

Redefining the NRR - A Change is Coming

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ABSTRACT

As the Environmental Protection Agency (EPA) rule for labeling hearing protection devices approaches age 30, change is in the offing. The Noise Reduction Ratings (NRRs) with which so many are familiar will likely be replaced with a new pair of NRR-like numbers computed using a new methodology based upon a recently issued American national standard, ANSI S12.68-2007 *Methods of Estimating Effective A-Weighted Sound Pressure Levels When Hearing Protectors are Worn*. The new ratings will indicate a range of performance that might be anticipated between what is possible for most *individually trained users* to achieve or exceed (an 80th percentile value designated the NRS_{A80}), and that which can be attained for a *few motivated proficient users* (a 20th percentile value designated the NRS_{A20}). Because the new ratings will likely be based on test data that are similar, but not identical to the values used in computation of the existing labeled values, the 80th percentile values will probably be somewhat, but not substantially lower than today's NRRs. Though the EPA rulemaking process is moving forward it is not likely that a new labeling rule could be promulgated before early 2009 or that new labels would appear for at least sometime thereafter.

INTRODUCTION

As the Environmental Protection Agency (EPA)¹ rule for labeling hearing protection devices (HPDs) approaches age 30, change is in the offing. The method of computing the Noise Reduction Ratings (NRRs) that are emblazoned on all hearing protection devices, as required by the 1979 EPA rule, may become a thing of the past. The NRR, widely recognized as the decibel value on hearing protector labels, has become influential in many companies' choice of HPDs. It was intended to be a simplified guide to consumers and professionals alike, that would accurately indicate the amount of noise reduction they might anticipate receiving from an HPD. Higher numbers would denote greater effectiveness. It seemed a fine idea. History has demonstrated otherwise (Berger, 2000).

The elderly rule has many shortcomings, not the least of which is the fact that labeled NRRs bear little resemblance to what groups of users can expect to obtain in actual hearing conservation programs. Unfortunately, the EPA's Noise Office has been essentially out of business since shortly after the regulation was promulgated and thus was unable to consider revising and updating that regulation. Much has been learned in the intervening time frame, and the rule is now being revisited. In a surprising move four years ago in 2003, EPA held a workshop to present and review data that would lead to a new proposed rule on hearing protector labeling. Since then, progress has continued, and a proposed new rule open for public comment is anticipated in 2008.

At the same time that EPA has been active in this area, so too has the American National Standards Institute² Working Group 11, *Hearing Protector Attenuation and Performance*. WG11 has been responsible for the ANSI standards describing real-ear attenuation and microphone-in-real-ear testing of hearing protectors, and also, was tasked in 2003 with a new assignment, the creation of an American consensus standard for computing number ratings for HPDs. This later assignment, successfully completed in 2007, is the topic of this article.

The EPA's NRR is based on a method defined in an earlier report by the National Institute for Occupational Safety and Health (Kroes et al., 1975), but the actual law differs slightly from the NIOSH recommendation, and neither the law nor the recommendation is based on a national consensus standard. As of the fall of 2007 the standardization issue was rectified; there now exists an American National Standard, ANSI S12.68-2007 *Methods of Estimating Effective A-Weighted Sound Pressure Levels When Hearing Protectors are Worn*, that specifies how to compute and use an NRR-like number for hearing protectors. ANSI S12.68 differs from the existing EPA rule in a number of substantive ways, and it is probable that the new rating will be featured in the forthcoming EPA rule that is likely to be announced in 2008.

Many issues, besides the method of computing a number rating are involved in estimating the protection that users achieve while wearing HPDs. These include obtaining valid estimates of the hearing protector's attenuation as influenced by user training and motivation, the proportion of exposure time during which users actually wear the devices, and accurate measurements of the noise exposure in question. Perhaps of greatest concern, regardless of the precision of the computations behind the rating,

¹ The EPA is the government agency responsible for the hearing protector labeling regulation. This arises from the Noise Control Act of 1972 that was passed by Congress and empowered the EPA to create rules to govern the labeling of noise producing and noise reducing devices. Because the EPA lost its Noise Office in the early 1980, few of these rules were created, but the hearing protector labeling law was one of them.

² ANSI is a non-governmental body that creates voluntary consensus standards for businesses and for regulatory purposes. ANSI standards are often specified in the regulations of EPA, OSHA and other agencies.

is the issue of variability in the fit and performance users achieve, and the impossibility of predicting individual performance in the field from group data measured in the laboratory.

SAME NAME, DIFFERENT RATING

When the anticipated EPA rule change is proposed, the rating you will see will still be called the NRR but, under the hood, it will probably be completely revamped. The purpose of a rating is to take a complex set of data, specifically the attenuation at different frequencies measured in the laboratory on a panel of subjects, and distill that information to one or a few numbers that make it easy to compare HPDs and estimate, for a given device, the effective noise exposure of a population of users.

At the request of Mr. Ken Feith of the EPA, WG11 produced an exhaustive report (Gauger & Berger, 2004) comparing the performance of many rating definitions. That project expanded upon the prior published literature by introducing new concepts and new data. Methods of varying complexity were examined, from an octave-band approach to ones involving ratings used with C-weighted sound levels or exposures, from those that work with A-weighted measurements to those that are simple class or grading schemes (i.e. assign an HPD to a Class 1, 2, or 3). It became apparent that the straightforwardness of what are called A – A' ratings is appealing. Such ratings predict, by simple subtraction from the A-weighted ambient noise levels, the effective A-weighted levels when an HPD is worn. A – A' ratings, which by their very nature are easier to understand and apply, are of sufficient precision for most applications considering the many sources of variability inherent in predicting protection.

WG11 drew upon the Gauger and Berger report in creating the two new ratings in S12.68 that it calls Noise Level Reduction Statistics (NRS). It is expected that the EPA will adopt the S12.68 ratings in a proposed new rule, though the NRR name will remain because the original enabling legislation from the U. S. Congress, dictates such.

WHAT ABOUT THE DATA?

An important collateral issue to the development of a rating procedure is the underlying attenuation data from which the rating is to be computed. Gauger and Berger examined various attenuation measurement approaches, especially Methods A and B as specified in the ANSI S12.6-1997 standard. Subsequent to publication of their report an interlaboratory study was completed (Murphy et al., 2006) and the results demonstrated differences in the repeatability and reproducibility of the two methods. Since both methods have merits and applications as discussed in ANSI S12.6 and the selection of one for labeling purposes is primarily a matter of public policy, the decision was made in ANSI S12.68 (the computational standard) to incorporate both methods as options.

Currently WG11 is revising S12.6 to improve both Methods A and B. Enhancements are intended to reduce interlaboratory variability for both procedures, and the modifications to Method A should make the attenuation values it produces somewhat more achievable in practice by motivated and trained users. At this time, it appears as though the procedure to be selected by the EPA for labeling purposes will be Method A. Though this is a change from the strictly experimenter-fitted optimized approach in the currently required ANSI S3.19-1974 procedure, it is not as close to the real world as the alternative Method-B approach. Therefore the new EPA label ratings will in all likelihood not differ substantially from the previous NRRs for most products since the underlying data from which they are computed will still not be the best prediction for typical real-world performance.

THE RATINGS

The standard presents three options in increasing order of complexity and accuracy, beginning with the Noise Level Reduction Statistic for use with A-weighting (NRS_A), followed by the Noise Level Reduction Statistic, Graphical (NRS_G) that requires both A-weighted and C-weighted sound levels, and finally the familiar and most complex method, the octave-band (sometimes called the “long” method) that requires sound pressure level values at seven octave bands from 125 Hz through 8 kHz.

A BIG CHANGE FROM THE NRR – A PAIR OF NUMBERS

A substantial divergence in this standard from prior publications and other standards around the world is the recommendation that the simplified ratings (NRS_A and NRS_G) be presented as pairs of numbers, instead of as a single number rating. This provides additional information about the precision of the ratings, and via a label, better user guidance too. The pair of values describes the range of performance at the 80th and 20th percentile level; the specific meaning depends upon whether Method-A or Method-B data are utilized in the computation. Because of the likelihood that Method A will be selected by EPA, the Method-A definitions found in the S12.68 standard, follow.

- NRS_{A80} (80th percentile value) - the protection that is possible for *most individually trained* users to achieve or exceed.
- NRS_{A20} (20th percentile value) - the protection that is possible for *a few motivated proficient* users to achieve or exceed.

The 80th percentile value, which will always be the smaller of the two numbers, is the best candidate for predictions for groups of occupational users who have received individual training. Note the emphasis on individual training, not commonly found in occupational hearing conservation programs. In practice, with usual group training or lack of training, typical performance in the field will likely be lower. The 20th percentile value is more suitable for a known individual with excellent skill in using the device and a high level of motivation to do so. This value may be suited to consumers who are strongly motivated to wear protection and strive to carefully follow package instructions.

There are many reasons for a dual-number rating, including:

- It indicates that a range of performance is to be anticipated.
- It represents, via the range, products that offer more or less between-subject variability.
- It diverts the attention of the buyer from a single value, and makes it more difficult to focus on small and unimportant differences between products.
- It supports the rating of the product with a conservative number (80th percentile) that may appear low to some observers, while still indicating a higher level of protection (20th percentile) that is potentially attainable when a hearing protector is fit in an exemplary manner.
- It draws attention, via the higher number, to the possibility of overprotection.
- It may also encourage more careful fitting of hearing protection, especially among consumers who are buying products for their own use, by explicitly demonstrating what an exacting fit of the product can achieve in terms of attention.

ANOTHER BIG CHANGE FROM THE NRR – USABLE WITH A-WEIGHTING

Though the math seems simple for correct use of the NRR, just subtract the NRR from the C-weighted exposure to estimate the A-weighted protected values, it is often misused, either purposely or by accident (Thomas and Casali, 1995). Besides the concerns about the unrealistically high values of the NRRs compared to field performance, undoubtedly the most substantial other issue raised with respect to its use is that the NRR should not be subtracted, without the oft-forgotten 7-dB correction, from A-weighted

values to predict A-weighted protection. For the devices that were predominant at the time the NRR was defined, the subtract-from-C approach is more accurate than a subtract-from-A rating, but this is not as true for the full range of devices in use today or anticipated in the future. Also, C-weighted exposure values are often not even known.

Designing a rating for subtraction from A-weighted exposures eliminates the application problems with the NRR. Furthermore, in most instances, due to the large spread of the sound attenuation provided by hearing protectors when worn by individual persons, a simple dBA computation is more than adequate. Thus the NRS_A , as found in S12.68, can simply be subtracted from an A-weighted sound level or sound exposure to estimate the corresponding protected level or exposure. This is a substantial simplification over the current NRR and makes misuse much less likely.

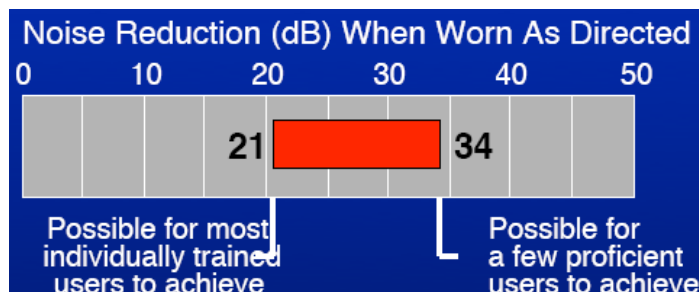
WHEN THE NRS_A IS NOT GOOD ENOUGH, REACH FOR THE NRS_G

It is only in special situations such as extreme noise exposures over 100 dBA or with noises that have substantial low-frequency energy as indicated by a C- A value that exceeds 5 dB, that more complex methods such as the NRS_G or octave-band approach are required. The NRS_G is preferable to the octave-band method in most cases since it is simpler to apply while being only marginally less accurate, and the required input noise data are easier to obtain (C- and A-weighted levels versus octave-band levels).

The NRS_G values, according to the standard, are provided graphically for a range of differing C-A values that represent noises with varying spectral balance,³ or in other words differing proportions of low-frequency energy. From the graph, or alternatively using a simple equation provided in the standard, one then finds the Estimated Noise Level Reduction (ENR) for the 20th or 80th percentile as desired. The estimated protected exposure is then computed by subtracting the ENR from the A-weighted sound level. Like the old NRR, the NRS_G requires both C and A measurements to be used correctly, but unlike the old NRR the computation takes better account of spectral balance and hence provides a more reliable prediction. The NRS_G will not appear on the new EPA mandated labels but will be available as supporting information.

A POSSIBLE LABEL FORMAT

Although at this time the EPA has not proposed a new label format, suggestions were provided during a meeting held at EPA headquarters in January 2007. One such possibility is shown in Figure 1. It displays the NRS_{A80} and NRS_{A20} on a single horizontal bar with the range between highlighted in red.



³ Spectral balance refers to the distribution of sound energy at different frequencies within the audible range. When sounds have a boomer sound (more energy in the low frequencies) their dBC values are greater than dBA and the C-A value increases. Conversely, hissier sounds (more energy in the high frequencies) have similar dBC and dBA values and hence their C-A values approach 0.

Since it is likely that the EPA will select Method-A testing procedures, the actual magnitude of the new labeled values will be similar to those on existing products, as typified by the figure above that is representative for a premolded earplug. The 80th percentile values will probably be somewhat lower than today's NRRs, and the range between the 80th and 20th percentiles will be typically be around 10 dB.

ADDITIONAL CONSIDERATIONS

The accuracy of the estimations using any of these new ratings is critically dependent upon the degree to which the real-ear attenuation data from which they are computed, and noise exposure data to which they are applied, correspond to the values experienced by the population or the users in question. With respect to the attenuation values, the protection performances are valid only when:

- the hearing protectors are worn correctly and in the same manner as worn during the test,
- the anatomical characteristics of the subjects involved in the laboratory test are a reasonable match for the population of actual wearers, and
- the hearing protectors are properly maintained.

The principal sources of potential error in the use of the methods in this standard are first and foremost the hearing protector attenuation data (which is strongly influenced by the training and experience of the test subjects), and the noise measurement data from which the NRS or octave-band values are subtracted.

In general, differences of 3 dB or less in the determination of the effective sound pressure levels for comparable HPDs are not significant for the purposes of distinguishing between products. For specific guidance refer to Annex D in S12.68.

EXPECTATIONS

As of now Mr. Ken Feith of the EPA, the man responsible for the 1979 labeling regulation and also the person responsible for making the current revisions, is projecting that a proposed new rule will be announced by the end of 2007 or early 2008. That would be followed by public hearings and the usual lengthy rulemaking process. Thus, although S12.68 does now exist, it is not likely that a new EPA hearing protector labeling rule could be promulgated before early 2009 and that rule would likely make provisions for manufacturers to have time to retest and relabel their products, at the minimum a 2-year process. So, don't count on seeing new NRR labels before 2011, and when you do, remember, the name is the same, but the meaning will be different.

A related question is how this will influence the Occupational Safety and Health Administration (OSHA) Hearing Conservation Amendment that now specifically incorporates EPA's NRR for enforcement purposes. At the very least OSHA would have to address this in an administrative guideline or formal interpretation, but potentially might choose to revise the law, which of course would open it to a public and lengthy rulemaking process.

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