Attenuation profiles of customized hearing protection devices

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It was interesting to study the various attenuation profiles of customized hearing protection devices.

How does attenuation vary with frequency?

What is a filter with uniform response attenuation made up of?

What is the maximum and minimum attenuation that can be expected of a protector?

This study covers three categories of filters: filters with controlled air flow, sealed filters, and uniform response filters.

Once the standard profiles have been established, a second part will cover the minimum and maximum attenuation measurable under CAPA (system to measure the effectiveness of hearing protection earplugs).

Protection against noise
E-110.1

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1. Profile type based on the type of filter of the hearing protector

The following profiles allow you to see the differences between the three types of filters. The protectors (outer casing) are similar; only the filters change.

The values were obtained from the CRITT certification results on ten models of hearing protectors of the COTRAL Laboratory. All hearing protectors have been made from the same scanned impression, the protections are identical, and only the acoustic filter or the absence thereof is the difference.

Seven models of controlled air flow hearing protectors, i.e. the following: Micra XS5, XS7, XS11, XS18, XS21, XS30, and XS35.
A uniform attenuation model, the Original White FT19
Two sealed models were analyzed: Micra XSP and XNP.

Each of these ten hearing protectors was measured under the conditions of the European standard EN24869 on 16 trained subjects.

For the "controlled air flow" profile, these filters allow air flow for pressure equalization; we will call them "ML" for Mastered Leak. They comprise an average of seven hearing protectors equipped with conventional filters with SNR ranging from 20 to 32 dB.

For the sealed profile, which we shall refer to as "SL" for "Sealed", there are an average of two "sealed" hearing protectors, both having a SNR of 32 dB.

For the uniform response profile across all frequencies, which we shall refer to as
"UA" for Uniform Attenuation, only one hearing protector is analyzed.

For each profile, an average attenuation is determined for each frequency. The base 100 is positioned on 1 kHz; the percentages of other frequencies correspond to deviations from this "reference" frequency of 1 kHz.

1.1 Attenuation profile of a hearing protector with a "ML" Mastered Leak filter

The hearing protector has an "ML" filter with controlled air flow. The attenuation is linear (equivalent regardless of the noise level) and non-uniform (different for different frequencies). When the filter is open, it allows air to pass for pressure equalization, and different levels of attenuation offer a wide choice to adapt to the wearer's conditions of noise exposure.

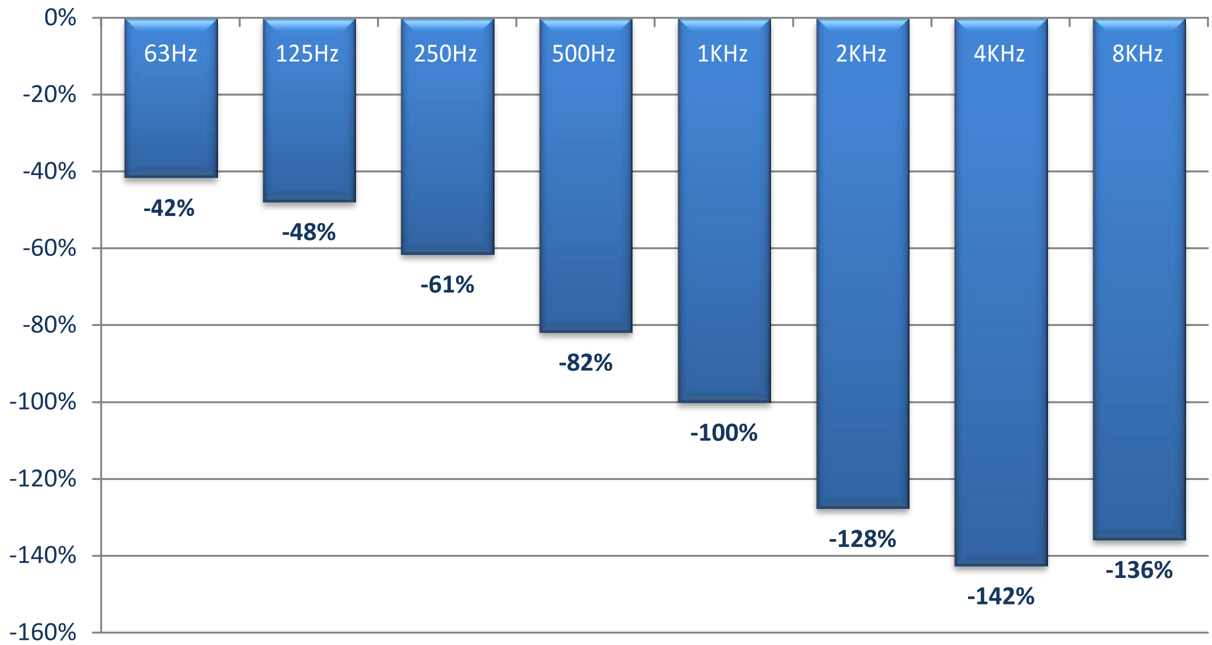

Chart 1: Profile of SL filters (controlled air flow)

An acoustic leak intentionally caused by the opening of the filter causes an attenuation of the low frequencies. The significant attenuation at high frequencies is due to the natural resonance of the ear that amplifies high frequencies, and which, once closed by the hearing protector, loses this amplification, thereby increasing the attenuation at these frequencies.
The increase in attenuation is from 63 Hz to 4000 Hz, which slowly reduces at 8000 Hz.

1.2 Attenuation profile of a hearing protector with an "SL" Sealed filter

The protector is either fitted with a sealed or blocked "SL" filter (no drilling, no filter). The objective is clearly to favor a significant attenuation. The comfort provided by equalizing the air is omitted here in favor of a significant reduction in the noise level perceived by employees exposed to high levels.

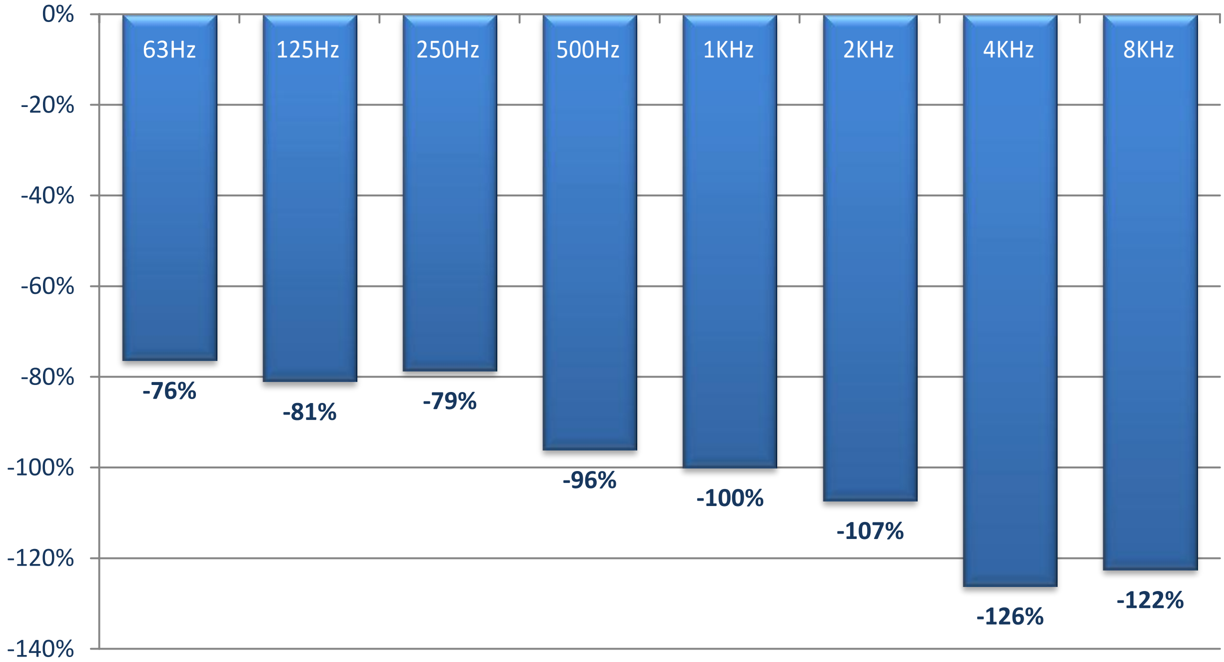

Chart 2: Profile of "Sealed" filters; the profile also concerns hearing protectors that are not equipped with filters, i.e. blocked.

On slight increase in attenuation from 500 Hz, the difference between low and high frequencies is limited with regard to an "ML" filter, whose controlled air flow causes immediate loss of attenuation at low frequencies.

Also note a slight "gap" in attenuation at 250 Hz, which does not appear for "ML" filters (given above). Its origin may be linked to the phenomenon of bone conduction (where part of the sound is transmitted to the eardrum not in an acoustic manner, but in a mechanical manner) or the discomfort experienced by subjects due to physiological noise, particularly active around that frequency.

1.3 Attenuation profile of a hearing protector with a "UA" Uniform Attenuation filter

This specific product is designed for people whose activity requires a reduced perception but without distortion of their environment.

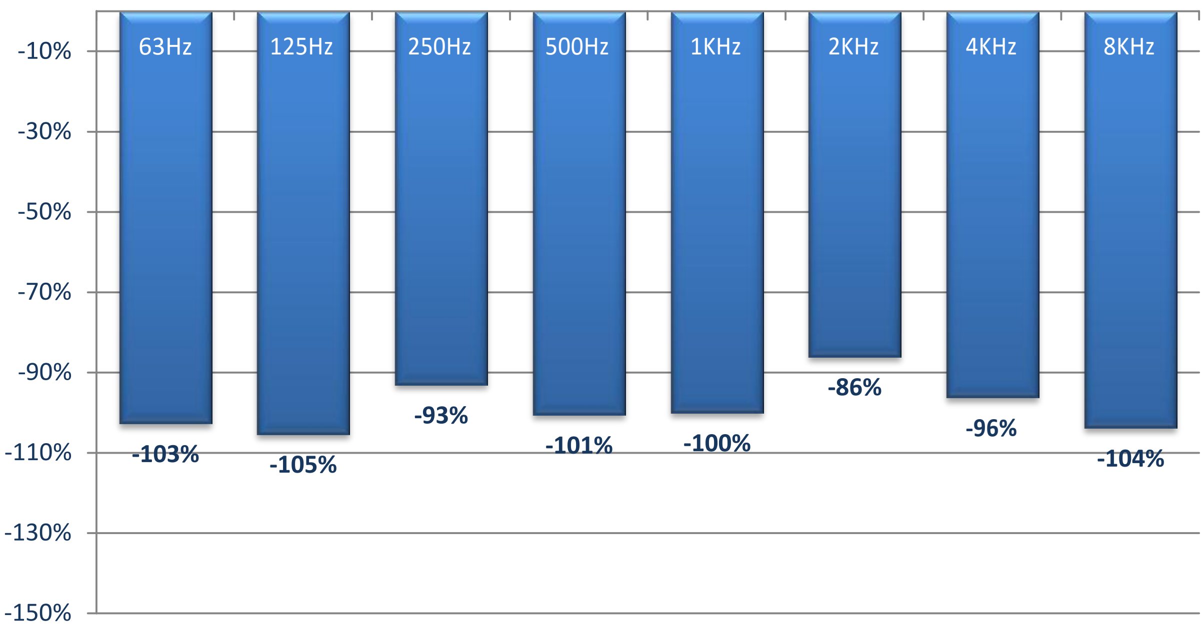

Chart 3: Profile of "UA" filters. Their attenuation is uniform across all frequencies.

Here we see the complete specificity of this type of product (Chart 3). The attenuation is almost equivalent at all frequencies. The hearing protector and the filter are sealed, thus providing good attenuation at low frequencies. Very high attenuation of the other filters at high frequencies here is offset by a re-amplification of the signal using the Helmholtz resonator principle.

This attenuation profile is for people with communication needs, including a "natural" and undistorted perception of their environment, e.g., musicians, people with hearing loss. Especially at high frequencies, an "ML" filter with controlled air flow further adds to the difficulty in perceiving treble sounds.

2. Minimum and maximum attenuation

What are the minimum and maximum values of attenuation of a personal hearing protector?

2.1 Maximum attenuation

The attenuation was measured on 9 subjects on whom the impression material was injected, so as to simulate a maximum sound attenuation (total obstruction and sealing of the ear canal).

Consecutively, 11 subjects were fitted with disposable earplugs (31dB SNR). The subjects were monitored to ensure correct implementation, and then the attenuation of two hearing protectors was measured.
Once these attenuation values were measured ((9 + 11) x 2 = 40 hearing protectors), an average for each frequency was calculated. Inconsistent values (too far from the mean) were not included in the calculation.

The results are compiled in Figure 4, which represents the maximum attenuation that can be measured by CAPA:

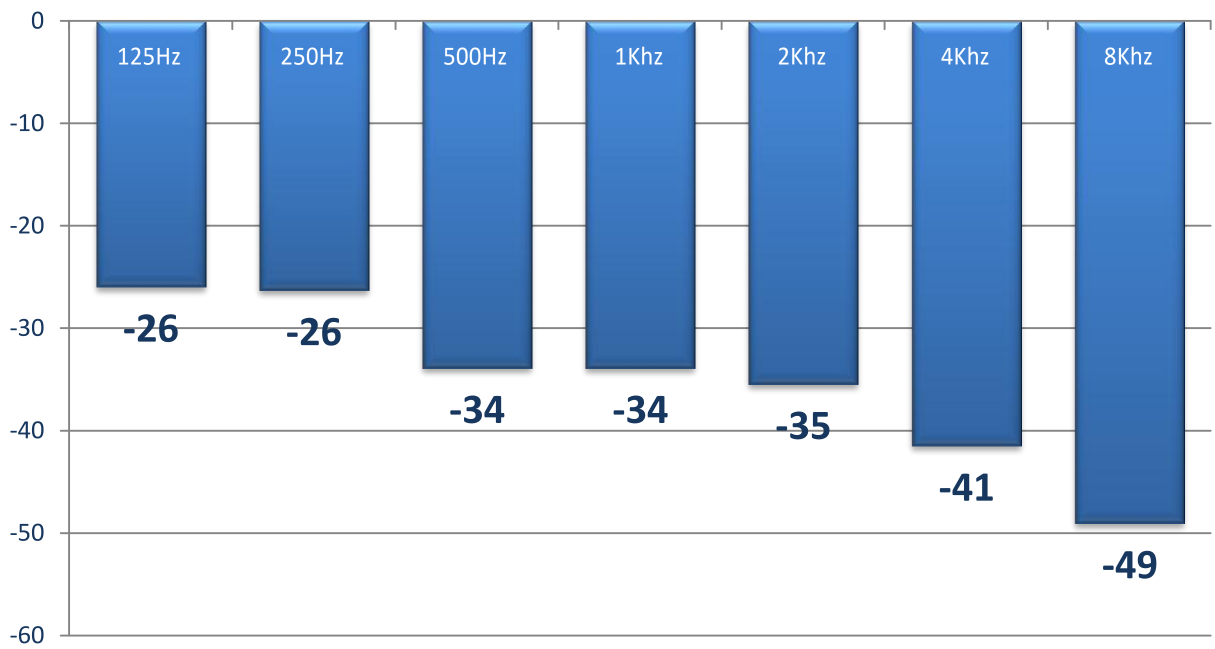

Figure 1: Maximum attenuation profile (frequency of 63Hz omitted)

2.2 Minimum attenuation

To find the minimum attenuation values that can be measured, 9 subjects were provided with customized hearing protectors with a bore of 3.5 mm, as opposed to an "ML" filter with a bore of about 0.2 to 0.4 mm. It is thus placed under the conditions of completely ineffective protection (exceptional fault of the hearing protector, or completely ineffective set up). The average for each frequency was then calculated to obtain a lower threshold of values that can be measured by CAPA.

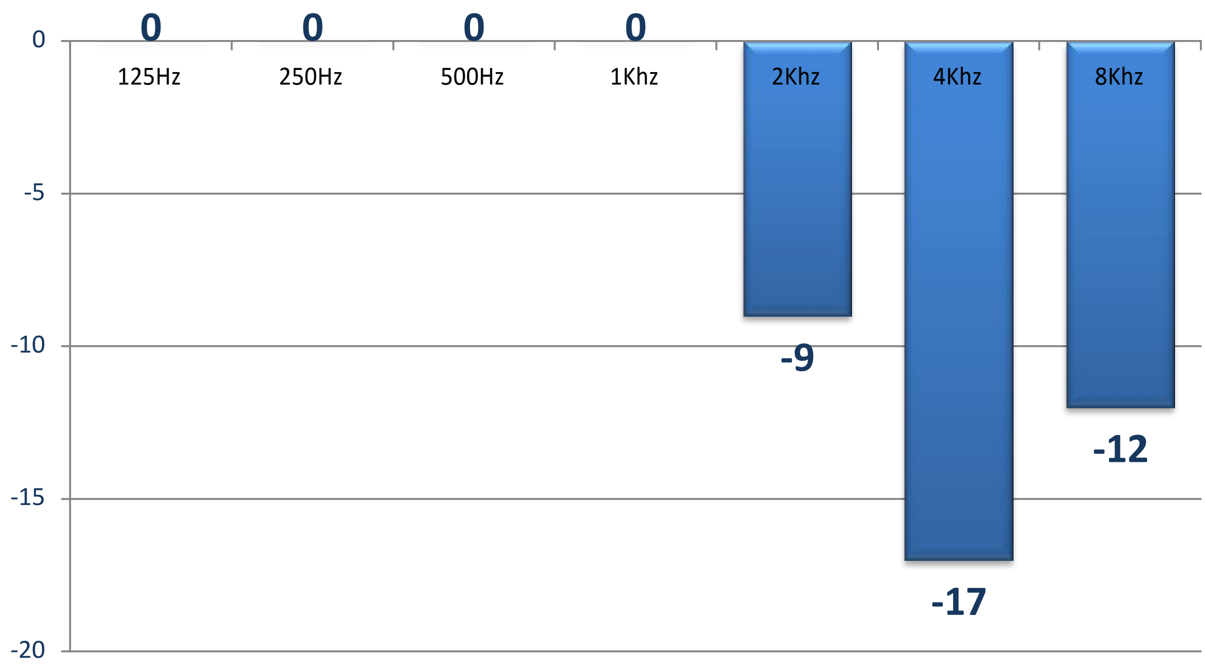

Figure 2: Minimum attenuation profile (frequency of 63Hz omitted)

In Figure 2, we clearly see the result of the natural amplification of the ear at high frequencies, and this loss in amplification is achieved by simply closing the ear canal, even if the closure is not completely sealed.

3. Conclusion

These attenuation profiles of the "ML", "SL", and "UA" filters show us how customized hearing protectors behave with regard to frequencies. They provide support for numerous studies and research.