▶**OCCUPATONAL HEARING CONSERVATION**

So, How Do You Want Your NRRs: Realistic or Sunny-Side-Up?

A commentary

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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 occupational hearing conservation program (OHCP), the expected protection from inadequately trained and motivated wearers in many of today's typical programs or some other value? How do you want your data provided: mean attenuation and standard deviation values at octave-band center frequencies, the Noise Reduction Rating (NRR)[1], the NRR(SF)[2], the HML[3], a Class rating[4] or some other value? And should it be 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 hearing protection devices (HPDs) were commonly available from manufacturers, but only in the form of octave-band values mentioned above. Although methods of computing single-number ratings were described in the literature, U.S. occupational hearing conservationists almost exclusively utilized the octave-band method of computation (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 computations requiring either a nomogram or antilogarithms.

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The advent of the NRR[1] 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 OHCP policies were based upon use of 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.

> The problems associated with hearing protector Noise Reduction Ratings (NRRs) are summarized, and a solution based upon the NHCA-recommended Noise Reduction Rating (Subject Fit), known as NRR(SF), which is computed from ANSI S12.6-1997 Method-B data is discussed.

Use of the NRR became even more entrenched in 1981-83 when OSHA included it as the preferred method for assessing HPD adequacy for compliance with the Hearing Conservation Amendment.[5] 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.[6]

Even more fundamental than grappling with the questions and 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 and much debate.[7,8] 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.[9]

The Danger of High Labeled NRRs

The average NRR for hearing protectors sold in North America today is greater than 23 dB. In the author's (and others') opinion, this number clearly overstates the protection afforded to most occupationally noise-exposed workers, and such NRRs are potentially dangerous because they may mislead both buyers and users of HPDs. Taking an NRR of 23 at face value, one is led to presume that his/her work force will be protected for time-weighted average exposures of over 100 dBA. Since this easily accounts for most noisy industries, it suggests that almost all workers in almost all environments will be protected if only they are simply given hearing protection.

We have learned that such expectations are far from the truth. Fostering such beliefs leads to hearing conservation programs in which inadequate attention is paid to the aspects of a program that can make it work—training, motivation, supervision and enforcement. The program managers may be lulled into a false sense of security.

A Solution

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)"[10] was the culmination of nearly a decade of research by ANSI's Accredited Standards Working Group, S12/WG11. The most exciting aspect of this new standard is that it includes a procedure, designated *Method B, Subject Fit*, that provides data intended to approximate the protection that can be attained by *groups* of informed users in workplaces with representative well-managed and well-supervised occupational hearing conservation programs. The 1997 standard also includes a Method A, Experimenter-Supervised Fit, which retains practices from the 1984-version of the same standard[11] 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.[9,12] 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 EPA, overestimate workplace protection for groups of users by as much as 25 dB, depending upon the hearing protector, as shown in Fig. 1.

That the new standard exists is the good news. The bad news is that the regulation which specifies the labeling of hearing protectors[1] not only does not recognize the new 1997 standard, but still requires testing by the government's interpretation of a 25-year old document that is no longer supported by ANSI.[13] Because there is no one home at the Environmental Protection Agency's (EPA) noise office—the agency that is 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 ANSI S3.19-1974 are of even less accuracy and value than the original much-maligned EPA fuel-economy ratings. The fuel-economy ratings have been improved; the hearing protector ratings have not been.

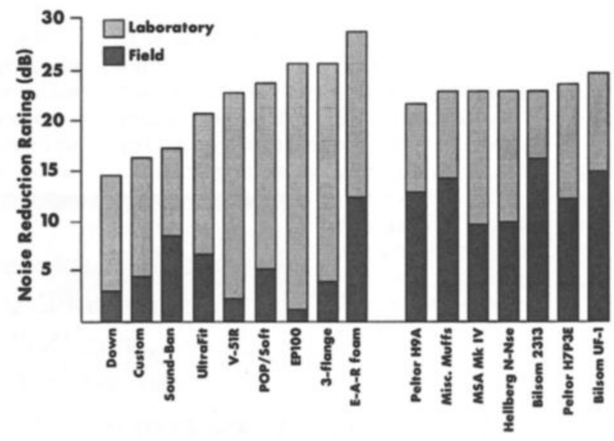

Fig. 1. *Comparison of NRRs published in North America (labeled values based on laboratory tests) to real-world "field" attenuation results derived from 22 separate studies.*

The 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 Assn.'s (NHCA) Task Force on Hearing Protector Effectiveness, called for testing and labeling according to the new Method-B procedure.[2] The recently revised NIOSH "Criteria for a Recommended Standard: Occupational Noise Exposure"[14] also specifies Method-B testing, although in the absence of such data NIOSH provides a variable derating based upon the work of Berger, Franks and Lindgren.[8] Furthermore, professional organizations such as the Council for Accreditation in Occupational Hearing Conservation (CAOHC), the Acoustical Society of America (ASA), the American Speech-Language Hearing Association (ASHA), the American Academy of Otolaryngology-Head and Neck Surgery (AAO/HNS), NHCA, and others have all written directly to the EPA petitioning them to revise the regulation. Yet, nothing has happened.

To get an idea of the magnitude of the problem and to be able to implement the newer type data in programs, review Fig. 1 or review the article by Berger and Royster.[2] Meanwhile, beware that, measured as a percentage of the laboratory-rated and labeled attenuation, the field NRRs for earmuffs yield only about 60%, foam earplugs provide about 40% and earplugs other than foam earplugs yield only about 25% of the labeled values. Concern for this issue is tempered by the fact that, in 90% of noisy industries, daily average exposures are less than or equal to 95 dBA, and in those environments virtually any well-fitted, correctly and consistently worn HPD can protect the ear. The apprehension is that inflated NRRs of 25-30 dB or greater make it appear as though any HPD worn in even a slipshod manner will protect virtually any user from any noise exposure. That is simply not the case. Therefore, the largest part of the problem for the practicing occupational hearing conservationist is training, motivation, supervision and enforcement—issues germane to all areas of personal protective equipment. However, in very high-level exposures (i.e., exceeding 95-100 dBA), the computation of expected hearing protector attenuation can become important. Under such conditions realistic data should be utilized. Those data can be gleaned from Fig. 1, the references cited in this paper[7,8] and in limited instances from those hearing protector manufacturers who make such data available.

As a last resort and a *very rough rule of thumb*, existing NRRs with the OSHA-specified[7] 50% derating can be utilized. Under *no circumstances* should the labeled NRRs be used as is.

The NRR(SF)

Besides the issue of how to *measure* attenuation, another question alluded to at the outset of this paper is how to *present* the data—or how to use the results to compute protected exposures. Since 1979, the most prominent method in the U.S. has been the NRR. The NRR as defined by the EPA specifies a test method (ANSI S3.19) and a means of computing a rating from the data (the NRR). The principal problem with the NRR procedure is the underlying data; the computational procedure is reasonable if only the data used in the computation are useful. Thus, in 1995 when the NHCA Task

Force set about making 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 developed, namely, the Noise Reduction Rating (Subject Fit), abbreviated NRR(SF).[2]

The intention of the Task Force was to make it clear that the new rating was indeed different than the existing NRR. Although the three-number HML (high/medium/low) method was considered, it was felt that the additional complexity it presented to the user, combined with the limited ability of laboratory test data 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.[15]

The NRR(SF) is computationally very similar to the existing NRR with the following exceptions:

1. The NRR is computed with a subtractive 2 standard-deviation (SD) correction, whereas the NRR(SF) is computed with a subtractive 1 SD correction. For subject-fit data of the type called for by WG11, 1 SD amounts to about 3-12 dB. Use of a 1 SD (smaller) correction instead of the 2 SD (larger) correction in existing NRRs offsets to some extent the change from best-fit (NRR) to subject-fit (NRR(SF)) data.

2. Although the actual computations involved in the NRR(SF) and the NRR are nearly the same, the NRR(SF) is based on the SNR procedure in ISO 4869-2:1994[3], whereas the NRR is based on prior NIOSH work.[16] Even if the same set of octave-band attenuation values is used as the input data for both single-number calculations, and the same number of SDs are subtracted (e.g., a 1 SD correction in both instances), small differences between the methods cause the computed NRR(SF) to exceed the computed NRR by 3.5 dB.

3. Besides the requirement in the NRR(SF) to use subject-fit data, another modification in the NRR(SF) as compared to the NRR procedure is that the NRR(SF) is intended to be subtracted from A-weighted values. By comparison, both the NRR and the SNR are designed to be subtracted from C-weighted values. Although use of single-number ratings with A-weighted values gives rise to a loss in accuracy, the Task Force determined that the increased ease of and likelihood of correct application by more users was the governing consideration.

4. To permit use with A-weighted decibels with no loss in safety, the NRR(SF) must include a constant 5 dB adjustment (i.e., NRR(SF) ratings are 5 dB less than SNRs computed from the same data). The Task Force's 5 dB correction is less stringent than the 7 dB value used by NIOSH for adjusting the NRR for use with A-weighted decibels, the method adapted by OSHA for the Hearing Conservation Amendment. The 5 dB adjustment can (and should) be eliminated when the NRR(SF) is ("correctly") subtracted from C-weighted values.

In summary, differences between the new NRR(SF) and the old NRR will vary by product, depending upon the relationship of the old EPA experimenter-fit test data to the new proposed subject-fit data. The divergence will also be affected by the change from a 2 SD to a 1 SD correction and the constant offset of 3.5 - 5.0=-1.5 dB as discussed in items 2 and 3 above. The new NRR(SF) will be less than the NRR by amounts of about 2-20 dB, with the differences being less for earmuffs than for earplugs.

Discussion

As mentioned above, since the EPA is the government agency that mandates and enforces hearing protector labeling, and since their noise office has been defunct since 1980, their regulation has not been updated. Although it may be revisited in the future, this is not likely to happen in the short term. Regardless, Method-B data and to some extent NRR(SF) values are starting to appear. In addition to the unanimous support of the professional community, the U.S. Military now requires testing to the new Method B, NIOSH specifies it as the preferred method of evaluating real-world hearing protector effectiveness[14], and OSHA has recognized the existence of such data in their current Technical Manual (see the web page at *www.osha-slc. gov/dts/osta/otm/otm_iii/otm_iii_5.html*). Meanwhile purchasers of hearing protectors can flex their muscles and let their wishes be known. They should write EPA to insist on a regulation that produces meaningful labeled values on the products they buy, and they should contact the vendors with whom they deal to demand Method-B results.

Although the focus of this article has been on hearing protector attenuation values, the hearing protector selection process should consist of more than merely scanning manufacturers' specification sheets and certainly more than studying price lists. Wear test the products intended for use, both on yourself and on small groups of employees. By developing firsthand knowledge and combining it with employee feedback, improvement will be achieved in selecting products that employees will accept, and workers will also be more successfully motivated by becoming involved in their own hearing conservation program. ◆

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