# NRR, ABC OR...

**Alberto, Behar, P.Eng., CIH****
**Jim Desormeaux, COHST**
Ontario Hydro, 1549 Victoria Street
Whitby, Ontario L1N 9E3

## ABSTRACT

This technical note examines the decision taken by the CSA Standard Committee on Hearing Protectors to continue with the use of the ABC system for the selection of hearing protectors. The basis for the ABC and the NRR systems are reviewed and the systems are compared. The Note provides some recommendations regarding the use of the attenuation figures for hearing conservation purposes.

## SOMMAIRE

Cette note technique examine la décision du comité des normes sur les protecteurs auditifs de la CSA de continuer d'utiliser le critère ABC pour l'évaluation des protecteurs auditifs. L'auteur compare les avantages des systèmes ABC et NRR et fait des recommandations concernant l'utilisation des valeurs d'atténuation aux fins de la préservation de l'ouïe.

## 1. INTRODUCTION

At the last meeting of the CSA Committee on Hearing Protectors, a decision was made to continue with the use of the ABC system for the classification of hearing protectors (described in the CSA Standard Z94.2[1]). CSA standards are revised at least once every 5 years, or earlier, if there is a reason for it. Therefore, the above decision means that we will keep the ABC classification at least for the next five years.

Hearing protectors are classified according to their attenuation. There are many systems in use. However, for the purposes of this paper, we will be focusing on only two: the NRR used mainly in the USA and the ABC, included in the CSA Standard.

## 2. ATTENUATION OF HEARING PROTECTORS.

There are two main characteristics of interest for users of hearing protectors: one is the **comfort** experienced by the user. Its importance is obvious: an uncomfortable protector is not used so there is a real interest in having comfortable protectors. However, because of the subjectivity of this characteristic and of the difficulty of its determination, there are no known national or international standards for comfort.*

**Attenuation** is the second of the characteristics. It is the reduction of the sound level at the ears of a person wearing the protector ("noise level of the protected ear"). Contrary to comfort, there are standards for its measurement. The CSA Z94.2 explicitly states, that attenuation should be measured following the procedures in the ANSI Standard S3.19[2].

The result of the measurement of the attenuation of a hearing protector is a table (or graph) representing the attenuation and the standard deviation at each of the standard measurement frequencies: 125, 250, 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz. Table 1 and Figure 1 show an example of a table and the corresponding graph of the characteristics of a hearing protector.

The attenuation is measured in specialized laboratories using highly trained subjects. Results from the measurement can be qualified as being the **highest achievable attenuation**.

* Ontario Hydro has developed an internal standard for comfort.
** Now at A. Behar, Noise Control Management, 15 Meadowcliff Drive, Scarborough, Ontario M1M 2X8

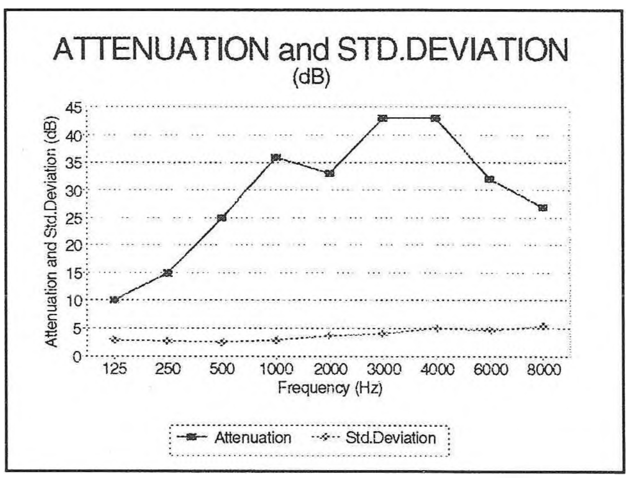
However, this attenuation could never be achieved in the real world. Many field studies have proven the above statement[(3)(4)], leading to several proposed derating schemes (e.g., how to reduce the measured attenuation so to correctly reflect what is observed in the field). Although there is no consensus on this issue, it is generally accepted that the "real" attenuation is at least 10 dB lower than the nominal.

**TABLE 1**

**Attenuation and Standard Deviation of a Hearing Protector (see Figure 1)**

| Frequency (Hz) | Mean Attenuation (dB) | Standard Deviation (dB) |
|---|---|---|
| 125 | 10 | 2.7 |
| 250 | 15 | 2.6 |
| 500 | 25 | 2.4 |
| 1000 | 36 | 2.7 |
| 2000 | 33 | 3.6 |
| 3000 | 43 | 3.9 |
| 4000 | 43 | 4.9 |
| 6000 | 32 | 4.5 |
| 8000 | 27 | 5.4 |

**FIGURE 1**




## 3. USE OF THE ATTENUATION

The attenuation is used to predict the noise level of the protected ear. In other words, by knowing the noise level in the workplace and the attenuation of a given protector, one should be able to determine the noise level that the wearer is effectively exposed to. If, for example, the noise level in a workplace is 105 dBA and the attenuation of the protector is 15, then the person wearing this protector will be exposed to

$$105 - 15 = 90 \text{ dBA}.$$

From the above, one would expect the issue of the use of the attenuation figure to be simple. However, this is not the case, because the attenuation of a protector changes at the different frequencies (see Figure 1) and the same occurs with the noise levels. In addition, the frequency content of the noise a worker is exposed to is constantly changing with the combined actions of different noise sources and/or the variation of worker's location with respect to these sources.

To make the situation even more complex, there is the variability of the attenuation with individuals: the way they fit their protectors, the shape of their heads, ear canals, etc., results in changes in the attenuation. [For this reason the attenuation test is taken over 10 subjects on 3 different occasions. The reported result is the mean value of all 30 measurements.]

Without entering into details, there is a method for the prediction of the noise level of the protected ear, that takes into account all of the above variables. This is the so called NIOSH "long" method. For the calculation of the predicted level, it requires the existing noise levels (measured in octave bands) and all the data (attenuation and standard deviation) of the protector. The noise level of the protected ear is then calculated in octave bands and/or dBA. [Again, for this method to work, the levels and frequency content of the noise has to be steady.]

From the above, it can be seen that the use of the NIOSH "long" method is quite cumbersome. For that reason other approaches using one number estimates have been developed. NRR and the ABC are just two of them. Neither requires noise levels of the environment to be measured in octave bands.

## 4. THE NRR***

The NRR (Noise Reduction Rating) is a single number, calculated using the attenuation and standard deviation data obtained from the attenuation measurement of the protector. The larger is the NRR, the higher is the attenuation of the protector. In practice NRR starts roughly at 14 and goes up to 32. It is a requirement in the USA that all hearing protectors have the NRR stamped on their envelopes. Because of the market's implications, the use of the NRR has been expanded worldwide, so that now this is the most frequently used estimate and the one most commonly found printed on hearing protector containers.

Noise level of the protected ear is calculated using the NRR as follows:

1. Measure the noise level in the workplace in dBC
2. Subtract the NRR from the above
3. The result of the calculation is the noise level of the protected ear in dBA.

Since, in many occasions, the noise level of the place is measured in dBA, NIOSH recommends that 7 dB be added to the dBA level to obtain the dBC, needed for the calculation. In practice it is equivalent to an increase of 7 dBA of the predicted noise level of the protected ear.

| | |
|---|---|
| Example 1: | |
| Noise level in the workplace | |
| Measured (in dBA): | 100 dBA |
| Calculated (in dBC): | 100 dBA + 7 = 107 dBC |
| Protector: | NRR = 28 |
| Noise level of the protected ear: | 107 - 28 = 89 dBA |

## 5. THE ABC SYSTEM

The ABC system is only used in Canada. A variation of the system (using 5 categories, A through E) has recently been adopted in Argentina.

With this system, protectors are classified in three categories: A, B and C on the basis of only their attenuations following specifications in the CSA Z94.2 Standard. As with NRR, it is manufacturers' (or suppliers') responsibility to provide the class of a given protector.

Table 2, (reproduced from Table 1.A, reference 1) indicates the Class of protector to be used for a given equivalent noise level $L_{eq}$. It has to be pointed out, that noise is not measured as a sound level (as with the NRR), but as $L_{eq}$. Therefore, not instantaneous but time weighted average is to be used.

| | |
|---|---|
| Example 2: | |
| Noise exposure level in the workplace | |
| Measured: | $L_{eq}$ = 100 dBA |
| From Table 1: | A Class A protector should be used |

The values in Table 2 are calculated after derating the attenuation of the protectors, so that the recommended protectors could be effective for the indicated equivalent noise levels in real life situations.

## 6. ADVANTAGES AND DISADVANTAGES

Following are some of the advantages and disadvantages from the use of both estimates:

- The NRR is widely used. The International Standard Organization (ISO) has incorporated a modified version of the NRR. The ABC is used only in Canada.

- The NRR has been favourably tested against the NIOSH "long" method[6], the ABC has not.

- Because of its extensive use, especially in the USA the NRR is well known by the safety professionals.

- The ABC does not use the standard deviation among subjects. In doing so an important piece of information is lost.

- The NRR divides protectors into too many groups by using increments of one dB. This may lead to the wrong assumption that a difference of a few dB is important (e.g., that a protector with NRR 25 is much better than other protector with NRR 23). Having only 3 classes, the ABC system can group the protectors better. However, again, one dB at one frequency can cause a protector to change from one Class to another.

- The ABC system is procedural: one does not have to do any calculations: once the $L_{eq}$ has been measured

*** Variations of the NRR are used in Australia, New Zealand and are also adopted by the ISO[5].

the appropriate Class of protector to use is found in Table 1A in the Appendix of the Standard.

- Both estimates use attenuation data that are far from the real life situations. Although the ABC system has derated somehow the system, it is still not scientifically proven and open to discussions.

## 7. CONCLUSIONS AND RECOMMENDATIONS

At this point some conclusions should be drawn regarding where to go. From all that was said above, the following can be concluded:

(a) The ABC system is here to stay for at least the next five years.

(b) Too many people are by now using the NRR. Therefore safety professionals should be knowledgeable of both systems

(c) Whichever system is used, it has to be kept in mind that both are using estimates that are far too "optimistic" and that in practice, attenuations are much lower (by about 10 dB in the case of the NRR).

(d) ***Most important:*** users should be trained on why, when, where and how to wear their protectors. (See appendices in the CSA Standard[1].)

## REFERENCES


1. SCA Standard Z94.2 Hearing Protectors. Canadian Standard Organization, 1984.

2. ANSI Standard S3.19 Method for the Measurement of Real-Ear Protection of Hearing Protectors and Physical Attenuation of Earmuffs. American National Standard Institute, 1974.

3. Behar, A.: Field Evaluation of Hearing Protectors. Noise Control Engineering Journal, Vol. 24, No. 1, 1985.

4. Behar, A., and Desormeaux, J.: Testing of Hearing Protectors at Ontario Hydro, Sound and Vibration, October 1986.

5. ISO/DIS 8353.2: Acoustics - Hearing Protectors - Part 2: Estimation of Effective A-weighted Sound Pressure Levels When Hearing Protectors Are Worn. International Standard Organization, 1991.

6. Behar, A.: Attenuation of Hearing Protectors and the NRR Factor. Am. Ind. Hyg. Assoc. (42) December 1981, 904-908.


**TABLE 2**

**Selection of Hearing Protectors**

| Maximum Equivalent Noise Level, dBA | Recommended Class of Hearing Protector |
|---|---|
| $L_{eq}$ less than 85 dBA | No protection required |
| $L_{eq}$ up to 89 dBA | Class C |
| $L_{eq}$ up to 95 dBA | Class B |
| $L_{eq}$ up to 105 dBA | Class A |
| $L_{eq}$ up to 110 dBA | Class A plug + Class A or Class B muff |
| $L_{eq}$ more than 110 dBA | Class A plug + Class A or Class B muff and limited exposure |