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The Magic 85 dBA

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It is well known that occupational hearing loss is the result of long exposure to high levels of noise. When asked about how long is "long exposure", the answer frequently is given as: "40 years of exposure, 8 hours a day, and 40 hours a week." And, to the question of how high a potentially damaging level is, the magic number of 85 dBA comes to mind. Anything above 85 dBA is potentially hazardous?

Have you ever asked yourself where did this number come from? What is the body of research and where is the main references, if any, to be found?

We do know that the concept of noise exposure is the sound energy averaged over a period of time (usually 8 hours). In that respect, we state that what counts is not the instantaneous sound level, but the one integrated over the work shift, denoted as $L_{ex,8hs}$ (also known as noise exposure level). So, as a matter of fact we set our "safe" limit to

$L_{ex,8hs}$ = 85 dBA.*

*There is another issue of the accuracy of the sound measurement itself. The accuracy of a field measurement of sound levels is +/- 2 dB (Behar et al., 1975). That means that a reading of 85 dBA on our sound level meter can be anything between 83 dBA and 85 dBA and that is a big difference!

In this article, we will focus only on the hearing loss predictions that are the basis for setting the 85 dBA limit and will leave the issue of accuracy of the measurement for another occasion.

But did you ever ask yourself if this number of 85 dBA applies to everyone, man or woman, young or old? Here is when the ISO Standard 1999 comes into the picture.

Predictions

The ISO 1999 model predicts hearing losses from noise exposures and age. The standard summarizes what is known regarding the factors that influence this phenomenon that is affecting a large portion of humanity, especially in the industrialized world.

The standard estimates the hearing loss of a population depending on the following variables:

- Sex (Male or Female)
- Age (between 19 and 60 years)
- Noise exposure level Lex,8hr (within the range of 75 dBA through 100 dBA)
- Length of the exposure (1 to 40 years)
- Percentage of the exposed population (between 0.05 and 0.95%)
- At the frequencies of 125, 250, 500, 1kHz, 1.5 kHz, 2kHz, 3 kHz, 4 kHz, 6 kHz, and 8 kHz

The ISO 1999 model estimates the hearing loss resulting from age (presbycusis), from noise exposure and the combination of both: noise and age.

The calculation is relatively complex because of the many variables shown above, so we won't get into it in too much detail, but just as an illustration of the results, we examine some of the predictions of hearing loss (combined from age and noise) of a group of:

- men,
- of 60 years of age,
- who have been exposed to Lex,8hr of 80, 85 and 90 dBA, and
- were exposed for 40 years.

Results are presented as the mean value at 1 kHz, 2 kHz, and 4 kHz.

There are 3 figures corresponding to hearing losses that will be experimented by 90% (Figure 1), 50% (Figure 2) and 10% (Figure 3) of the population after 40 years of exposure.

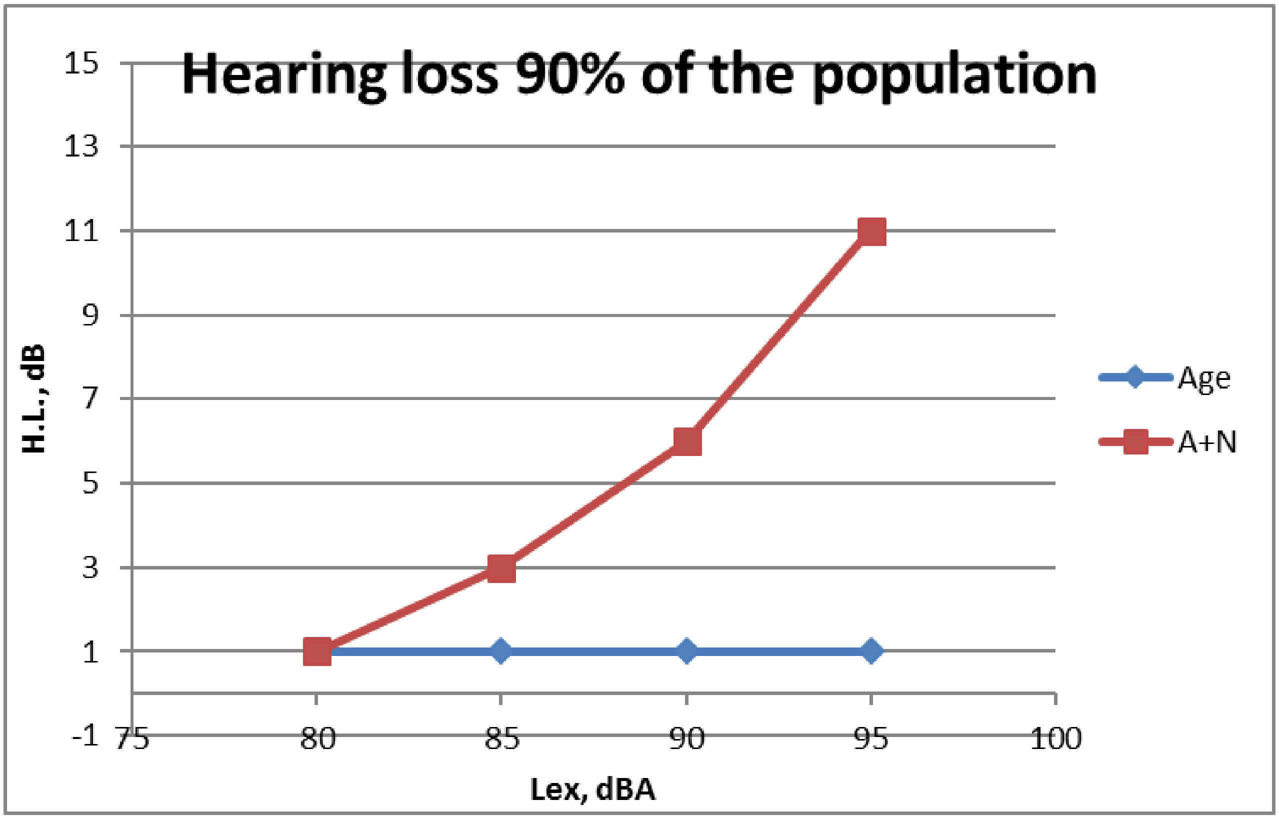

Figure 1. Information on the minimum hearing loss to be experienced by 90% of the population.

Figure 1 provides information on the minimum hearing loss to be experienced by 90% of the population. In other words, almost everyone will experience the hearing loss shown in this figure. The x axis shows the noise exposure $L_{ex,8hr}$ for the values of 80, 85, 90 and 95 dBA.

Two lines are shown: one (horizontal) corresponds to the hearing loss due only to age. As expected, this hearing loss due to age is independent of the noise exposure and it equal to 1 dBHL. Again, it tells us, that 90% of the male population will experience a hearing loss due to age of 1 dB or higher (average of 1, 2 and 4 kHz).

The second line (horizontal) corresponds to the combined loss of age and noise exposure after 40 years of exposure. While there is no increase of the hearing loss at $L_{ex,8hr}$ =80 dBA, it climbs steadily for larger exposures, reaching 11 dBHL for an exposure of 95 dBA.

This tells us that almost everyone exposed to 95 dBA for 40 years, will experience a hearing loss of at least 10 dBHL when they reach the age of 60 years.

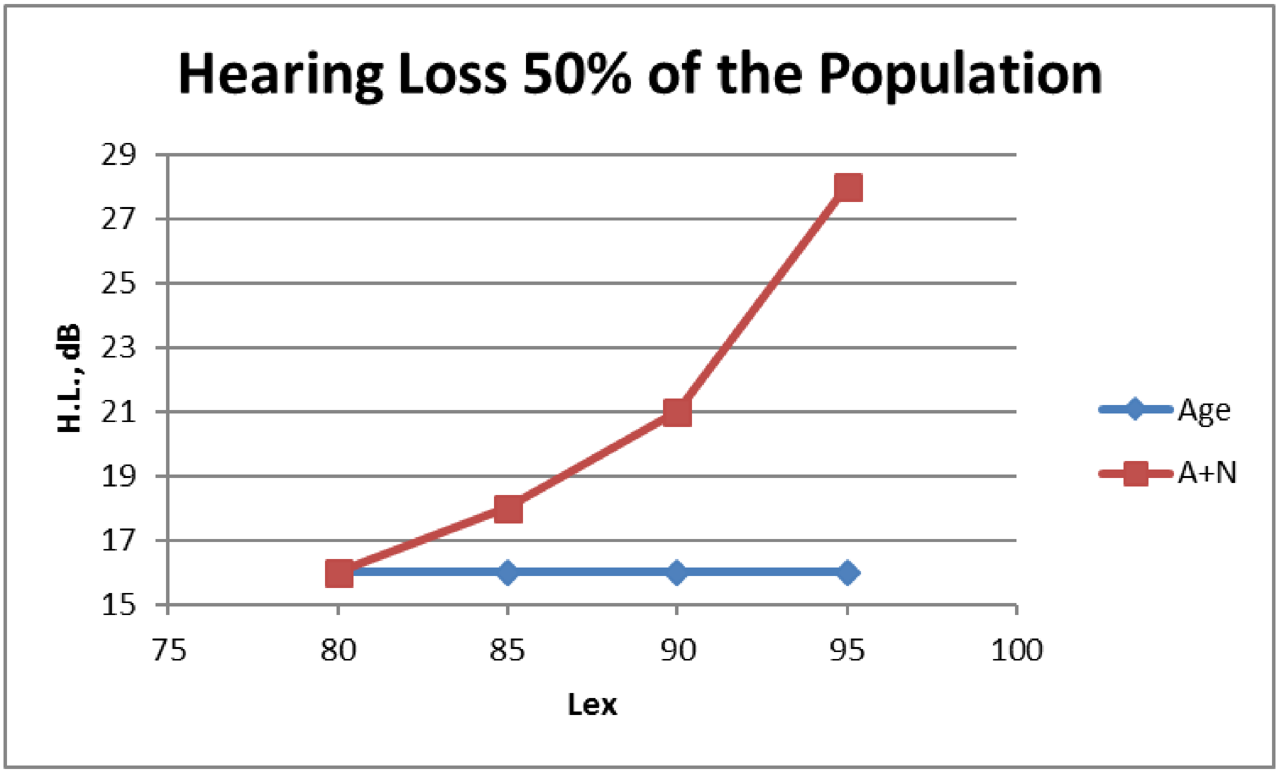

Figure 2. Results for 50% of the population.

Figure 2 shows results for 50% of the population. Here, again, we see a horizontal line, this time at 15 dBHL, indicating that half of the population will experience a 15 dBHL hearing loss due to age. While at $L_{ex,8hr}$ = 85 dBA, there is almost no increase (only 2 dBHL), it is 12 dBHL for $L_{ex,8hr}$ = 95 dBA.

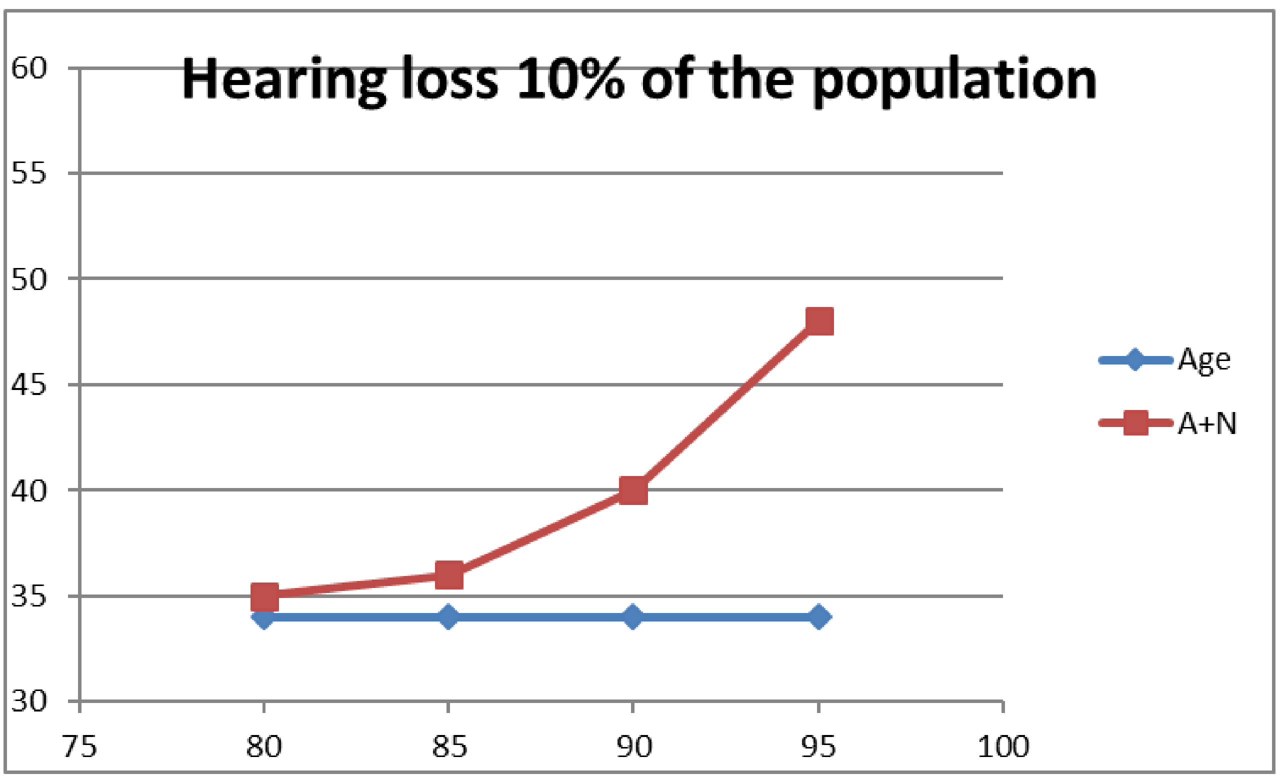

Figure 3. Situation of the 10% who are the most sensitive portion of the population.

Figure 3 shows the situation of the 10%, the most sensitive portion of the population. Here the hearing loss due to age is already 34 dBHL! There is almost no increase in the hearing loss when this population is exposed to $L_{ex,8hr}$ =85 dBA – only 2 dBHL. The exposure to $L_{ex,8hr}$ =95 dBA leads to an increase of only 12 dBHL.

Some Observations

The examination of the 3 figures shows that hearing loss is greatly influenced by individual susceptibility to noise: in identical circumstances, some people suffer larger hearing. This can be seen even in the absence of noise: merely the effects of presbycusis in the 90%, 50%, and 10% range of susceptibilities of the 60-year-old male population. The expected hearing loss is respectively 1 dBHL, 16 dBHL, and 35 dBHL!

Surprisingly, when presbycusis is combined with noise exposure, the increase of hearing loss appears to be similar in all 3 groups: it is 10, 12 and 13 dBHL for all of them. It may appear that presbycusis "protects" the hearing from further deterioration, since the already damaged ear perceives the noise as being of lower level. For instance, for a person from the 10% group who has already a hearing loss (from age) of 34 dBHL, a sound of 95 dBA will "sound" as of only 61 dBA! (This, of course is a speculation that needs to be confirmed). The literature refers to this as "asymptotic hearing loss".

What About the "Magic" 85 dBA?

The 3 figures have the answer to the question of the "magical 85 dBA." The hearing loss of a population exposed to $L_{ex,8hr}$ = 85 dBA tells us that for 90% of the population, 85 dBA will not increase the hearing loss by more than 1 dB. For the 50% and the 10% of the population, there will be an extra hearing loss of 2 dB due to the noise exposure.

Acknowledgement

Calculations were made using a spreadsheet created by Dr. Martin Liedtke (IFA, Germany).

Suggested Reading

Behar A, Domenech A, Moncaglieri R, et al. Accuracy in the measurement of sound levels "in situ" with sound level meters. Appl Acoust 1975;8(1):67–69

Canadian Standards Association. CSA Standard Z107.6 audiometric testing for use in hearing loss prevention programs Toronto: Author; 2016.

International Organization for Standardization ISO Standard 1999:2013 (Rev. 1999:1990) Acoustics - Estimation of noise-induced hearing loss. Geneva: Author; 2013.