HOW TO ASSESS HEARING PROTECTION EFFECTIVENESS: WHAT IS NEW IN ANSI/ASA S12.68

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In July 2007, the Acoustical Society of America published ANSI/ASA S12.68 American National Standard Methods of Estimating Effective A-Weighted Sound Pressure Levels When Hearing Protectors are Worn.[1] The standard is an advance relative to the Noise Reduction Rating (NRR) as currently mandated by the U.S. Environmental Protection Agency and it is also an advance relative to the standards that have been developed by the International Organization for Standardization (ISO). Since the promulgation of the EPA's hearing protection labeling rule in 1978, the Noise Reduction Rating has been criticized as overestimating the performance that users achieve in the workplace.[2] The NRR attenuation data are measured with subjects who have had the hearing protection fitted solely by the experimenter. ANSI/ASA S12.68 standard utilizes attenuation data that are derived from subjects who have either minimal experience with hearing protection and protector testing or with subjects who have been trained by the experimenter. Let us examine the novel techniques contained within the ANSI/ASA S12.68 standard.

> *"Hearing protection is essential to protect our ears from the insidious effects of noise."*

First, the standard provides three methods of estimating the performance of a protector based upon the attenuation measurements for that device. The first method is a two-number Noise Reduction Statistic for A-weighting (NRS_A) which informs the user about the lower and upper range of performance that can be expected from the hearing protector. To utilize the NRS_A, the user need only measure the A-weighted noise exposure and then subtract the rating to estimate the exposure. Use of the lower number provides a conservative estimate of the exposure that most users will not exceed when wearing the device. Use of the higher number can provide an estimate of whether the protector may give one too much protection and potentially lead to impaired communication in a noisy environment. The range between the two ratings provides a more subtle indication about the use of the product. If the upper and lower numbers are relatively close together, this gives an indication that the protector was consistently fit across the test panel and that variation in performance across different noise spectra is small. Research studies have shown that varied performance across users was the single most important factor in how much attenuation one received while wearing the protector (in addition to whether it is worn whenever you enter the noisy environment).

To use the first method, the noise exposure can be measured using a sound level meter set for the A-weighting scale. Suppose that the exposure was measured to be 97 dBA, and the hearing protector represented in Fig. 1 is to be worn. The NRS_A then estimates that the exposure when wearing this protector will be between 78 and 70 dBA. The industrial hygienist or hearing conservation professional can have some level of confidence that worker exposures are below 85 dBA when the protector is worn properly.

The second method in the S12.68 standard provides a graphical approach (NRS_G) that accounts for the variability of the spectral noise environment. If a person works in an environment that has predominantly low-frequency noise, then this should be considered in estimating hearing protector performance, since attenuation is typically worse at lower frequencies. A simple approach to characterizing the proportion of noise at low frequencies is to measure both the A-weighted and C-weighted levels. The difference between the two measurements yields a C-A metric—more positive C-A values tend to indicate more low frequency exposure. The NRS_G graphical method provides two curves indicating attenuation as a function of C-A. For example, if

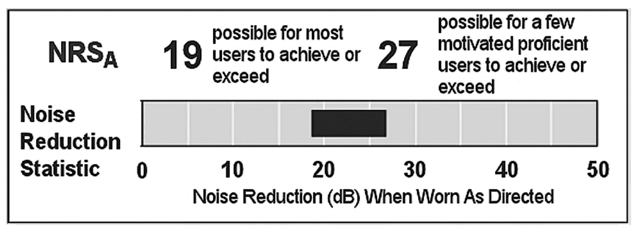

Fig. 1. Noise Reduction Statistic for A-weighting (NRS_A). The lower value represents the attenuation which is possible for most users to achieve or exceed. The upper value is what is possible for a few motivated proficient users to achieve or exceed.

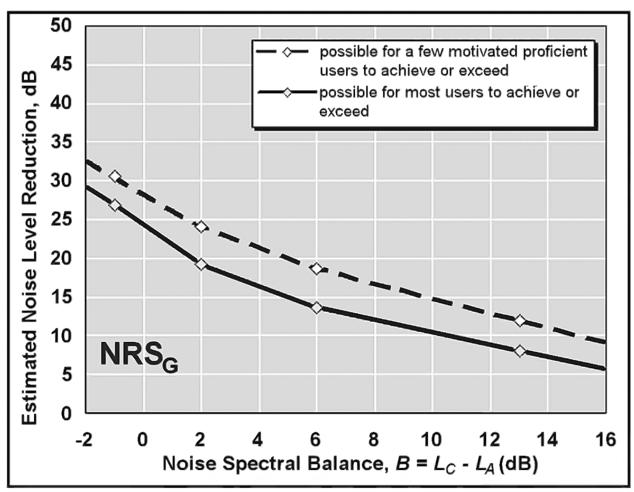

Fig. 2. Noise Reduction Statistic for A-weighting graphical method (NRS_G). The curves illustrate the effective hearing protection as a function of varying the spectral balance (L_C-L_A). The lower curve represents the attenuation which is possible for most users to achieve or exceed. The upper curve is what is possible for a few motivated proficient users to achieve or exceed.

Table 1. Noise Reduction Statistic for A-weighting sample octave band calculation.

Octave-band center frequency, *f*, Hz	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Measured octave-band sound pressure level of the noise, L_f (NIOSH noise 43 from Annex A)	98	93	89	92	88	83	75
Frequency weighting A (from ANSI S1.4)	-16.1	-8.6	-3.2	0.0	1.2	-1.0	-1.1
A-weighted octave-band sound pressure level of the noise, $L_f + A_f$	81.9	84.4	85.8	92.0	89.2	82.0	73.9
APV_{f80} from Table C.1	6.2	7.8	19.0	26.5	27.4	32.3	31.1
$L_f + A_f - APV_{f80}$	75.7	76.6	66.8	65.5	61.8	49.7	42.8
Note: All values in decibels.							

one measured an exposure to be 100 dBC and 92 dBA then the C-A value is 8 dB. The graph in Fig. 2 indicates an NRSG lower value of about 12 dB and an upper value of about 17 dB. Using these two protector ratings, the range of exposure while wearing the hearing protector could be between 80 and 75 dBA [92-12= 80 and 92-17 = 75 dBA]. Using the guidance of acceptable exposures, the protector would be an appropriate choice for that noise. The standard provides guidance on how to interpolate the points on the curve if a more precise estimate of exposure is needed.

The third method provided in the S12.68 standard is the octave-band method. In this case the user must know the octave or one-third octave-band levels of the noise exposure (L_f). The levels are combined with the octave-band attenuation values for the protector (A_f). An example is given in Table 1.

The last row of the table is summed logarithmically to find an estimated exposure of 79.7 dBA that rounds to 80 dB. The 80th percentile of the attenuations across subjects and noises are the assumed protection values (APV_{80}) and are calculated by the mean attenuation minus a multiple (0.8416) of the standard deviation. To estimate the performance with the better fit, the APV_{20} is the mean attenuation plus a multiple (0.8416) of the standard deviation. The higher APV_{80} translates to a lower exposure level.

In the United States, occupational noise exposures are measured using the A-weighting scale. The difference between C and A weighting introduced an unnecessary conversion factor which, if forgotten, added to the inaccuracy. According to EPA, 7 decibels must be subtracted from the rating to convert between the rating from dBC and dBA. In subsequent years, the typical industrial noise has been characterized as having a C-A difference of 5 dB and 3 dB.[3,4] In the development of the S12.68 standard, Gauger and Berger developed a unique approach of calculating the noise reduction across the range of 130 noises. The overall standard deviation used in determining the two-number rating combined the variance across subjects and the variance across noise spectra. In this manner, the spectral variation is already incorporated into the rating. Furthermore, the rating was calculated for A-weighted noise spectra eliminating any conversion factor.

Now that a new ANSI standard exists, of what use is it? Since 2003, the EPA has been working on writing a revision of the hearing protector labeling regulation (40 CFR 211 Subpart B).[2] The revised regulation will address more than just the Noise Reduction Rating. It is expected to provide regulatory guidance for devices such as active noise reduction hearing protection and devices intended for impulsive noise. EPA and NIOSH sponsored an interlaboratory test of hearing protector attenuation that compared experimenter-supervised and naïve subject fitting protocols. The results from this study were reported at the December 2006 Acoustical Society Meeting in Honolulu and were integral in the development of the new rating standard.[5] As well, the results provided greater insight into the issues of how to compare ratings when products are retested or when they are tested in a different laboratory. In the new standard, an annex on computing the uncertainty associated with the rating has been included. In contrast to what has been the norm for the ISO standards where all of the elements of the measurement process are quantified (e.g., equipment calibration, threshold variance, etc.), ANSI/ASA S12.68 has applied a computational statistical approach to the attenuations measured for the subject panel. Since the variance is largely derived from the subject's unoccluded and occluded hearing thresholds and the fit of the protector, a "bootstrap" technique that resamples the attenuations of the subjects was applied to estimate the confidence interval for the Noise Reduction Statistic. For each protector test, the uncertainty for that particular device is estimated and can be used to understand the variability of the rating. For instance, the interlaboratory study compared experimenter-supervised and naïve subject fit attenuations. The uncertainty on the NRS_A was larger for the naïve subject-fit data than it was for the experimenter fit data. Different laboratories demonstrated varying degrees of uncertainty. The effect of the experimenter involvement was seen in reduced uncertainty when the subjects were required to precisely fit the product. This application of computational statistics to uncertainty can be translated to other acoustical standards as well. Sound power, occupational exposure, measurement of a person's hearing threshold all can benefit from the approach that has been pioneered in the hearing protector rating standard.

What is the bottom line? The use of the ANSI/ASA S12.68 method provides more relevant and useful numbers that describe what a person might expect when using hearing protection. However, unless one wears the protection when exposed to hazardous levels of noise, the numbers will be meaningless. Noise-induced hearing loss is entirely preventable. Just as Norm Abrams of the New Yankee

Workshop™ reminds viewers on a weekly basis to read the equipment manuals and always wear your safety glasses, we should remember that hearing protection is essential to protect our ears from the insidious effects of noise. **AT**

Disclaimer: "The findings and conclusions in this report are those of the author and do not necessarily represent the views of the National Institute for Occupational Safety and Health (NIOSH)."

References

1 ANSI/ASA S12.68–2007. *American National Standard Methods of Estimating Effective A-Weighted Sound Pressure Levels When Hearing Protectors are Worn* (Acoustical Society of America, Melville, NY, 2007).

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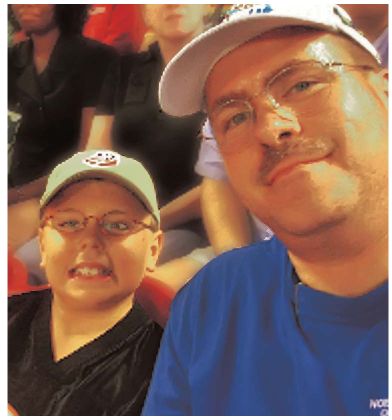

Bill regularly takes his son Aaron out to the ballgame. Aaron roots for the Reds, Bill for the Cubs.

William J. Murphy is co-leader for the Hearing Loss Prevention Team in the Division of Applied Research and Technology, National Institute for Occupational Safety and Health (NIOSH) in Cincinnati. A graduate of Iowa State University (B.S. and M.S.), he completed a Ph.D. in physics at Purdue University and joined NIOSH in 1992. He was commissioned as a scientist officer in 1993 and holds the rank of Captain in the U.S. Public Health Service. Currently he is developing ratings for the performance of passive and active hearing protection devices. He is an active member of the Acoustical Society of America, is a member of the Technical Committee on Noise, and serves as the Vice Chair of ANSI Standards Committee S12 to develop national and international acoustic standards on noise. Outside of work, Bill arranges music, plays trombone, guitar and piano, leads worship at church, and teaches high-school physics to home-schooled students. Bill and his wife Deb school their three children at home.

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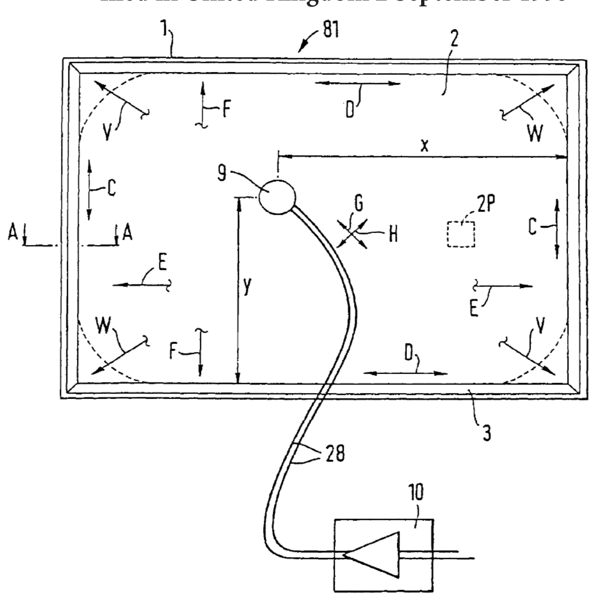
43.38.Ja ACOUSTIC DEVICE

Henry Azima et al., assignors to New Transducers Limited 2 January 2007 (Class 381Õ152); filed in United Kingdom 2 September 1995



This is a long and unusual patent. It contains more than 70 illustrations and a ten-page summary of planar loudspeaker design, including the extensive prior work patented by New Transducers Limited. In effect, the patent can serve as a handbook of the state of the art in this field. Anyone interested in planar loudspeakers is advised to order a copy.—GLA