Hearing Protection For The Critical Listener

By Elliott H. Berger, M.S.

Hearing is one of our most important senses; the one, it can be argued, without which our lives are most impacted (Gasaway, 1996). For critical listeners and acoustic ecologists, hearing has special significance. Since relatively modest changes may effect our aural perceptions and the enjoyment we derive from the aesthetic and professional aspects of audition we should exercise special care in the protection of our ears. It is truly regrettable that about 10 million Americans, and countless others worldwide, experience hearing loss that is at least partially attributable to noise exposure, since hearing loss due to noise (with the exception of unexpected explosive sounds) is virtually entirely preventable through the use of hearing protection devices (HPDs).

Hearing protection can sometimes be achieved through common-sense actions that will reduce our exposure to noise, either by decreasing the level or the duration of the exposure (i.e., our cumulative noise dose). For example, excessively loud sound from personal music systems is something we can control. At other times, either due to occupational exposures (noisy jobs), or recreational activities (shooting, woodworking, snowmobiling, flying light aircraft, attending concerts, public events, etc.), our only viable choice may be to purposely exclude sound from our ears. Though our fingers can do this quite effectively, functioning as the equivalent to a 25-dB HPD,[1] a preferred alternative is a bona fide personal hearing protection device, generally an earplug or earmuff, or as an alternative, a semi-insert (earplug or pod-like tips on a lightweight spring-loaded band).

Hearing conservationists normally recommend that HPDs be worn whenever sound levels regularly exceed 85 dBA for extended periods. Such levels are generally present if you feel the need to shout in order to be heard by a normal hearing person who is only about 3 feet away. To familiarize yourself with sound levels see the accompanying article in this issue on hearing loss, or visit www.e-a-r.com/pdf/hearingcons/T88_34NoiseLevels.xls to download a file with hundreds of representative sound levels.

Today, more than ever, there are a wide variety of hearing protectors available in both consumer and professional markets. Following are a few ideas that may help you choose and use those devices most effectively.

1. HEARING PROTECTORS MUST BE COMFORTABLE AND WELL FITTED. You should try different brands and types to find what is best for you. Be sure to carefully read the instructions and practice proper insertion. Two of the most common consumer complaints I receive about foam earplugs are "they don't block enough sound," and "they don't stay in." Nine times out of ten the reason is incorrect fitting. The goal is a proper, very tight and crease-free roll down (thinner than a pencil), accompanied by a pinna pull to facilitate full insertion well into the earcanal (see Figure 1). This takes practice. Without it, you will still get protection, but the fit is not as comfortable or secure, the noise attenuation not as great, and the occlusion effect more annoying (see Item 7 below). An in-depth brochure called *Tips and Tools for Fitting and Using E•A•R® Foam Earplugs*, applicable to all brands and types of roll-down foam earplugs, is available at www.e-a-r.com/pdf/hearingcons/tipstools.pdf.

Figure 1—Illustration of the correct method of pulling the pinna (outer ear) by reaching over the head with the opposite hand to the ear being fitted.

Other types of HPDs also require correct use. See E•A•RLog 19 for numerous suggestions on fitting a broad range of products: http://e-a-r.com/hearingconservation/earlog_main.cfm.

2. DON'T GET HUNG UP ON THE NOISE REDUCTION RATING (NRR), the US. government-mandated noise protection factor that must appear on the packaging for all HPDs.[2] It is based on optimized laboratory-based tests that, in practice, represent what only a few of the most motivated and best-trained users can achieve. During the test the devices are worn for only brief periods, comfort is irrelevant, and, especially for earplugs, most users will rarely achieve the test results in practice. Unfortunately NRRs don't even necessarily rank order products in an appropriate manner. This means that small differences in NRRs, less than 4 or 5 dB, should definitely be ignored. The more rigorous you are about fitting, the closer your achieved protection will approach the

NRR, which is intended to indicate the approximate reduction in decibels (dB) of the overall sound level that the device can provide to those wearing the device in an optimal manner.

Your best bet is to simply use the NRR as an indicator that a product was designed for and tested for noise reduction. As a rough guide you can presume that devices with NRR of 29 and greater are among those providing the highest possible protection, and those with NRRs of 16 and lower provide modest protection. The lower values of protection are often quite sufficient (and even preferred) for common recreational exposures, other than shooting or the loudest of rock concerts.

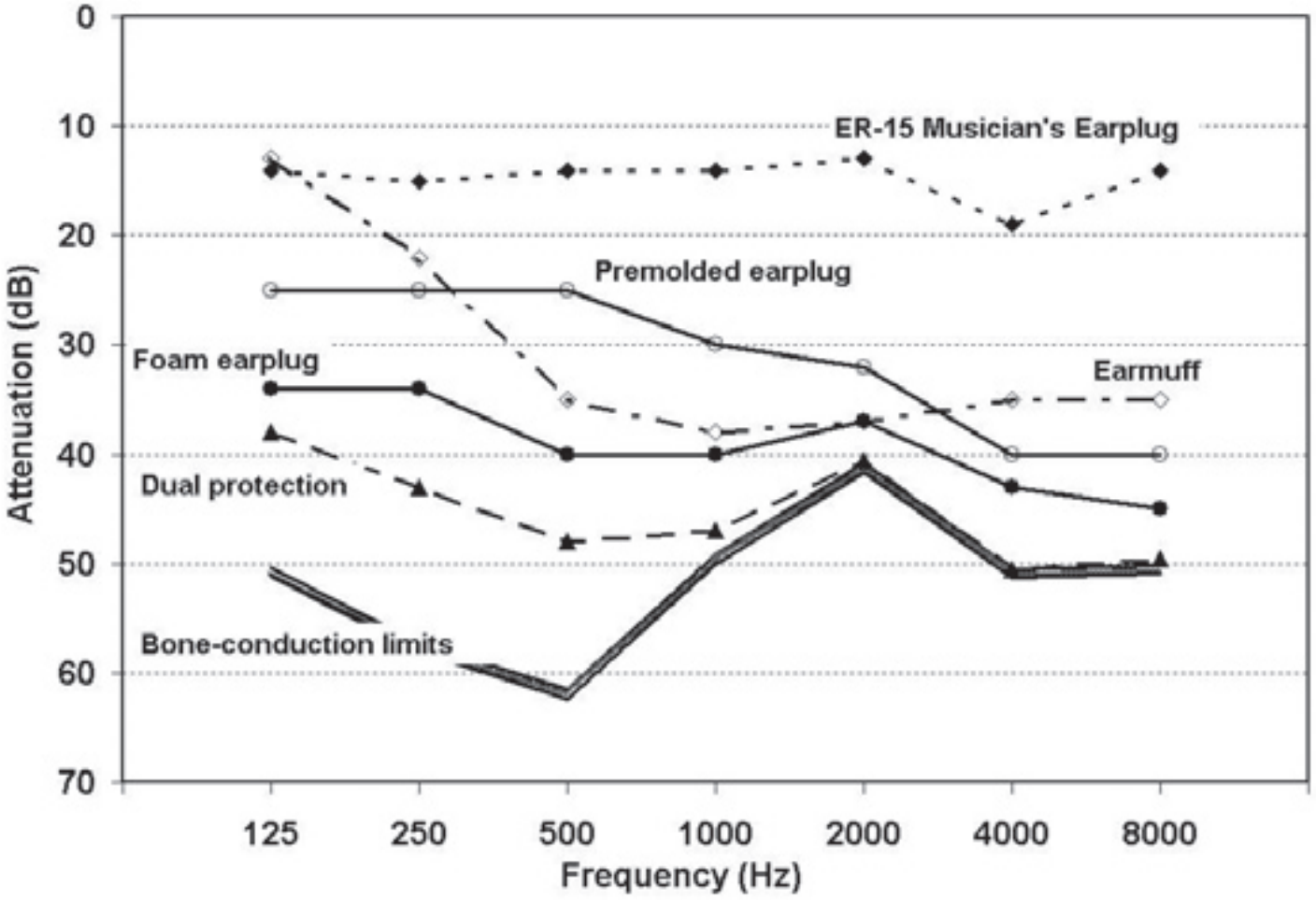
3. NO HEARING PROTECTOR WILL BLOCK ALL SOUND. Sometimes users are worried that they won't hear anything at all; other times they are worried that the device won't be protective enough. Figure 2 provides an indication of the amount of noise reduction (also called "attenuation"), on average, that well-fitted hearing protectors will provide. To achieve these values you *must* read the instructions for fitting and use and be sure the device is scrupulously inserted in the earcanal or placed over the ears to fully seal against sound. Devices providing the 30- to 40-dB of protection shown in the figure will make it sound as though you are in the room adjacent to the sound source, with a solid-core door tightly shut and sealed around its perimeter.

The bone-conduction limits, also illustrated in Figure 2, represent the noise reduction that can be achieved if the earcanal is perfectly sealed and blocked so that no sound can traverse that route to the inner ear. Even in this case, sound vibrates and to some extent (as indicated in Figure 2) passes through the bone and tissues of the skull, bypassing the hearing protector. Normally, HPDs are not worn well enough to provide noise reduction that approaches these limits; so much sound comes through the hearing protector that the small amount filtering through the bone-conduction paths is inconsequential. However, these limits are reached in the case of a deeply fitted earplug worn together with a well-positioned earmuff (dual protection), at which point the small amount of vibration transmitted by bone conduction becomes the most important contributor to what is heard.

When wearing well-fitted dual protection, a person with normal hearing will have difficulty even detecting the presence of speech delivered at a normal level from 3 feet away. Typically, dual protection is recommended for extreme noise levels in excess of 100 dBA where communication is not essential and is difficult regardless of whether or not hearing protection is worn.

4. THE CHOICE BETWEEN AN EARPLUG AND AN EARMUFF IS GENERALLY ONE OF PERSONAL PREFERENCE or ergonomics, as both types, when well fitted, can block sounds similarly. However, the better earplugs typically outperform the better earmuffs at the lower frequencies, which are those below approximately 250 Hz (see Figure 2), or in musical terms, middle C on the piano. Earplugs are of course more portable and less conspicuous to use in public places. Earmuffs are easier to put on and take off for short-term exposures, and for those who are averse to the idea of putting something in their ears, a more desirable solution. Semi-inserts are a compromise between the two, usually not as protective as plugs, but easier to don and doff, and convenient to store around the neck when not in use. The key is to use something that you like and fits your lifestyle. A variety of HPDs are shown in Figure 3.

Figure 2—Attenuation (noise reduction) for various hearing protectors as compared to the bone conduction limits (see text). Notice the tendency for most products to be more effective in blocking high-frequency sound, which makes them sound muffled.



5. THERE ARE MANY BASIC STYLES OF EARPLUGS. In the consumer market, those products that I am often asked about include roll-down foam (the foam is rolled into a tiny cylinder and inserted in the earcanal where it expands in place), premolded rubber-like plugs (usually with multiple flanges or sealing rings), formable wax or silicone slugs (the slug is pressed into the entrance of the earcanal), and custom-molded plugs (wherein a liquid with the consistency of thick honey is injected into the ear to make a custom-shaped device). Although all can work and block sound, there are a few things to keep in mind.

Figure 3—Representative hearing protectors (clockwise from lower left): foam earplugs, earmuffs, semi-insert device, premolded earplugs, (center) custom earmolds with ER-15 acoustic feature.

Foam plugs, as noted above, require some skill to insert properly. However, they are forgiving and even when not inserted optimally will provide a reasonable noise-blocking seal, though one that is not as secure or effective as otherwise could be achieved. Overall, they tend to be the most comfortable and effective style of earplug, providing protection equivalent to high-attenuation earmuffs. Premolded plugs can also seal well, but as a group tend to be somewhat less comfortable and protective. Unlike foam plugs that can be inserted very deeply with little discomfort, deeper and more protective fittings of premolded earplugs tend to be less acceptable. Formable plugs made of wax or silicone can only seal at the entrance of the canal. This limits the noise exclusion they can provide, primarily in the low frequencies, and also creates a large occlusion effect as discussed in Item 7, below. Custom earmolds, which can be among the most comfortable of earplugs, are more expensive, and contrary to intuition are not normally the most protective. Taking a good impression and making a well-fitting mold requires training, skill, and attention to detail. Even when well fitted, custom earmolds can easily break or lose their seal since they lack the dynamic accommodation of foam plugs or the flexible flanges of premolded earplugs.

6. WHEN WORN IN MODERATE NOISE HPDS WILL MAKE TINNITUS (A RINGING, BUZZING, OR HUMMING IN YOUR EARS) MORE APPARENT for those who already experience it, since the ambient noise that normally partially masks the tinnitus will be substantially eliminated by the noise reduction of the HPD. However, in higher noise levels enough sound will usually penetrate the hearing protector to provide a degree of masking or covering up of the tinnitus. Use of the HPD will help keep the noise from worsening the tinnitus, and once the protector is removed the masking provided by ambient sounds will immediately return.

7. WHENEVER YOU PROPERLY FIT AN EARPLUG OR EARMUFF YOU WILL EXPERIENCE THE OCCLUSION EFFECT (OE). This effect, which increases the efficiency with which body-conducted sounds are transmitted to the inner ear, causes a change in the perception of one's voice and body sounds. They become fuller, boomier, hollow-sounding, and muffled. The OE is easily demonstrated by sealing your earcanals with your thumbs while reading this sentence aloud. The OE is both a nuisance to HPD wearers, that can be minimized by proper selection and fitting (deeper-seated plugs reduce the OE), and an aid to wearers to use as a fit test; its presence indicates a proper seal. See E•A•RLog 19 for more information (http://e-a-r.com/hearingconservation/earlog_main.cfm).

8. MANY NOISE EXPOSURES ONLY REQUIRE 10 DB OF NOISE REDUCTION, SO DON'T OVERPROTECT with high-attenuation products unless you simply prefer the extra quieting they provide and won't be troubled by the greater degree of isolation they will create between you and the sounds around you. An excellent, but expensive, moderate-attenuation product I often wear is the ER-15 Musicians Earplug™ (cost in excess of US $120/pair, see www.etymotic.com/ for availability information for the US and worldwide). This custom molded earplug requires two trips to an audiologist to create and fit, but in return provides a comfortable, truly high-fidelity hearing protector that blocks sounds equally, regardless of their pitch, avoiding the muffling effect so common with conventional products (see Figure 2).

An alternative, much less costly one-sized product (from about US $12/pair), with nearly equivalent sound quality can be purchased off the shelf—Professional Musician E•A•R® Plugs www.aosafety.com/hbc/music.htm (and for international availability see www.e-a-r.info), also sold as ER-20 High Fidelity Earplugs (www.etymotic.com). Like the ER-15 these plugs avoid excessive protection and are ideal for music exposures and many public entertainment events.

9. MANY POTENTIAL HPD USERS ASK ABOUT "HIGH-TECHNOLOGY" SOLUTIONS SUCH AS EARMUFFS THAT INCORPORATE ACTIVE NOISE REDUCTION (ANR; sometimes also called noise cancellation). This method takes sound picked up underneath the earmuff cup and processes it so that it can be reintroduced via a small earphone to cancel the incoming sound. The applications are limited and only effective for low-frequency sound below about 400 Hz, such as the loud rumbling engine noise inside a light aircraft.

Another application for ANR is in earmuffs designed to provide an earphone-listening experience while reducing nuisance noise. Such devices are useful for travel applications such as in commercial aircraft when you want to listen to music or the movie soundtrack while at the same time reducing the perception of the noise in the cabin (see www.bose.com and www.peltoracoustics.com for representative products). However, for good noise protection, consumer ANR devices offer little that can't be achieved with a conventional and much less costly passive (non-electronic) device. So if you are comfortable wearing an earplug, an effective alternative is to use insert earphones (like the ER-6 Isolator™ earphones by www.etymotic.com) that passively block sound and, like their ANR counterparts, include the ability to accept an electronic input to reproduce music or other audio information.

10. LISTEN TO YOUR EARS TO MAKE SURE YOU ARE GETTING THE PROTECTION YOU NEED. If, immediately following a noise exposure you experience increased tinnitus, or for those blessed with normally quiet ears, you experience the onset of tinnitus, the noise was too loud for your ears. Regular exposures of that nature will likely lead to hearing loss and permanent or increased

tinnitus. Another, post-exposure effect that indicates inadequate protection is if your hearing seems dulled or your ears feel full after an exposure. Again, the indication is that the exposure was too great and there is potential for permanent effects. In such cases you should re-check how well you fitted your hearing protection, and/or consider using a more protective product, and if you still experience noise aftereffects, reduce the severity, duration, or repetition of your exposures.

11. NOT ONLY DO HPDs PROTECT YOUR EARS, BUT THEY CAN BE FUN AND USEFUL TOO. Want to hear a new sound? Take a shower while wearing earplugs. Not only will you keep your earcanals dry, but the impact of the water pouring upon your scalp will make interesting sounds in your ears due to the occlusion effect. Do you need to hear distortion in audio equipment at high sound levels? Listen through earplugs. If you audition at very high levels (over 100 dB) your inner ear sends a distorted signal to the brain. This should be no surprise. Those levels cause hearing damage so it makes sense that your ear is being overstressed when that is happening. Reducing the level with earplugs lessens the distortion in your hearing mechanism so that you can better hear the true performance of the sound system.

Or perhaps you want to "cleanse" your auditory palate to enjoy the next listening experience. Nature recordist, Gordon Hempton, who says earplugs should be as common as aspirin, shared with me the following. He occasionally takes an earplug-break during his field recording sessions even though he is often listening to extremely subtle and quiet sounds, in order to re-equilibrate his ears prior to his next listen, much as you would savor a taste of sorbet between courses at a fine meal.

Other types of artists may "need" hearing protection too. In 1981 Robert Hamon, a performance artist, created a video/sound installation entitled *Archangel, An Opera*, sponsored by the Western Front gallery in Vancouver. In this case there were no performers, only an audience full of participants; the subject being the personal experiences of those in attendance. The presentation was set in a four-court tennis bubble.

Guests arrived in soft-soled shoes and were handed yellow foam earplugs, a flashlight, and a glass of champagne. The installation included five video monitors displaying views of the constellations, hundreds of silver metal paper clips lying on a large felt-covered vibrating silver tray that was mounted on three red and white battery-powered electric toothbrushes, and 40 frogs with torsos wrapped in silver tinsel garlands distributed throughout the bubble. The audience was instructed to insert the plugs, and turn on their flashlights while sipping the champagne. The occlusion-effect enhanced sensation of bubbles popping within their mouths sounded like wild applause as their flashlight beams danced across the dome while they wandered about experiencing the space.

Concluding Remarks

Once you have selected a hearing protection device and learned to wear it properly, the key is to have it available when needed. Since you can't always predict when you will be exposed to noise, keep your HPDs handy, just like you might carry a pair of sunglasses. Obviously this type of application dictates earplugs instead of earmuffs due to their portability. I find foam plugs are small, lightweight, and easy to store in jacket or pants pockets or a travel bag, and if lost the cost for replacement is trivial. However, many times they are more protective than I require, so I like to also have available one of the low-attenuation "high-fidelity" protectors such as a Musicians earplug. My goal is to assure that I always have handy the protection I need, when I need it.

So there you have it—my best tips for selecting, using, and enjoying your hearing protection. Remember, life can be loud—be prepared.

Endnotes

1 Did you ever need immediate and brief hearing protection with only one hand free? Reach over your head with your free hand to use a finger to block the opposite ear while lifting the shoulder of that same arm to press against and seal the ear that it naturally contacts.

2 Other countries also specify noise reduction factors for hearing protection, numbers like the Single Number Rating (SNR) and Sound Level Conversion (SLC), but they are based on more realistic testing procedures. Though still optimistic, they better reflect what can be achieved in practice.

References

Gasaway, D. C. (1996). "To Prevent Noise-Induced Hearing Loss—Aim Between the Ears," Spectrum Suppl. 1(13) p. 28.

For additional information on noise and hearing protection visit www.e-a-r.com/hearingconservation for reprints, FAQs, audio presentations, current news, and links.

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