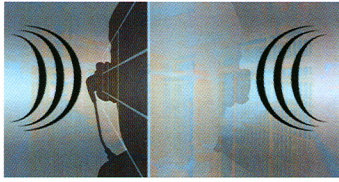


# THE Hearing Review®



SPECIAL SECTION HEARING CONSERVATION | **techtopic**

## Uniform Attenuation Hearing Protection Devices

It's a noisy world, and everyone is at risk for noise-induced hearing loss (NIHL). Noise-induced hearing loss typically develops over many years, and is insidious in nature due to the fact that it's painless, progressive, and permanent. At present, prevention of cochlear damage is the only way to prevent NIHL and the sometimes debilitating effects that may accompany it: tinnitus, hyperacusis, and diplacusis.

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This article will describe the importance of flat attenuation for anyone who needs hearing protection yet wants to hear clearly in high-sound environments.

### Real-World Sound Exposure and HPDs

The open ear has a natural resonance (a peak of approximately 17 dB at 2700 Hz) which is eliminated when an earplug is inserted into the ear canal. The loss of canal resonance, in addition to the unbalanced attenuation of traditional earplugs (15 to 20 dB greater attenuation for high frequencies than for low frequencies), results in a "treble deficiency," making music and voices sound muffled and unclear. If the user already has some high frequency hearing loss (common in noise-exposed populations), hearing protection that muffles high frequencies further reduces the ability to communicate in noise.

As a result, standard hearing protectors are often either modified or used inconsistently (or not at all) in an effort to hear more clearly in high sound environments. Consistent use of hearing protection for the full duration of high sound exposures is critical: Assuming a 3 dB time-intensity tradeoff, removing a 20-dB hearing protector for just 20 minutes out of an 8-hour exposure will reduce the actual protection to 13 dB<sup>1</sup> (Killion, unpublished data, 2007).

### Flat Attenuation and Why It's Important

Flat attenuation is an equal reduction in sound *across frequency*. In hearing protectors, flat attenuation is achieved by re-introducing a resonant peak in the earplug response to simulate that of the average normal open ear. Combined with a moderate amount of sound reduction, a flat-attenuation earplug preserves the tonal balance of music and the clarity of speech. The result is that sound has the same quality as the original, only quieter.

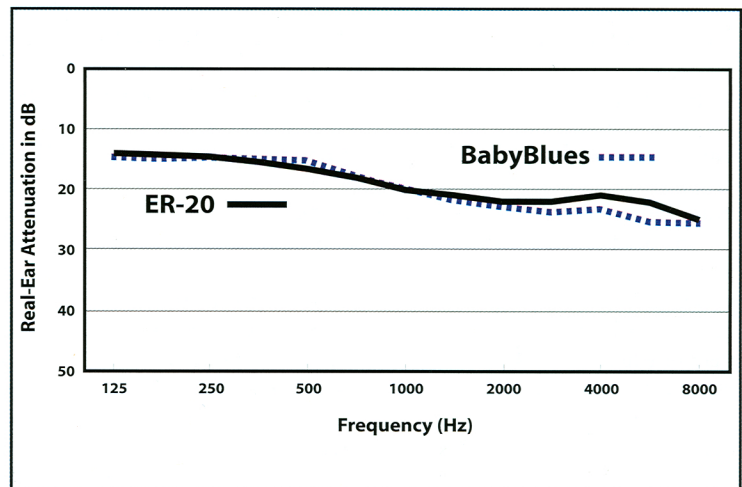


FIGURE 1. In-ear attenuation of ER-20 Hi-Fi and BabyBlues eartips on KEMAR.

### Who's It For?

The original beneficiaries of flat attenuation earplugs were musicians. The first high-fidelity hearing protector was based on a design by renowned hearing industry engineer Elmer Carlson. Carlson's earplug concept replicated the natural response of the open ear, resulting in a smooth, flat attenuation across frequencies.

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In 1988, Etymotic Research transformed Carlson's flat attenuation design into a custom product known as Musicians Earplugs™. Musicians Earplugs are used worldwide by musicians, music educators, and sound engineers who require hearing protection that allows them to hear accurately and clearly. Shortly after the introduction of Musicians Earplugs, Etymotic Research and Aearo Corporation jointly developed the ER-20 High Fidelity Earplug™ (also labeled the E-A-R® Hi-Fi Earplug and Etymotic ETY-Plugs™), an affordable, flat attenuation, one-size-fits-most non-custom earplug that provides 20 dB of sound reduction.

The benefits of flat attenuation earplugs are not limited to those in the music industry or their audiences: High-fidelity earplugs are for anyone who needs hearing protection that allows them to hear clearly. ER-20 High Fidelity earplugs are suitable for average size adult ears, but are too large for small adult ears and many children's ears. In 2006, Etymotic Research introduced BabyBlues™ flat attenuation earplugs for smaller ear canals. As shown in Figure 1, the frequency response of the BabyBlues, as measured on a KEMAR® manikin, is nearly identical to that of the ER-20 High Fidelity earplug.

Successful earplug use depends on achieving a seal that is comfortable for the user. The ER-20 earplug shown in Figure 2a sealed the ear; however, the user reported it was uncomfortable and thus it was unlikely to be worn consistently for any length of time. The ER-20 BabyBlues earplug shown in Figure 2b provided a deeper seal in the same ear, and the user reported it was comfortable.

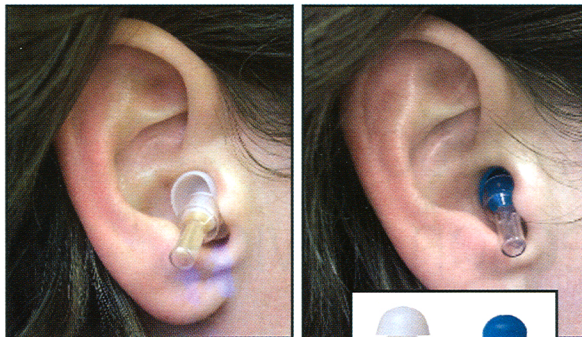


FIGURE 2a-b. ER-20 and BabyBlues earplugs.

### How Much Attenuation is Adequate?

The need for flat, moderate attenuation earplugs for musicians and audiophiles has been previously discussed.<sup>2,4</sup> Moderate attenuation high-fidelity earplugs have a much broader application: In 90% of noisy industries, where daily average noise exposures are less than or equal to 95 dBA<sup>5</sup>, 10 dB of actual hearing protection is all that most workers need.<sup>3</sup> In the real world, if people can hear clearly with earplugs they're more likely to wear them correctly—hence hearing will be more consistently protected.

### The Dilemma of the NRR

The US Environmental Protection Agency (EPA) was authorized by the Congressional Noise Control Act of 1972 to label noise reducing devices, including hearing protection. In 1979, the EPA promulgated a labeling regulation for hearing protection devices. The result was the *Noise Reduction Rating* (NRR) which was based on ANSI S3.19-1974.<sup>6</sup> As stated in Berger,<sup>7</sup> the intention behind the NRR was to provide a simplified guide that would accurately indicate the amount of noise reduction that a given hearing protector could be expected to provide. The higher the NRR, the greater the amount of protection a hearing protector was supposed to provide.

It has been demonstrated that labeled NRRs based on the ANSI S3.19-1974 formula show little resemblance to actual protection achieved in typical real-world conditions.<sup>7</sup> Example: Clinical measurements of properly inserted ER-20s indicate that these earplugs provide an average of 20 dB attenuation across frequencies, but the labeled NRR of ER-20 earplugs is 12 dB. The required formula used to determine

NRR includes an adjustment for individual variability and for those persons who don't wear hearing protection as instructed. NRRs for foam earplugs are artificially high (most users obtain less attenuation than the NRR label indicates<sup>7</sup>) and NRRs for ER-20 earplugs are artificially low (most users obtain more attenuation than the label indicates<sup>1</sup>).

### Outdated Labeling Prevails

The basis for the NRR, ANSI S3.19-1974, has since been withdrawn; however, the EPA's Noise Office was defunded shortly after the issuance of the hearing protector labeling requirements, so the outdated labeling standard remains to this day. A new ANSI Standard, S12.6-1997 ("Methods for Measuring the Real-Ear Attenuation of Hearing Protectors")<sup>8</sup> was created in order to provide a means of calculating noise reduction values that would better correspond to real-world data, and the procedures in this standard were supported by the National Hearing Conservation Association Task Force on Hearing Protector Effectiveness.<sup>9</sup> Unlike the previous standard, which required hearing protectors to be "expert fit" by a trained experimenter, S12.6 Method B utilizes a

"subject fit" approach in which naive users (inexperienced in using hearing protection) are given the hearing protection along with the packaged instructions and receive no training or fitting assistance from the experimenter. The merit of this approach is that it produces NRRs that better approximate real-world data.<sup>1</sup>

### The Noise Reduction Statistic

In March 2003, the EPA held a workshop to revisit the issue of hearing protector labeling. At the request of the EPA, Gauger and Berger<sup>1</sup> prepared a report delineating relevant issues for a new label, new noise reduction ratings, and a preferred method of obtaining the test results from which the ratings are computed.

Gauger and Berger analyzed over a dozen different methods of computing ratings of hearing protector performance for 20 popular hearing protection devices that were in the marketplace in the late 1990s (foam plugs, premolded plugs, semi-insert plugs, earmuffs, a flat attenuation earplug, and a flat attenuation earmuff). Based on their findings, they concluded that single-number ratings are insufficient to properly describe the range of performance likely to be obtained from hearing protectors. Instead, Gauger and Berger recommended labeling hearing protectors with two values: One value representing the level of protection (in dB) that would be possible for most users to exceed (called the 80% value), and one value representing the level of protection possible for some motivated users to achieve (called the 20% value).

In this scheme, the resulting *Noise Reduction Statistic* (NRS) considers both inter-subject and inter-spectrum variability in protection. The range between the 80% and 20% values indicates the "uncertainty" factor; the smaller the range between numbers, the more dependable the amount of protection. While there is no way to precisely predict the amount of attenuation a hearing protection device will provide a given individual (unless personal noise monitoring is done and the attenuation of the protectors are measured on that person), the NRS provides a far better estimate of the actual range of protection most users will likely achieve, and as such is an enormous step forward in providing useful labeling of all hearing protectors.

The NRS for the ER-20 earplugs is 14 dB (“low value” which 80% of users should be able to exceed) to 20 dB (“high value” which highly motivated users may be able to achieve). The 6 dB range between these values was the smallest range for all 20 hearing protectors measured, indicating less variability and better reliability with flat attenuation earplugs.

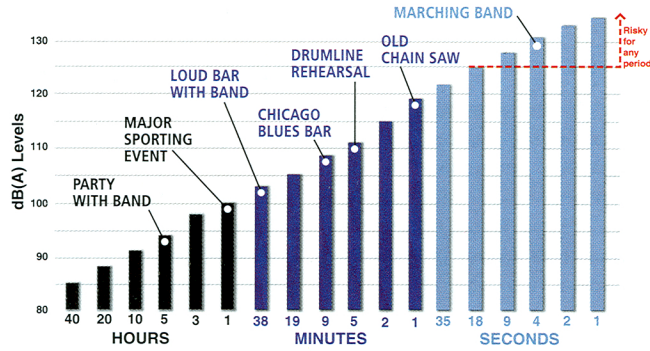
## Conclusion

The need for hearing protection is almost universal in scope: High sound levels are encountered by both adults and children in a multitude of occupational and non-occupational situations. The high-fidelity ER-20 and BabyBlues earplugs provide reliable hearing protection while preserving the quality of the original sound, making them the ideal choice for nearly everyone who needs hearing protection yet wants to hear more clearly in high-sound environments. ▀

## References

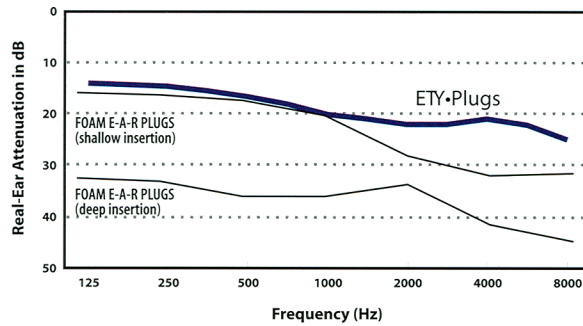
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## Allowable Weekly Sound Exposure To Be Safe



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## ETY•Plug Noise Reduction



ETY• Plugs provide almost equal sound reduction (20 dB) across the range of hearing. Foam earplugs reduce the high frequencies, resulting in muffled speech and music.

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## Maximum Weekly Noise Exposure (NIOSH, 1998)

Sound (dB)	Exposure Type	No Protection	Using ETY• Plugs
60	Conversation	SAFE	—
80-85	Noisy restaurant / Vacuum / Average factory	40 hrs	SAFE
88	Circular saw / Loud party / Motorcycle	20 hrs	SAFE
94	Subway / Riding mower	5 hrs	SAFE
97	Live band	2.5 hrs	40 HRS
100	Sporting event / Chain saw / Snowmobile	1.25 hrs	20 hrs
112	Blues bar / Rock concert	5 mins	1.25 hrs
115	Ambulance siren	2.5 mins	36 mins
140	Jet engine / Gun shot / Firecracker	INSTANT LOSS	*

\* Above 125 dB you are at risk for any period without maximum protection

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