E·A·RLOG® 21

Twenty-first in a comprehensive series of technical monographs covering topics related to hearing and hearing protection.

Hearing Protector Testing - Let's Get Real

[Using the new ANSI Method-B Data and the NRR(SF)]

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So what's the deal? Here it is at the turn of the millennium and purchasers of hearing protection devices (HPDs) still can't trust the numbers. They still have no easy way to measure the effectiveness of hearing protectors, and the Noise Reduction Rating (NRR) wars continue. There is still disagreement as to the solution of the problem and most manufacturers of HPDs persist in stonewalling any proposal that would lead to lower NRRs. Users are beguiled into focusing most of their attention on high NRRs either because at some gut level they feel this will protect more workers or perhaps because it makes it easier to comply with hearing conservation regulations, or both. What is a hearing conservationist to do? This EARLog[1] will explore the dilemma, providing both a perspective and suggested alternatives, including the application of "Method-B" testing as described in the most recent U. S. standard on measuring HPD attenuation, ANSI S12.6-1997.[2]

Background

A basic question of interest to users and specifiers of hearing protection is the amount of protection that such devices provide. Unfortunately the question has more than one answer. Do you want to know the maximum protection for well-fitted users, the average protection for groups of users in a typical hearing conservation program (HCP), the expected protection for inadequately trained and motivated wearers in many of today's typical programs, the values obtained by a given individual, or some other value? How do you want your data provided: mean attenuation and standard deviation values at octave-band center frequencies, the NRR[3], the NRR(SF) [Noise Reduction Rating (Subject Fit)],[4] the HML,[5] a Class rating,[6,7] or some other value? And would you like it derated with a one-size-fits-all value or perhaps a device-type specific value, and should the derating be included in the number as provided, or incorporated by the user after the fact?

Prior to 1979, attenuation data for HPDs were commonly available from manufacturers, but only in the form of octave-band values mentioned above, and indeed, U. S. occupational hearing conservationists almost exclusively utilized the octave-band method of computing protection (also called the "long" method or NIOSH Method #1). In fact, in most instances HPD attenuation values were simply ignored because of the difficulty of acquiring octave-band workplace noise measurements with the instrumentation of that era, combined with the difficulty in the pre-calculator and pre-PC age of performing multiple tabular computations.

The advent of the NRR, and the accuracy and simplicity that it seemed to provide, substantially changed the picture. Much attention was then focused on HPD attenuation values. In many instances, either purchasing specifications or HCP policies were based upon the NRR. As a result, manufacturers highlighted the NRR to a greater extent in their literature, and a battle of numbers arose as more attention was directed at this ostensibly critical parameter. In many cases, purchasing decisions came to be predicated upon differences in NRRs of as little as 1 dB.

Use of the NRR became even more entrenched in the 1980s when OSHA included it as the preferred method for assessing HPD adequacy for compliance with the Hearing Conservation Amendment.[8] One result has been that in many instances additional key parameters of performance such as comfort, compatibility, communication needs and hearing ability are neglected or overlooked in favor of choosing the HPD with the highest possible NRR. This can lead to wearer dissatisfaction and consequent misuse or even non-use, resulting in inadequate protection or none at all. At the other extreme, correct use of products with too much noise reduction can create communication and safety problems, especially for workers with preexisting hearing losses.[9]

Even more fundamental than grappling with the issues mentioned above is the complexity of answering the natural and seemingly straightforward question - How much noise reduction can hearing protectors provide? In fact, the accurate estimation of the attenuation that wearers of HPDs receive under conditions of actual use (also called "real-world" attenuation), has been a topic of substantial research. The facts are presented in EARLog 20 along with commentary about the dangers of high-labeled NRRs. (EARLog 20 should be read in conjunction with this one.) Although the technicalities of the measurement problem are well understood and documented, the methods of modeling the behavioral aspects of real-world users in a laboratory setting have only been recently standardized.[2,10]

One Solution - Individual Fit Testing

Arguably the best approach to assigning HPDs with the proper attenuation is to individually fit test each wearer. This is time-consuming, but well worth the effort. Not only does it provide the most accurate assessment for an individual user (presuming they wear the device in the same manner in actual use as they did during the test), but it affords an excellent opportunity to train and motivate the employee as well. A number of methods are available, but the most practical is to use large circumaural cups with built-in speakers to conduct a real-ear attenuation at threshold evaluation.[11] Today, off-the-shelf devices are available for such testing,[12] but few companies can find the time to implement such a procedure. In the future American National Standards Institute (ANSI) Accredited Standards Working Group, S12/WG11 (Hearing Protector Attenuation and Performance), will look at standardizing such an approach.

An Alternative Solution - Improved Laboratory Testing

A new approach to resolving the above dilemma is now available. In 1997 a national standard that describes how to measure, in the laboratory, the real-ear attenuation of HPDs, was approved by the American National Standards Institute (ANSI). The standard, entitled *Methods for Measuring the Real-Ear Attenuation of Hearing Protectors* (S12.6-1997)[2] was the culmination of nearly a decade of research by

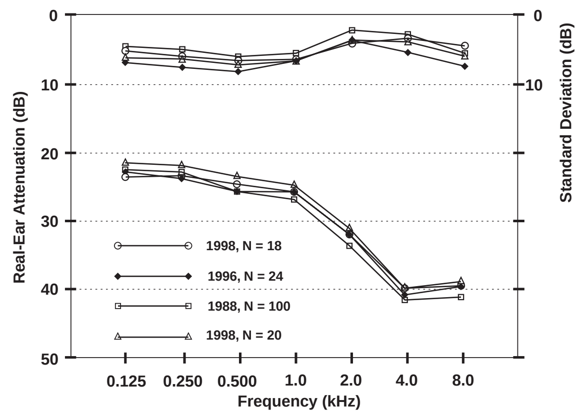

Figure 1 - Four subject-fit estimates of attenuation for a foam earplug.

S12/WG11.[10] The most exciting aspect of this new standard is that it includes a procedure, designated *Method B, Subject Fit*, which provides data that approximate the protection that can be attained by *groups* of informed users in workplaces with representative well-managed and well-supervised occupational HCPs. The 1997 standard also includes a Method A, Experimenter-Supervised Fit, which retains practices from the 1984-version of the same standard that are designed to describe the capabilities of HPDs under ideal conditions.

The new standard was developed after years of research and a four-facility interlaboratory study.[10,13] It specifies laboratory-based procedures for measuring, analyzing, and reporting the noise-reducing capabilities of conventional HPDs using tests conducted on human subjects. The standard is not a method of approval of products, nor a quality assurance procedure. It simply provides noise-reduction data. However, the existence of the Method-B procedure is quite valuable since leaders in the field have pointed out for over a decade that labeled NRRs computed from existing data, as specified by the Environmental Protection Agency (EPA), overestimate work-place protection for groups of users by as much as 25 dB, depending upon the hearing protector, as shown in Figure 1 of EARLog 20.

The keys to Method B are the subjects and how the experimenter works with them. In the EPA-specified procedure the subjects behave as test fixtures while the experimenter optimally fits the product (often for earplugs in an unrealistic and uncomfortable manner). In Method B, the subjects, although trained and experienced in audiometric test taking, are naive with respect to use of hearing protection and are simply told to fit the device to the best of their ability. They work from the manufacturers' printed instructions with no assistance whatsoever from the experimenter.

That the new standard exists is the good news. The bad news is that the regulation which specifies the labeling of hearing protectors,[3] not only does not recognize the new 1997 standard, but still requires testing by the government's interpretation of a 25-year old standard that is no longer supported by ANSI (S3.19-1974[14]). Because there is no one home at the EPA's noise office, the agency responsible for the promulgation and maintenance of the regulation, nothing is being done to revise the existing rule. In short, the current hearing protector NRRs, based upon testing to the old ANSI standard are of even less accuracy and value than the original much-maligned EPA fuel-economy ratings. The procedures behind the fuel-economy ratings were improved; those behind the hearing protector ratings have not been.

The HPD rating situation is even more egregious, since the advice of the professional community has been ignored. Their consensus recommendations, developed in 1995 by the National Hearing Conservation Association's (NHCA) *Task Force on Hearing Protector Effectiveness*, called for testing and labeling according to the new Method-B procedure.[4] The recently revised NIOSH *Criteria for a Recommended Standard: Occupational Noise Exposure*[15] also specifies Method-B testing, although in the absence of such data NIOSH provides a variable derating based upon the work of Berger et al.[11] Furthermore professional organizations such as the Acoustical Society of America (ASA), the American Speech-Language Hearing Association (ASHA), the American Academy of Otolaryngology / Head and Neck Surgery (AAO/HNS), the Council for Accreditation in Occupational Hearing Conservation (CAOHC), NHCA, and others, have all written directly to the EPA petitioning them to revise the regulation. Yet nothing has happened.

Curiously, the only participant in the NHCA Task Force that has been steadfastly opposed to the new test data is the Industrial Safety Equipment Association's (ISEA) Hearing Protector Group, composed of representatives of the manufacturers of HPDs. Exactly why the majority of this group does not see the benefits of representative and useful ratings would appear to be due to reasons other than good science, but it will be up to the readers of this article to contact manufacturers with whom they do business, or the ISEA itself, to further explore those issues.

Representative Method-B Data

Aearo Company's E•A•RCAL℠ laboratory is currently involved in implementing the new Method-B testing. The laboratory is examining various aspects of the protocol as well as acquiring data on a large range of available products. One concern regarding Method-B testing has been the repeatability (variability within a lab) and the reproducibility (variability between different labs) of such data. S12/WG11 addressed Method-B interlaboratory variability and found it as good or better than other laboratory protocols.[10] Figure 1 provides illustrative data derived from E•A•RCAL laboratory testing.[16] Four sets of results for the E•A•R® Classic foam earplug are compared, as collected by three different experimenters over a 10-year period. The values closely compare across the four studies with the computed overall NRR-type values falling within a range of 3 dB.

More to the point, however, Method-B data have been shown to provide a much better indication of "achievable" results than do existing labeled values.[13] "Achievable," means values that are among the higher levels of attenuation attained by groups of informed users in well-managed industrial and military HCPs. Current E•A•RCAL Method-B data are presented in Figure 2. The products shown are a subset of those in the Figure-1 bar chart from EARLog 20. The labeled test values and field data are the same as in EARLog 20, except that in this chart field data are plotted using the NRR(SF) instead of the NRR (see rating discussion later in this article). The Method-B values [also using the NRR(SF)] are included as well. Note that the Method-B values

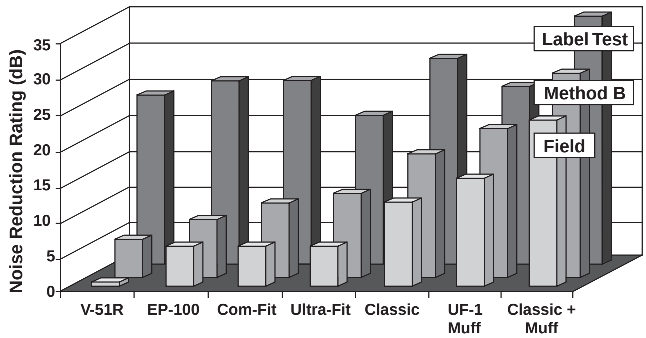

Figure 2 - Comparison of labeled data (ANSI S3.19) to field performance,[11] and to Method B (ANSI S12.6). Labeled NRRs computed with a 2-SD correction; field and Method-B data are NRR(SF)s computed with a 1-SD correction to represent 84% of the users.

properly rank order the field data (which the labeled values do not) and they also provide a reasonable estimate of absolute performance, albeit still somewhat of an overestimate, as was intended by the writers of the standard. Thus, Method-B values are a goal to shoot for, an achievable goal, but still not one that will generally be realized by groups of users in occupational settings.

Group vs. Individual Predictions

An important distinction must be made between group and individual data. Because the variability of attenuation values in real-world situations is large [standard deviations (SDs) are generally 8 dB or larger; see Figure 4, EARLog 20] the ability to predict the performance for an individual can only be addressed in terms of statistical likelihood. That is why real-world data are generally implemented with a minus 1-SD adjustment in order to predict what at least 84% of the wearers will obtain. Some will get substantially higher values, but about 16% will do more poorly. Had optimum-fit data, or the current NRR which is based on such data, been utilized to estimate field performance, the predictions for the group would have been substantially in error. Although a few select users in the group might well have obtained such high levels of protection, most would not.

The hearing conservationist must be clear on how the data are applied. To predict group performance that is achievable in field conditions, Method B data are the best choice. To estimate what a few of the outliers at the upper end of the performance range can obtain, one could either take Method-B data and add one or more SDs, or one could use the existing optimum-fit data as provided.

The Shape of the Distribution

Besides predicting the average performance in the field, some have also examined the distribution of observed attenuation values across subjects, with the concern that laboratory and field measures should be the same. In practice, just as field NRRs can differ from program to program, so too can the shape of the distributions, which can be bell-shaped, bimodal, or even more complex in nature. Two examples are provided in Figure 3 for a foam and a premolded earplug in two different studies.[12,17] Notice that the Method-B values do overestimate the field performance as is normally expected. The good news is that Method B, even with only 20 laboratory subjects, provides a creditable correspondence to field values, including the pronounced bimodal shape for the premolded data. Bimodality suggests that some users are not motivated or trained and do poorly, whereas others are motivated and do fairly well, a common occurrence for certain types of earplugs.

Computing a Rating Value - The NRR or What?

Besides the issue of how to measure attenuation, another question alluded to at the outset of this paper is how to present the data, i.e. how to use the results to compute protected exposures. Since 1979 the method of choice in the U. S. has been the NRR. As defined by the EPA, the NRR specifies a test method (ANSI S3.19[14]) and a means of computing a rating from those data (the NRR). The principal problem with the NRR is the underlying data, that is the octave-band mean attenuation and SD values from which it is computed; the computational procedure is reasonable, if only the data used in the computation were suitable. Thus, in 1995 when the NHCA Task Force set about developing new labeling recommendations they had to define a test procedure and a rating method. As mentioned above, their preferred test procedure was Method B of the 1997 ANSI standard. The preferred rating method was a new one that the Task Force devised, namely, the Noise Reduction Rating (Subject Fit), abbreviated NRR(SF).[4] The intention of the Task Force was to make it clear that the new rating was indeed different from the existing NRR.

The Task Force also considered the three-number HML (high/medium/low) method, but it felt that the additional complexity the HML presented to the user, combined with the limited ability of laboratory attenuation values to represent any given individual or group of individuals, offset the small theoretical increases in accuracy that it could provide. A recent study supports the wisdom of that decision since it indicates that with or without training, both experienced and inexperienced users make more errors in computing protected noise exposures when using an HML procedure than when using the NRR.[18] See Table 1 for a comparison of ratings

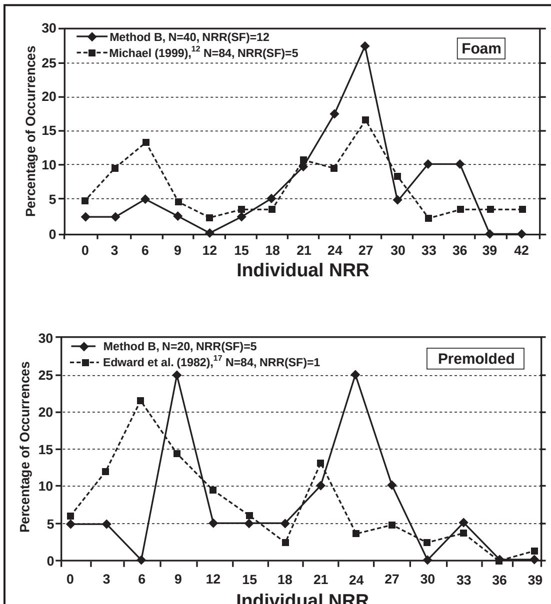

Figure 3 - Distribution of observed values of attenuation in two field studies as compared to Method B. NRR(SF)s computed from group data. N = number of subjects.