The ANSI Standard S12.68-2007 Method of Estimating Effective A-Weighted Sound Pressure Levels When Hearing Protectors are Worn: A Canadian Perspective

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1. INTRODUCTION

The most serious and difficult issue with hearing protection devices (HPD) is to estimate the protected noise level at the wearer's ear. Such estimation is difficult for two reasons. First, the effective field attenuation of an HPD on a given user is rarely known. Instead, the Noise Reduction Rating (NRR), specified in the USA by Code of Federal Regulations CFR 40 Part 211, that represents the 98th percentile of the group attenuation of test-subjects tested in a laboratory, is currently used. Such use of the NRR provides a highly unrealistic assessment, not only because the NRR value dramatically overestimates the attenuation with respect to real-life situations, but also because the NRR does not reflect the inter-subject variability in terms of attenuation for a given HPD. Second, is the issue associated with the practical use of the NRR is that it requires the C-weighted exposure level, which is rarely available in practice, and assumes that the noise spectrum is flat per octave-band (pink noise).

Finally, although the Canadian Standards for HPD [1] is referring to classes and grades to assist the end-user with the proper selection of HPD, it should be noted that these classification are based on the average attenuation values achieved by the HPD in laboratory. Hence, they are affected in a similar way by the lack of realistic laboratory attenuation data (that are to be measured using ANSI S3.19 [2] or ANSI S12.6 [3]) and furthermore, it can be easily demonstrated that a very minor change (less than one dB) of the average attenuation at only one frequency band can change the HPD from one class or grade to another. This demonstrates the weakness of such classification scheme and the need for the hearing conservationist to have access to a single number rating of the attenuation of a given HPD..

For the reasons mentioned above, the current NRR is a poor indicator ("not really relevant") of the attenuation that a worker will experience in the field. Such inadequacy of the NRR is not new [4] and various attempt have been made in the past to either come up with more realistic attenuation data (like in the Method B of ANSI S12.6-1997 that describe an experimental protocol on naïve subjects that would fit the HPD themselves, therefore hopefully providing more realistic attenuation values) or like in the past attempt to promote a "derating" rule [5] that would be applied on the laboratory data in order to lower the attenuation values and hopefully obtain values that would be more realistic. None of these approach have been found to be satisfactory and the ANSI standard S12.68 [6] has been recently developed to specifically address these the issues of the inter-subject-fit variability and noise-spectrum content variability previously mentioned. The standards presents 3 methods to estimate from laboratory attenuation data, the sound pressure levels when HPD are worn. The first one is the use of the Noise Reduction Level Statistics, that will be further explained in this paper. The second one is a graphical representation of the Noise Reduction Level as a function of the C-A values of the exposure level. The third one is the use of the exact "octave-band" method. These last two methods won't be detailed here, but have already been vulgarized [7].

2. A new proposal: the Noise Reduction Level Statistics, NRS_A

A substantial divergence in this standard from prior publications and other standards already cited is the recommendation that the simplified ratings be presented as pairs of numbers at the 80th and 20th percentile level. Furthermore, an exhaustive set of 100 actual industrial spectra, denoted "NIOSH 100", will be used for the computation of this single number rating rather than only 8 spectra, as in the previous section.

$$\Delta L_{A_{pn}} = 10 \cdot \log_{10}\left(\sum_{i=1}^{7} 10^{\frac{L_n^i + A^i}{10}}\right) - 10 \cdot \log_{10}\left(\sum_{i=1}^{7} 10^{\frac{L_n^i + A^i - REAT_p^i}{10}}\right) \quad (1)$$

where $L^i n$ is the sound pressure level in decibels for the octave centered on i for the n th noise in an industrial noises database; $REAT^i_p$ is the attenuation in decibels measured for the hearing protector on the p th subject at octave-band center frequency i, averaged across several trials (usually 2, as in the ANSI S12.6).

The NRS_{Ax} is defined as :

$$NRS_{Ax} = m - \alpha \cdot \sqrt{s^2_{subject} + s^2_{spectrum}} \quad (2)$$

where m is the average attenuation across subjects across spectrum, obtained as:

$$m = \frac{1}{P \cdot N} \sum_{n=1}^{N} \sum_{p=1}^{P} \Delta L_{A_{pn}} \tag{3}$$

and the standard deviations $s_{subject}$ and $s_{spectrum}$ are respectively -classically- defined by:

$$s_{subject} = \sqrt{\frac{1}{P-1} \sum_{p=1}^{P} (m_p - m)^2} \tag{4}$$

and

$$s_{spectrum} = \sqrt{\frac{1}{N-1} \sum_{n=1}^{N} (m_n - m)^2} \tag{5}$$

The effective A-weighted sound pressure level for protection performance x percent is computed by subtracting the NRS_{Ax} from the A-weighed exposure level, using the following equation:

$$L'_{Ax} = L_A - NRS_{Ax} \tag{6}$$

The attenuation values to be used in the calculation are not specified and both the use of Method B ("subject-fit", already described, where naïve or inexperiences subject are used) attenuation data or the use of Method A ("supervised-fit", where the testing laboratory would supervise the HPD insertion and fit) are possible. The NRS_A, is finally expressed at the 20th and 80th percentile values, in order to reflect both this variability's on the noise spectrum content and on the change in the attenuation from individual to individual. It is also expected that theses 2 percentile values would respectively represent the attenuation that "most individually trained users to achieve or exceed" and that "a few motivated proficient users to achieve or exceed."

3. NRS_A: some concerns for use in Canada?

Although the NRS is much more easy to use and also more realistic, its direct use in the Canadian workplaces may require some further investigations on three aspects. The first aspect is the representativity for the Canadian workplaces of the NIOSH 100 spectrum used: although a comprehensive analysis has been conducted by Berger and Gauger [8], it is not clear how the relative weight of the industrial workplaces has been taken into account in the database used. At least five spectrum are repeated more than once in that dataset, and may be intentionally or not, making some spectrum more preponderant. Furthermore it could be argued that some Canadian industrial areas (like the mining, wood and forestry industries) may be significantly underrepresented in that dataset [9].

The second issue associated with the use of the NRSA is that the attenuation values to be used in that calculation are not specified and both the use of Method B ("subject-fit", already described, where naive or inexperiences subject are used) attenuation data or the use of Method A ("supervised-fit", where the testing laboratory would supervise the HPD insertion and fit) are possible.

The third issue is related to the fact that field validation are still missing to ascertain what percentile should be used to give a realistic assessment of the field attenuation values that a group of user can achieve. Such value was assumed to be 80%, but the foreseen use of "Method A" attenuation data for the calculation of the NRSA urged some authors to ask for consideration of other percentile value (such as the 90% value discussed among the ANSI S12 working group WG11). A field validation in the Canadian workplace is definitely required and would consist in the statistical comparison of field attenuation data to NRS_{Ax} expressed at various percentiles *x*.

4. CONCLUSION

The recent developments of ANSI S12.68 is certainly very good news for the Canadian hearing conservationist: it provides 3 different practical tools to estimate from laboratory data the attenuation that user may achieve in the field, with a built-in uncertainty that accounts for the inter-subject-fit variability and noise-spectrum content variability. Its use and reference by the Canadian standards could also be considered, after several validation have been successfully conducted.

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