. The threshold of the bone conduction is not taken into account in this case.

At first the calculations are carried out for each individual ear separately and then total loss is calculated for both ears. The calculations are carried out on the basis of the threshold values of four basic frequencies: 500, 1000, 2000, 4000.The mentioned frequencies are considered to be the most important for understanding human speech. The most important frequency of the mentioned above is considered to be frequency of 2000 Hz, because at this frequency it is possible to acquire the highest values of hearing loss.

For calculations of losses it is necessary to have a table based on Fowler, in which we can find the mentioned values with corresponding values of the particular frequency of a certain level (3).

The procedure of the calculations for the year 2009 has been the following: The final medical examination of the evaluated worker was carried out in 2009 by means MAICO MA 52. The acquired results from the audiogram were recorded into Table 1 separately for the left ear (LE) and for the right ear (RE). Only the measurements of air conduction (AC) have been used for calculations.

The results for the right ear in Table 1 for the year 2009 showed 4.9% hearing loss of the RE..

The calculations have been done on the basis of threshold values of four basic frequencies, i.e. 500, 1000, 2000, and 400 Hz at air conduction (AC)

For calculations of losses it is necessary to apply Fowler's Table (3) where we can find the values corresponding with frequencies of the particular levels.

The similar procedure can be applied for the left ear (LE) as well

The results for the left ear in Table 1 for the year 2009 represent 5.1% hearing loss. The total hearing loss can be calculated on the basis of the equation 1 F(%) EQUATION.

The total hearing loss (%) calculated from the measured data of individual medical examinations of the evaluated worker according to Fowler is implemented into Table 1 and depicted in Figure 3.

Graph 1 depicts hearing loss of the right ear (%) of the examined worker in individual years on the basis of medical examinations carried out in 2001 – 2009. The graph1 is processed on the basis of equations (2) and (3) that can serve for determining dynamics of loss hearing development of the right ear in the following years and for taking suitable measures for improving health condition of the evaluated worker. The equations are based on the measured statistical results of the selected type of the trend and regression in the program Excel.

The equations are the following: $Y = 0.3747\ x - 748.07$; $R^2 = 0.6333$

Graph (Figure3) depicts total hearing loss (%) of the examined worker in individual years on the basis of medical examinations carried out in the years 2001-2009. In Figure 3 we can find equations (6) and (7) applied for determining dynamics of total hearing loss development in the following years and for taking suitable measures for improving the state of the evaluated worker. The equations are based on the measured statistical results of the selected type of depicting trend and regression in the program Excel.

The equations have been being applied in the investigation in the following way:

For example: If we would like to find out the range of total hearing loss of the examined worker in the year 2013, we have to substitute for x the year 2013 and we can calculate "y"

$$Y = 0.2839\ X - 566.2 = 0.2839 \times 2013 - 566.2 = 5{,}29\ \%$$

where: y – expresses total hearing loss (%) of the evaluated worker in the year 2013

x – stands for the year in which we would like to find out total hearing loss in noisy working environment, in our case the year 2013

The results are measured and calculated with mathematical precision $R^2 = 0.7521$.

4. CONCLUSION

The conclusions of the evaluation of the investigation of the dynamic hearing loss of the evaluated worker. Total hearing is deteriorating with age at higher frequencies above 2000Hz that means the hearing threshold is becoming higher and it gains values higher than 20dB at frequencies 4000 and 6000 Hz. At frequency 6000Hz the hearing threshold reaches value of 40dB. From audiometric medical examinations we can find out, the worker has a perceptional impairment of the hearing on the right as well as on the left ears because hearing threshold at bone conduction exceeds limiting value 20dB by 10 dB at the frequency of 4000Hz.

Perceptional impaired hearing is characterized by raised threshold of air conduction as well as by the raised threshold of bone conduction. The worker has to be under a constant medical supervision and the doctor determines a medical examination every 6 months.

The final medical examination in 2009 assessed loss hearing development as feasible in the period 2001 to 2009 as the dynamics of hearing loss development reached only the value 0.54% per year (see Table 1) not exceeding the limit of 1%.

We can presuppose that the limit of the evaluated worker will not be exceeded in 2013 either.

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