E·A·R LOG® 12

Twelfth in a comprehensive series of technical monographs covering topics related to hearing and hearing protection.

The Hearing Conservation Amendment (Part II)

BY ELLIOTT H. BERGER,
Senior Scientist, Auditory Research

In the previous EARLog[1], # 11, the principal components of the Hearing Conservation Amendment were briefly summarized. In this EARLog we conclude discussion of the Amendment by examining the portions of the regulation specifically pertaining to hearing protection devices (HPDs). Emphasis will be placed upon the OSHA prescribed methods of estimating the adequacy of hearing protector attenuation.

Hearing Protector Acceptability
As discussed in EARLog #11, the Amendment defines when a hearing conservation program must be established, when HPDs are to be made available and/or their use is to be enforced, and to what levels HPDs must reduce employee noise exposures. However, the decision concerning which protectors to utilize is up to the program administrator since OSHA does not approve or certify particular devices. A product is acceptable for use if it is shown to be adequate by any of the methods outlined in Appendix B of the Amendment[2]. Utilization of those methods requires the availability of the manufacturers' published Noise Reduction Rating[3] (NRR) and/or octave band attenuation data at the frequencies from 125 Hz to 8 kHz.

The Methods of Appendix B
Appendix B presents what appear at first glance to be six primary methods and three alternative methods for estimating hearing protector
adequacy. They are:

1) NRR with C-weighted dosimetry
2) NRR-7 dB, with A-weighted dosimetry
3) NRR with representative sampling using C-weighted sound level meter
4) NRR-7 dB, with representative sampling using A-weighted sound level meter
5) NRR with area sampling using C-weighted sound level meter
6) NRR-7 dB, with area sampling using A-weighted sound level meter
7) NIOSH Method #1
8) NIOSH Method #2
9) NIOSH Method #3

Examination of the first six items reveals that they represent only two different methods of utilizing the NRR, each paired with three separate methods of estimating employee time-weighted average noise exposures (TWAs). The two NRR-based procedures will be referred to as the NRR Method and Adjusted NRR Method, as illustrated in Table I. The list may be further simplified when one realizes that the NRR and Adjusted NRR Methods were derived from the work of NIOSH[4] and are equivalent to NIOSH Method #2 and Method #3 respectively[5].

The only additional alternative that actually appears in Appendix B is NIOSH Method #1. It is significantly more complex than the single number methods such as the NRR or Adjusted NRR, since it requires octave band noise data and detailed calculations for each protector/noise spectrum combination. By comparison, the NRR that is utilized in the single number methods is precalculated by the hearing protector manufacturer, and is independent of the noise spectrum in question.

Comparing the Methods
The three distinct methods for estimating the adequacy of HPDs are summarized in Table I. They are listed in order of descending accuracy. The Octave-Band Method provides a greater potential degree of precision than is afforded by the single number methods. This potential is often limited due to the poor estimate of real world attenuation that is typically provided by laboratory data[6].

The NRR Method, as taken from NIOSH Method #2, embodies the most accurate type of single number rating procedure[7], in that it requires the subtraction of the single number from a C-weighted workplace measurement to estimate an A-weighted exposure. It is essential to use this "C minus A concept" to estimate HPD adequacy when utilizing single number ratings, since the A-weighted noise reduction provided by an HPD is inversely related to the difference between the C- and A-weighted noise levels (C-A value) in the particular environment.

Considerable accuracy is lost in estimating protected noise exposures when, as in the Adjusted NRR Method, a single number rating is subtracted from an A-weighted sound level. The 7 dB adjustment that is made in the NRR for use with the Adjusted NRR Method arises from the mathematics of this less accurate computational procedure. The adjustment ensures that the errors arising from this approach are more likely to underestimate rather than overestimate the protection that would be predicted using the more precise Octave-Band Method. The 7 dB adjustment has nothing to do with the differences between laboratory and real world performance. It is not to be confused with any constant decibel or percentage deratings of the NRR that have been proposed to account for such discrepancies[6].

Alternative to the Adjusted NRR
Due to the poor accuracy of the Adjusted NRR Method it is advisable to use the Octave-Band or NRR Methods. However, the method of noise monitoring that is preferred by OSHA is personal dosimetry, and no commercially available dosimeters currently provide
C-weighted dose assessments. A solution to this dilemma is to estimate the C-weighted noise dose from the
A-weighted dosimetry-derived TWAs.

(over)

Table I

Summary of OSHA Approved Methods for Estimating Hearing Protector Adequacy

Technique		Description
Octave-Band Method Long Method NIOSH Method #1	*	Mean attenuation less 2 standard deviations is subtracted from workplace noise levels at each frequency from 125Hz - 8 kHz. Resultant values are A-weighted and summed to yield estimated dBA exposure.
NRR Method NIOSH Method #2	**	dBC (↑ workplace noise level or TWA) -- NRR = dBA (↑ estimated protected exposure)
Adjusted NRR Method NIOSH Method #3	**	dBA (↑ workplace noise level or TWA) -- [NRR - 7] = dBA (↑ estimated protected exposure)

*Three alternative names for the same technique.

** These two methods are identical except for minor mathematical differences which result in NRRs being approximately 0.5 dB less than the corresponding NIOSH methods.[5]

Although this procedure is not explicitly presented in the Amendment, it is scientifically acceptable and has been implemented elsewhere[8].

The procedure is as follows:

1) Obtain an A-weighted noise dose.
2) Using a sound level meter possessing C- and A-weighting, develop a C-A value for typical processes, areas, or job descriptions.
3) Add the C-A value to the measured A-weighted TWA to calculate the estimated C-weighted TWA.
4) Subtract the NRR from the estimated C-weighted TWA.

To the extent that an accurate C-A value can be estimated, this procedure will provide enhanced accuracy over the Adjusted NRR Method for those situations in which C-weighted TWAs are unavailable.

EPA Labeling Requirements

A point of confusion exists between OSHA's Appendix B and the information which, according to EPA regulations[3], must accompany hearing protector packaging. The confusion arose since EPA chose to accommodate those users whom it feared would lack C-weighted measurement capabilities. It did this by effectively developing a two-number rating system, without ever explicitly stating that fact[9].

The EPA method requires that the user subtract the (unadjusted) NRR from an A-weighted sound level to estimate the wearer's protected exposure. A cautionary note is included which states: "For noise environments dominated by frequencies below 500 Hz the C-weighted environmental noise level should be used." Thus, depending upon the particular C-A value of the noise environment, which will increase in proportion to the amount of lower frequency energy present, the NRR is to be subtracted from either an A- or a C- weighted sound level. In practice, it matters little from which weighted sound level the NRR is subtracted when C-A values are near zero, but for noises with significant low frequency energy and therefore higher C-A values, errors of 10 dB or more can arise if the NRR is misapplied.

Unfortunately it is precisely those individuals for whom the EPA Method was intended who are most likely to misuse the NRR. Since they lack C-weighted instrumentation they will be unaware when dominant energy is present below 500 Hz, and thus will be unable to judge from which weighted sound level the NRR must be subtracted. In comparison to the NRR Method, or even the Adjusted NRR Method, the EPA's procedure is less accurately defined, more easily misapplied, and less effective at estimating HPD adequacy.

Real World Attenuation

OSHA does not require that an employer estimate the actual attenuation that its workers obtain from the devices as worn. This actual or real world attenuation is known to be significantly less than published laboratory data for a number of reasons[10] primarily involving differences in training, motivation, and utilization, between users (the noise-exposed work force) and testers (laboratory subjects). The problem is well recognized by experts in the field, and deratings such as subtracting 10 dB from published NRRs have been proposed[6]. But, thus far there has been no consensus in the professional or regulatory communities on how to derate laboratory data, or how to otherwise account for the discrepancies.

In the Hearing Conservation Amendment, acknowledgement of disparities between laboratory and real world data is limited to a short note in Appendix B which states:

> *The employer must remember that calculated attenuation values reflect realistic values only to the extent that the protectors are properly fitted and worn.*

This warning is crucial, since proper fitting and wearing of HPDs by the industrial work force is probably the single most difficult element to execute in a hearing conservation program. It requires not only education, training, and the selection of comfortable and effective HPDs, but perhaps more importantly, motivation, enforcement, and responsiveness to the needs of the hearing protected employees. Guidance on these issues may be found in EARLogs 3, 5, 7, and 8- 10[1].

References and Footnotes

1. Berger, E.H. - The EARLog Series is available upon request from Aearo Company.
2. The Amendment does not specify a particular test procedure for developing attenuation data. However, for current manufacturers' data to be in compliance with the EPA labeling regulations[3], tests will be in conformance with ANSI S3.19-1974.
3. EPA (1979). "Noise Labeling Requirements for Hearing Protectors," Fed. Regist. 42(190), 40CFR Part 211, 56139-56147.
4. NIOSH (1975). "List of Personal Hearing Protectors and Attenuation Data," U.S. Dept. of HEW, Report No. 76-120, Cincinnati, OH.
5. Berger, E.H. (1980). "Suggestions for Calculating Hearing Protector Performance," Sound Vibration 14(1), 6-7.
6. Berger, E.H. (1983). "Using the NRR to Estimate the Real World Performance of Hearing Protectors," Sound and Vibration 17(1), 12-18.
7. Sutton, G.J. and Robinson, D.W. (1981). "An Appraisal of Methods for Estimating Effectiveness of Hearing Protectors," J. Sound Vib. 77(1), 79-81.
8. Dept. of Transportation (1982). "Navigation and Vessel Inspection Circular No 12-82, Recommendation on Control of Excess Noise," U.S. Coast Guard Report, Wash., D.C.
9. When the EPA first published the labeling regulations for public comment (1977, Federal Register, V42(120) 40CFR, Part 211, 31730-31738), they chose to implement the NRR in the mathematically correct manner, i.e. subtracting it from a dBC level. It was only in the final and existing version of the regulation[3], that the procedure described in the text appeared.
10. Berger, E.H. (1980). "EARLog #5 - Hearing Protector Performance: How They Work - And - What Goes Wrong in the Real World," available upon request from Aearo Company.

E·A·R®

Aearo Company
5447 West 79th Street, Indianapolis, IN 46268
(317)692-6616 FAX (317)692-6775

LIT. CODE 30297 2/99 AG