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EVALUATION OF HEARING IMPAIRMENT DUE TO NOISE

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ABSTRACT

The authors approach the problem of the relationship between the exposure to noise and hearing impairment from the point of view of hearing impairment using statistical methods. They conclude that an analysis of the characteristic signs of impairment is of basic importance and suggest that the place of appearance of the dip in the audiogram be considered as an aspect of group forming. Patterns formed on this principle can be considered as statistically homogeneous and of normal distribution and are suitable for describing a mathematical definition of the relationship between noise exposure and hearing impairment.

The development of noise induced hearing loss is influenced by various factors[1,3,7,10]. Of these, the workers' auditory threshold diagrams, the level of noise at their place of work and the exposure time spent at noisy working sites are considered to be measurable basic points. We are going to deal only with the auditory threshold diagram, which is a variable of the supposed functionality and as such can be used to characterize the hearing damage.

SUBJECTS AND METHODS

The audiometric investigations were performed with a Peters Type AP-6 clinical audiometer, standardized according to the 1964 ISO recommendation[5]. The measurements were done 16 hours after the last noise exposure in an anechoic chamber corresponding to the ANSI S 1.3–1960 standard[2].

In the evaluation of the audiograms the ISO[6] and AAOO[4] recommendations were taken into account. The actually noise induced hearing loss was determined from the audiograms taking into consideration the sociacusis according to sex[8,11]. From the audiograms corrected according to the above procedure, the mean values of the hearing curves (D_{50}) were calculated.

In total, 922 employees were medically examined in a cast-cleaner factory (code number 04), two textile factories (06, 31) a smelting works (30) and two metal-industries (11, 23). The audiograms of only those workers were evaluated, 669 persons, whose hearing loss on the basis of the medical history and otological examination could be ascribed with high probability to noise exposure of occupational origin only.

RESULTS AND DISCUSSION

The general results of the different examinations published in the literature seem to agree about the average threshold changes caused by exposure to noise. This is shown in Figure 1, where we can observe both Taylor's data[12] (A) and our own results[9] (B).

The average audiograms which can be seen in the graph show a typical picture of the noise induced hearing loss. With increasing exposure to noise hearing is gradually impaired, but the exact degree of the impairment cannot be established as it is not enough to take into consideration only the average audiograms when investigating the mechanism of hearing damage. It is essential

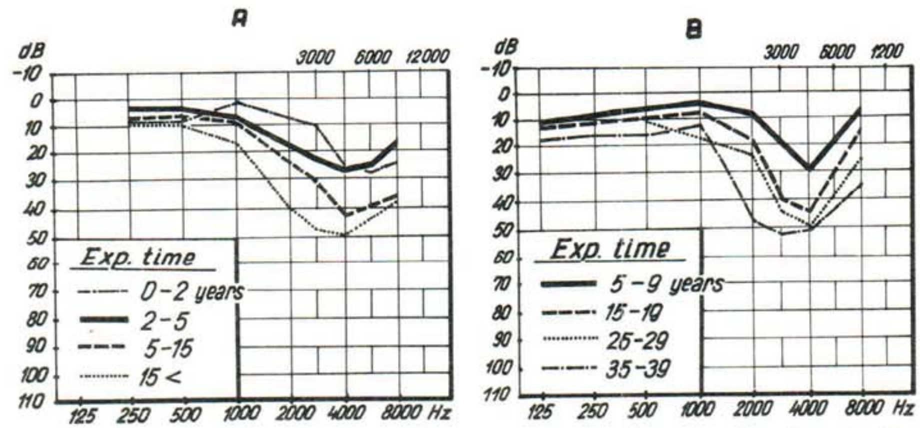

FIG. 1 – Average auditory threshold diagrams in the function of exposure time. A = the data according to Taylor[12], B = own data[9].

to get to know the time function of the development of hearing loss too[9]. This means, that the function of impaired hearing and exposure time must be interpreted according to the individual frequency components of the audiogram. Figure 2 shows the results of the examinations which where accomplished in this way. The upper part (A) of the figure shows Passchier-Vermeer's data[8] from 1968, the lower part (B) represents our own data[9]. We have plotted the average and D_{50} (Passchier-Vermeer) values of hearing loss of the workers from different industrial units – measured at 4000 Hz – against the exposure time.

It appears from the diagrams, that the results of the examinations dealing with the exposure time as a function of hearing loss are not so unambiguous at a given frequency as the results shown in the average diagrams. The only

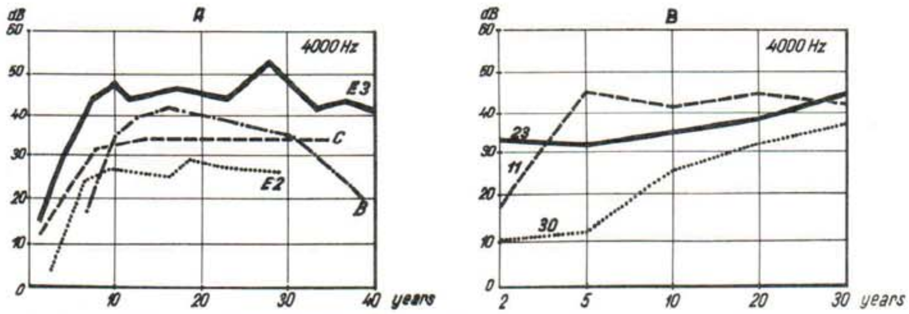

FIG. 2 – Average auditory threshold values in the function of exposure time measured at 4000 Hz from different samples of industrial workers. A = Passchier-Vermeer's data[8], B = own data[9].

resemblance is that the graphs approach a given impairment value which differs from group to group more or less asymptotically.

We looked for the factors which cause difficulties in determining the explicit form of the function. It is a generally accepted fact, that at the beginning the noise induced hearing loss develops at 4 000 Hz or occasionally at 3 000 or 6 000 Hz in the shape of a dip[3,7,9,10]. However, when means and patterns are analysed from the literature the place of dip is not taken into consideration. In our examinations we separated the audiograms with different dip maxima. The obtained results are shown in Figure 3. In the upper part of the figure are average auditory threshold values of the samples which were composed

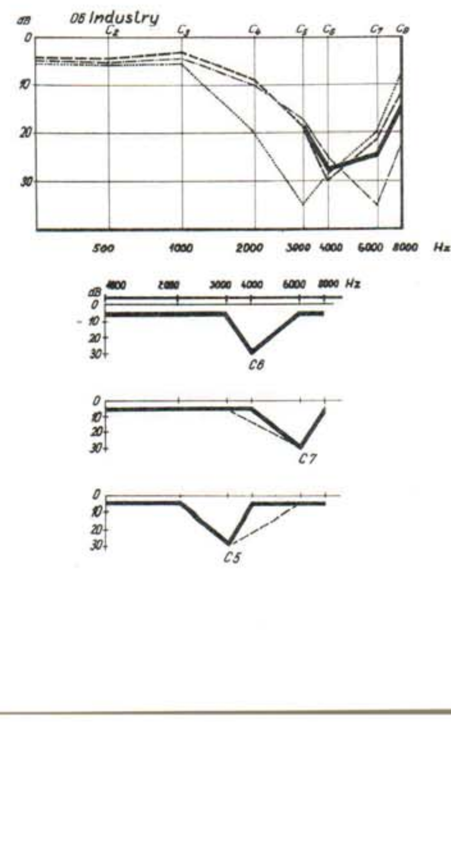

FIG. 3 – Average audiograms, calculated according to dip maxima.

considering the place of the dip maxima. The average audiogram of all workers with impaired hearing is illustrated by a thick, continuous, curved part of the graph. The sketch-planned diagrams in the lower part of the figure demonstrate well that the average audiogram of the patterns formed without considering dip maxima may lead to false conclusions when the relationship between the impairment and the effect of noise is studied. On the basis of the average audiograms fixing the static position we can give only a very approximate statistical estimation of the changes occurring in the course of time. For this reason we further analysed the audiograms of the 3000, 4000, 6000 Hz maxima separately in our subjects[9].

Statistical methods are needed to establish quantitative relations. We shall now examine the basic average audiograms from the mathematical point of view using the above facts. We may conclude that the measuring results at each audiological frequency may be regarded as a mass of disordered data, which give the frequency distribution of the pattern. Statistically, the distribution includes all necessary information about the pattern. Usually it is not the distribution of the sample – the population – that matters, but some determined attribute or property of it or its numerical value.

However the performance of mean value forming implies certain conditions. The most important among these is the normal or Gauss distribution of the sample.

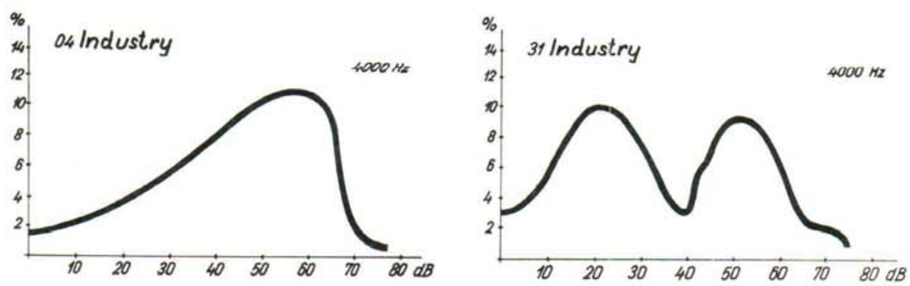

FIG. 4 – Distribution of auditory hearing threshold values measured at 4000 Hz.

Figure 4 shows the plotting of the distribution of some patterns which were previously characterized by their average values. We may observe that the upper diagram (industry code number 04) shows an asymmetrical distribution and the lower one (industry code number 31) may be divided into two independent patterns, having a 20 dB and a 55 dB mean value respectively. The diagrams prove that the condition of normality is not fulfilled on the upper graph, while the lower one is not homogeneous. Therefore we cannot characterize the presented dispersions by their average value. It would seem easy to declare that a wrong view was chosen and that this is the reason for the non-normal distributions. In the literature the parameters of the impaired hearing and exposure time function are generally taken into consideration by fixed limits. Such fixed limits exist both for the noise level and the exposure time and age, for example the exposure times of 2 – 5 or 5 – 15 years or the noise levels given in 5 – 6 dB classes. In our opinion it is more proper to set out from homogeneous normal distribution patterns when shadowing permanent hearing threshold changes or rather to determine the function relying on these. In the interest of this we divided the workers into groups according to their profession or rather according to their jobs, considering the exposure to noise. So the pattern can be characterized by seemingly larger noise level flutterings but its elements constitute a well defined group of workers (e.g. wood industry machine workers or joiners characterized by noise levels produced by wood industry machines). It was on the basis of the above group composing principles that we formed the patterns in our examinations and these proved to show a normal distribution and to be already statistically homogeneous. The so obtained results are shown in Figure 5 (industry code number 04).

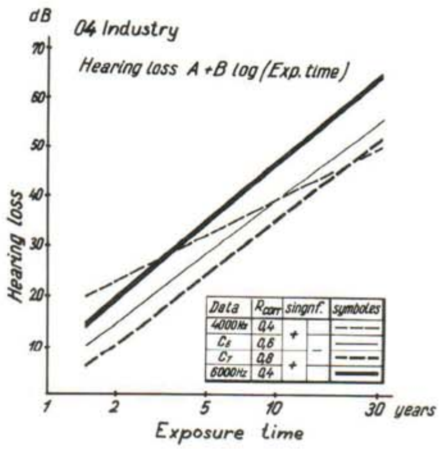

FIG. 5 – The probable tendency of damages at 4 000 and 6 000 Hz plotted against the exposure time.

As a function approximating the functional mechanism we applied the relation $Y = A + B \times \log X$. In this equation Y is the degree of hearing loss and X is the exposure time. The dotted line represents the indiscriminately measured values at 4 000 and 6 000 Hz respectively, the unbroken line shows the data of the patterns chosen according to the place of dip maxima. The table includes the correlation values and the marking of the changes found to be significant. After the discrimination of dip maxima the results at the examined frequencies are better than before, the graph fitting gives a larger correlation coefficient. The difference among those patterns which were grouped according to the place of dips, happened to be unambiguous and significant, while the graphs fitted nonselected values upon the dips cannot be considered to be statistically different. The patterns produced on the basis of the related principles seem to be mathematically suitable for determining the relation between exposure time and the given frequency of hearing loss.

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