Method for Calculating and Using the Noise Reduction Rating -NRR

The NRR is a single-number rating which is required by law to be shown on the label of each hearing protector sold in the United States. The NRR is specified by 40 CFR (Code of Federal Regulations) Part 211, Product Noise Labeling, Subpart B - Hearing Protective Devices. It is independent of the noise spectrum in which it is applied. The following description of the method of measurement and calculation of the NRR is taken from Method 2 of the NIOSH Compendia (Kroes et al., 1975) and a similar table can be found in 44 FR (Federal Register) page 56142 (1979).

Calculating the NRR:
The values of sound attenuation used for calculation of the NRR are determined in accordance with ANSI S3.19-1974, "American National Standard for the Measurement of Real-Ear Hearing Protector Attenuation and Physical Attenuation of Earmuffs." The experimenter-fit method must be used; that is, the experimenter (not the test subject) must fit the hearing protector onto the head or into the ear of each test subject for each occluded test. Mean attenuations and standard deviations are calculated in accordance with the standard. The NRR is then computed from the mean attenuations and standard deviations according to the following equation:

$$\text{NRR} = 107.9\ \text{dBC} - 10 \log \sum_{f=125}^{8000} 10^{\,0.1(L_{Af} - APV_{f98})} - 3\ \text{dB}.$$

where L_{Af} is the A-weighted octave band level at frequency f of a pink noise spectrum with an overall level of 107.9 dBC, and APV_{f98} is the mean attenuation value minus 2 standard deviations at frequency f (2 standard deviations accounts for 98% of the variance in a normal distribution).

The equation can be broken down into the steps shown in the table on the following page. The NRR assumes a pink noise with octave-band levels of 100 dB (line 1). The corrections for the C-weighting scale (line 2) are then subtracted to compute unprotected C-weighted octave-band levels at the ear (line 3). These octave-band levels are logarithmically summed to obtain the overall sound level in dBC at the unprotected ear; this value is the first term of the equation (i.e., 107.9 dBC). The corrections for the A-weighting scale (line 4) are then subtracted from the pink-noise octave-band levels (line 1) to compute the A-weighted octave-band levels at the ear (line 5). The average attenuations (line 6) minus twice the standard deviations (line 7) are subtracted from the A-weighted octave-band levels to compute the protected A-weighted octave-band level at the ear. Note that the attenuation data for 3000 and 4000 Hz and for 6000 and 8000 Hz are averaged to derive the attenuations at 4000 Hz and 8000 Hz. Note also that the standard deviations for 3000 and 4000 Hz and 6000 and 8000 Hz are summed (in lieu of multiplying by 2) to calculate the total standard deviation for 4000 Hz and 8000 Hz. The protected A-weighted octave-band levels at the ear are then logarithmically summed to calculate the overall protected A level. This is the second term of the equation. The NRR is computed by subtracting 3 dB from the difference between the unprotected C-weighted and the protected A-weighted levels at the ear.

Using the NRR:
The Hearing Conservation Amendment to the Occupational Noise Standard (OSHA, 1983) describes six methods for using the NRR to determine a worker's protected A-weighted noise exposure. These methods vary according to the instrumentation and parameters used to determine the unprotected noise levels. However, they can be summarized into two basic formulas, depending on whether unprotected exposure levels were measured on a C-weighted or an A-weighted scale.

For C-weighted measurements:
protected dBA = unprotected dBC - NRR

where the protected dBA and the unprotected dBC are 8-hour time-weighted averages determined according to the Occupational Noise Standard. This method is how the NRR was designed to be used. For example, if a protector has an NRR of 17 dB and it is used in an environmental noise level of 95 dBC, the noise level entering the ear could be expected to be 78 dBA [95 - 17 = 78] or lower in 98% of the cases if the protector is worn according to manufacturers specification.

For A-weighted measurements:

Method for Calculating and Using the Noise Reduction Rating -NRR

protected dBA = unprotected dBA - [NRR - 7]

where, again, the protected and unprotected dBA are 8-hour time-weighted averages determined according to the Occupational Noise Standard. This method is an adaptation for those whose instrumentation does not have C-weighting capabilities. The 7 dB correction factor is used to account for the de-emphasis of low-frequency energy inherent to the A-weighting scale. So, for example, if a protector has an NRR of 17 dB and it is used in an environmental noise level of 95 dBA, the noise level entering the ear could be expected to be 85 dBA [95 - (17 - 7) = 85] or less in 98% of the cases.

NIOSH recommends derating the NRR by a multiplicative factor of 75%, 50% and 30% for earmuffs, slow-recovery formable earplugs and all other earplugs, respectively. This variable derating scheme considers the real-world performance of most different types of hearing protectors (NIOSH, 1998). Also, the NIOSH derating scheme does not affect the 7-decibel dBC-to-dBA correction as it is applied to the NRR only. This compendium uses the NIOSH derating of the NRR when searching for protectors based on user input of noise exposure levels in dBA, dBC, or octave band levels. Derating is not applied to custom or "make in place" earplugs; however, how well they work is entirely dependent upon the quality of the ear impression and so they may range from extremely effective (meeting labeled NRR) to completely ineffective (providing no protection at all).

Computation of the Noise Reduction Rating

	Octave Band Center Frequency (Hz)									
Frequency in Hz	125	250	500	1000	2000	3000	4000	6000	8000	**Log Sum**
1. Assumed pink noise (dB)	100	100	100	100	100		100		100	
2. C weighting corrections (dB)	-.2	0	0		-.2		-.8		-3	
3. Unprotected ear C-weighted level	99.8	100	100	100	99.8		99.2		97	**107.9**
4. A weighting corrections (dB)	-16.1	-8.6	-3.2	0	1.2		1.0		-1.1	
5. Unprotected ear A-weighted level	83.9	91.4	96.8	100	101.2		101		98.9	
6.Average attenuation in dB	21	22	23	29	41	43	47	41	36	
at each frequency	21	22	23	29	41		45.0*		38.5*	
7. Standard deviation in dB	3.7	3.3	3.8	4.7	3.3	3.3	3.4	6.1	6.5	
at each frequency	x2	x2	x2	x2	x2					
	7.4	6.6	7.6	9.4	6.6		6.7**		12.6**	
8. Compute APV_{98} in dB at each frequency (line 6 - line 7)	13.6	15.4	15.4	19.6	34.4		38.3		25.9	
9. Protected ear A-weighted level (average attenuation minus 2 standard deviations develops the ear A-weighted Levels (line 5 - line 8)	70.3	76.0	81.4	80.4	66.8		62.7		73.0	**85.1**
10. NRR is unprotected ear "C" level (line 3) minus protected ear "A" level (line 9) minus 3 dB									**19.8**	

* average attenuation at 3000 and 4000 Hz and at 6000 and 8000 Hz.
** summed standard deviation for 3000 and 4000 Hz and for 6000 and 8000 Hz.

Method for Calculating and Using the Subject-Fit Noise Reduction Rating - NRR(SF)

The Subject-Fit Noise Reduction Rating, NRR(SF), is a single number rating method which describes real-ear attenuation at threshold (REAT) measurements obtained according to ANSI S12.6-1997, *Methods for Measureing the Real-Ear Attenuation of Hearing Protectors*, method B. The NRR(SF) was developed by the National Hearing Conservation Association's *Task Force on Hearing Protector Effectiveness* to address labeling related issues (Royster, 1995). The NRR(SF) method is derived from the Noise Reduction Rating (NRR) presented in *Calculating NRR* and the Single-Number Rating (SNR) method presented in *Calculating SNR* for a protection performance of 84% (EPA, 1979; ISO, 1992). In principle, the rating methods examine the amount of noise reduction achieved by a hearing protector, but minor differences separate the methods. Like the NRR, the NRR(SF) uses a pink noise at a level of 100 dB SPL in the octave bands. Like the SNR, the NRR(SF) includes the octave-band frequencies between 63 and 8000 Hz in its calculation whereas the NRR includes only frequencies between 125 and 8000 Hz and includes the half-octave frequencies 3150 and 6300 Hz.

Calculating the NRR(SF):
The NRR(SF) is calculated with the following equation:

$$NRR = 108.5\ dBC - 10 \log \sum_{f=63}^{8000} 10^{\,0.1(L_{Af}-APV_{f84})} - 5\ dB.$$

where L_{Af} is the A-weighted octave band level at frequency *f* of a pink noise spectrum with an overall level of 108.5 dBC, and APV_{f84} is the mean attenuation value minus 1 standard deviation at frequency *f* (1 standard deviation accounts for 84% of the variance in a normal distribution).

The C-weighted noise levels are determined by subtracting the C-weighted corrections from 100 dB for each of the octave band frequencies (line1). The sum of the C-weighted noise levels is 108.5 dBC. Similarly, the L_{Af} (line 3) are determined by correcting the 100 dB octave band noise levels with the A-weight corrections at each frequency (line 4). The APV_{f84} are determined by subtracting one standard deviation (line 7) from the mean REAT attenuation measured for the noise band centered at frequency, *f* (line 6). The half-octave data at 3150 and 6300 Hz are not used in the calculation of the NRR(SF). The 5 dB which is subtracted at the end of the calculation is representative of the approximate difference between C-weighted and A-weighted industrial noise (Miller, 1995). By compensating for the difference in the calculation, the NRR(SF) may be subtracted directly from A-weighted noise to estimate the noise level under the protector. When data for 63 Hz are lacking, one should use the 125 Hz data in its place; i.e., use the 125-Hz data twice with the appropriate A and C weightings.

Using the NRR(SF):
The NRR(SF) is intended to be used with A-weighted noise exposures. Hence, the NRR(SF) is subtracted directly from the A-weighted noise exposure to provide the protected exposure:

protected dBA = unprotected dBA - NRR(SF).

If the C-weighted noise exposure is used, a 5-dB adjustment is made to account for predicted differences in the A and C levels (which effectively undoes the 5-dB correction in line 12 of the following table):

protected dBA = unprotected dBC -5 dB - NRR(SF).

If the octave-band noise exposures are used, the best approach is to apply the A-weighting corrections and log sum the levels to provide the A-weighted noise exposure level for use with the NRR(SF).

Availability of the NRR(SF):
The adoption of ANSI S12.6-1997 as the standard that replaced ANSI S3.19-1974 did not change the regulatory requirements that all protectors sold in the United States be labeled with the NRR as described in Appendix A1 and obtained by testing according to the experimenter-fit method of ANSI S3.19-1974. After ANSI S12.6-1997 was adopted, many hearing protector manufacturers began testing their products in accordance with Method B, the subject-fit method. However, no manufacturer has released the data and, in spite of being invited to, none provided Method B data for this compendium.

Method for Calculating and Using the Subject-Fit Noise Reduction Rating - NRR(SF)

If and when the U.S. Environmental Protection Agency is successful in promulgating a revised Hearing Protector Labeling regulation that requires the use of the NRR(SF)or some other subject-fit based rating in lieu of the present NRR, then manufacturers will start providing data that they already have.

In the absence of Method B data, NIOSH recommends derating the NRR using NIOSH derating schemes as described in the NIOSH revised noise criteria document (Criteria For a Recommended Standard: Occupational Noise Exposure *Revised Criteria 1998.* DHHS(NIOSH) Pub. No. 98-126). The derating schemes which are specific to hearing protector type and based on real-world data are explained in *Calculating NRR*.

NIOSH suggests that consumers contact manufacturers to request the NRR(SF) for any protectors they are considering purchasing or recommending.

The NRR(SF) Calculation

Frequency in Hz	63	125	250	500	1000	2000	4000	8000	**Log Sum**
1. Assumed Pink Noise (dB)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
2. C-weighting correction (dB)	-0.8	-0.2	0.0	0.0	0.0	-0.2	-0.8	-3.0	
3. Unprotected ear C-weighted level (dB) line1 -line 2	99.2	99.8	100.0	100.0	100.0	99.8	99.2	97.0	**108.5**
4. A-weighting correction (dB) . . .	-26.2	-16.1	-8.6	-3.2	0	1.2	1.0	-1.1	
5. Unprotected ear A-weighted . . . level (dB) line 1 - line 4	73.8	83.9	91.4	96.8	100.0	101.2	101.0	98.9	
6. Average REAT attenuation at each frequency (dB)	19.7*	19.7	19.7	20.7	21.2	28.3	36.6	37.8	
7. REAT standard deviation at each frequency (dB)	8.7	8.7	9.7	9.4	8.4	7.4	9.1	10.4	
8. Assumed Protection Value for 84% performance (dB) line 6 - line 7	11.0	11.0	10.0	11.3	12.8	20.9	27.5	27.4	
9. Protected ear A-weighted level (dB) line 5 - line 8	62.8	72.9	81.4	85.5	87.2	80.3	73.5	71.5	**90.7**
10. Log sum of line 3 (dB)	108.5								
11. Log sum of line 9 (dB)	90.7								
12. NRR(SF) (dB) . . line 10 - line 11 - 5 dB	12.8								

***** the data for 125 are used at 63 Hz without alteration because 63 Hz is optional.

Method for Calculating and Using the Single Number Rating -SNR

The SNR is a single-number rating which is calculated in accordance with ISO 4869 2.2 (1992), "Estimation of Effective A-weighted Sound Pressure Levels When Hearing Protectors Are Worn." It is very much like the NRR in terms of its calculation method with a couple of notable exceptions. First, the SNR can be calculated for various levels of protection performance - that is, percentage of the population which can be considered to receive no less than the calculated attenuation - while the NRR is fixed at 98%. Second, there is not an additional 3 dB subtraction as in the NRR. Various protection performances levels (%) are shown in Table 1 along with the appropriate multiplier (α) which is applied to the standard deviation.

When a protection performance level is selected, the SNR is so designated by a subscript. Thus for a protection performance of 80%, the designation would be SNR_{80}. For the SNR to be similar to the NRR, its designation would be SNR_{98} - 3 dB. When the protection performance is yet to be selected, the designation is SNR*x*.

The ISO 4869 2.2 test procedure calls for the use of 16 subjects who fit the protectors under the supervision of the experimenter. Each subject provides one unoccluded and one occluded threshold.

Table 1.
Value of α for various protection performances, *x*

Protection Performance *x* in %	Value of α
75	0.67
80	0.84
84	1.00
85	1.04
90	1.28
95	1.64

Calculating the SNR:
The calculation of the SNR*x* is based on an assumed background of pink noise with an overall level of 100 dBC and Assumed Protection Values, APV*x*, of the hearing protector (see *Calculating APV*). The SNR*x* is independent of the actual noise spectrum to which it is applied and is calculated using the equation:

$$SNRx = 100 \text{ dBC} - 10 \log \sum_{f=63}^{8000} 10^{0.1(L_{Af} - APV_{f}x)}$$

where: L_{Af} is the A-weighted octave-band level at frequency *f* as shown in Table A.3.2, and $APV_{f}x$ is the Assumed Protection Value for each frequency. If data are not available for 63 Hz, the summation begins at 125 Hz.

Note 1: The term $10 \log \sum_{f=63}^{8000} 10^{0.1(L_{Af} - APV_{f}x)}$ equals $L_{A}x$

Note 2: 100 dB represents the total C-weighted sound pressure level of the reference pink noise in Table 2.

The values of L_{Af} are derived in Table 2. They are simply the octave band levels of a 100 dB pink noise corrected to reflect the A-weighting scale.

Method for Calculating and Using the Single Number Rating -SNR

Using the SNR:

The SNRx is used to estimate the noise level under the hearing protector for a specific protection performance level (L'_Ax) given a specific C-weighted noise level (L_C). The effective A-weighted sound pressure level, L'_Ax, under a hearing protector is calculated by subtracting the SNRx from the C-weighted sound pressure level of a specific noise. For example, if L_C = 103 dB, and the SNR_{84} = 21.6 dB, L_{A84} is calculated using the equation:

$$L'_Ax = L_C - SNRx,$$

so that

$$L'_{A84} = 103 \text{ dB} - 21.6 \text{ dB} = 81.4 \text{ dB}.$$

It can be stated that the effective A-weighted sound pressure level, L'_{A84}, will be less than or equal to 81.4 dB in 84% of the situations when the hearing protector is properly worn by various users in this noise environment.

Table 2.
A-weighted octave-band sound pressures levels, L_{Af}, of a pink noise which has a C-weighted sound pressure level of 100 dB

Octave-band center freq. f in Hz	63	125	250	500	1000	2000	4000	8000	Log Sum
Assumed pink noise band level	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	**100.0 dBC**
Total pink noise								100	
A-weighting correction factors	-26.2	-16.1	-8.6	-3.2	0	+1.2	+1.0	-1.1	
L_{Af}	65.3	75.4	82.9	88.3	91.5	92.7	92.5	90.4	
L_A (total A-weighted sound level)									**98.5 dBA**

An example SNR calculation is shown in Table 3. The APV values used are taken as derived in *Calculating APV* for 1 standard deviation - a protection performance level of 84%.

Table 3.
Calculation difference between APV_{f84} and L_{Af}. All values are in decibels.

Octave-band center freq. f in Hz	63	125	250	500	1000	2000	4000	8000	Log Sum
L_{Af}, from Table A.3.2	65.3	75.4	82.9	88.3	91.5	92.7	92.5	90.4	
Example APV_{f84}	4.1	6.4	10.8	15.0	18.8	22.4	33.4	28.9	
$L_{Af} - APV_{84}$	61.2	69.0	72.1	73.3	72.7	70.3	61.1	61.5	**78.4 dBA**

$$SNRx = 100 \text{ dBC} - 78.4 = 21.6 \text{ dB}$$

Method for Calculating and Using the High, Middle, Low (HML) Rating

The HML is a rating which is calculated in accordance with ISO 4869 2.3 (1992), "Estimation of Effective A-weighted Sound Pressure Levels When Hearing Protectors Are Worn." Using the H, M, and L ratings requires both C-weighted (L_C) and A-weighted (L_A) sound pressure levels of the noise. The H and M values are used in the calculation of the protected exposure level for noises which have primary energy in the middle and high frequencies and for which the L_C and L_A levels differ by 2 dB or less. The M and L values are used in the calculation of the protected exposure level for noises which have appreciable low-frequency components and for which the L_C and L_A levels differ by more than 2 dB.

Calculating the HML:
The calculation of the H, M, and L values is based on eight reference noise spectra with different (L_C - L_A) values as shown in Table 1 and the Assumed Protection Values (APV_{fx} - see *Calculating APV*) of the hearing protector. The eight reference noise spectra were derived from the NIOSH 100 noises (Johnson and Nixon, 1974). The index, i, is used to refer to a particular noise spectrum. The constant, d_i is an empirically-determined value. The HML values are independent of the actual noise situation to which they are applied.

The HML values are calculated using the following equations:

$$Hx = 0.25 \sum_{i=1}^{4} PNRx_i - 0.48 \sum_{i=1}^{4} (d_i * PNRx_i)$$

$$Mx = 0.25 \sum_{i=5}^{8} PNRx_i - 0.16 \sum_{i=5}^{8} (d_i * PNRx_i)$$

$$Lx = 0.25 \sum_{i=5}^{8} PNRx_i + 0.23 \sum_{i=5}^{8} (d_i * PNRx_i)$$

where:

$$PNRx_i = 100 \text{ dBA} - 10 \log \sum_{f=63}^{8000} 10^{0.1(L_{Afi} - APV_{fx})}$$

Note 1. $PNRx_i$ refers to the predicted noise reduction for a protection performance level *x* and a reference noise spectrum i. L_{Afi} and d_i are given in Table 1. If data are not available for 63 Hz, then summation begins at 125 Hz. The value 100 dB represents the total A-weighted sound pressure level of each of the noises in Table 1. The resulting H*x*, M*x*, and L*x* values are to be rounded to the nearest integer.

Note 2. To calculate the H, M, and L values for a particular protector, it is necessary to obtain the Assumed Protection Value for the desired protector performance for each frequency (see *Calculating APV*). For example, if the sample protector from *Calculating APV* were used, the APV_{f84} would be as in Table 2.

Note 3. After the APV_{fx} are obtained, the A-weighted octave-band noise levels under the protector are calculated for each of the reference noises (L_{Afi} - APV_{f84}). For the protector in this example, these levels would be as shown in Table 3.

The eight $PNR_{i,84}$ values are then calculated by substituting the differences from Table 3 into its equation as shown in Table 4.

The H_{84}, M_{84}, and L_{84} values are calculated for the example using the appropriate equations, the $PNR_{i,84}$ values from Table 4, and the constants d_i from Table 1. The calculations are shown in Table 5 for *Calculating APV* and the values are rounded to the nearest integer.

Method for Calculating and Using the High, Middle, Low (HML) Rating

Table 1.
A-weighted octave-band sound pressure levels, L_{Afi}, of eight reference noises normalized to an A-weighted sound pressure level of 100 dB, L_C - L_A values and constants d_i. All values are in decibels.

Index i	63	125	250	500	1000	2000	4000	8000	Difference (L_C-L_A)	Constant d_i
	Octave-band Center Frequency (*f*)									
1	51.4	62.6	70.8	81.0	90.4	96.2	94.7	92.3	-1.2	-1.20
2	59.5	68.9	78.3	84.3	92.8	96.3	94.0	90.0	-0.5	-0.49
3	59.8	71.1	80.8	88.0	95.0	94.4	94.1	89.0	0.1	0.14
4	65.4	77.2	84.5	89.8	95.5	94.3	92.5	88.8	1.6	1.56
5	65.3	77.4	86.5	92.5	96.4	93.0	90.4	83.7	2.3	-2.98
6	70.7	82.0	89.3	93.3	95.6	93.0	90.1	83.0	4.3	-1.01
7	75.6	84.2	90.1	93.6	96.2	91.3	87.9	81.9	6.1	0.85
8	77.6	88.0	93.4	93.8	94.2	91.4	87.9	79.9	8.4	3.14

Table 2.
Example APV_{f84} for the hearing protector in Calculating APV.

Octave-band center freq. (*f*) in Hz	63	125	250	500	1000	2000	4000	8000
Example APV_{f84}	4.1	6.4	10.8	15.0	18.8	22.4	21.4	28.9

Table 3.
Calculated difference spectrum for L_{Afi} - APV_{f84}

Octave-band center freq. *f* in Hz	63	125	250	500	1000	2000	4000	8000
L_{Af1} - APV_{f84}	47.3	56.2	60.0	66.0	71.6	73.8	73.3	63.4
L_{Af2} - APV_{f84}	55.4	62.5	67.5	69.3	74.0	73.9	72.6	61.1
L_{Af3} - APV_{f84}	57.7	64.7	70.0	73.0	76.2	72.0	72.7	60.1
L_{Af4} - APV_{f84}	61.3	70.8	73.7	74.8	76.7	71.9	71.1	59.9
L_{Af5} - APV_{f84}	61.2	71.0	75.7	77.5	77.6	70.6	69.0	54.8
L_{Af6} - APV_{f84}	66.6	75.6	78.5	78.3	76.8	70.6	68.7	54.1
L_{Af7} - APV_{f84}	71.5	77.8	79.3	78.6	77.4	68.9	66.5	53.0
L_{Af8} - APV_{f84}	73.5	81.6	82.6	78.8	75.4	69.0	66.5	51.0

Table 4.
$PNR_{i,84}$ values for the sample hearing protector.

$PNR_{1,84}$ = 100 dBA - 10 log $(10^{0.1*47.3} + \ldots + 10^{0.1*63.4})$ = 21.7 dB
$PNR_{2,84}$ = 100 dBA - 10 log $(10^{0.1*55.4} + \ldots + 10^{0.1*61.1})$ = 20.7 dB
$PNR_{3,84}$ = 100 dBA - 10 log $(10^{0.1*57.7} + \ldots + 10^{0.1*60.1})$ = 19.6 dB
$PNR_{4,84}$ = 100 dBA - 10 log $(10^{0.1*61.3} + \ldots + 10^{0.1*59.9})$ = 18.4 dB
$PNR_{5,84}$ = 100 dBA - 10 log $(10^{0.1*61.2} + \ldots + 10^{0.1*54.8})$ = 17.3 dB
$PNR_{6,84}$ = 100 dBA - 10 log $(10^{0.1*66.6} + \ldots + 10^{0.1*54.1})$ = 16.1 dB
$PNR_{7,84}$ = 100 dBA - 10 log $(10^{0.1*71.5} + \ldots + 10^{0.1*53.0})$ = 15.2 dB
$PNR_{8,84}$ = 100 dBA - 10 log $(10^{0.1*73.5} + \ldots + 10^{0.1*51.0})$ = 13.3 dB

Table 5.
Calculated H_{84}, M_{84}, and L_{84} values

H_{84} = 0.25*(17.7 +...+14.4) - 0.48*(-1.20*17.7 +...+ 1.56*14.4) = 20.1 dB.

M_{84} = 0.25*(13.2 +...+9.4) - 0.16*(-2.98*13.2 +...+ 3.14*9.4) =15.5 dB.

L_{84} = 0.25*(13.2 +...+9.4) + 0.23*(-2.98*13.2 +...+ 3.14*9.4) = 15.5 dB.

Using the HML:
The values H_{84}, M_{84}, and L_{84} may be used to estimate L'_{84} (total A-weighted noise level at the ear) for a particular protector in a specific noise situation. Using the calculated values from Table 5, an example is shown below.

1. **Calculate L_C - L_A.** The difference (L_C - L_A) is calculated.

2. **Calculate PNR_x.** If this difference is ≤ 2 dB, the predicted noise reduction level, PER, is calculated using the equation:

$$PNRx = Mx - \left(\frac{Hx - Mx}{4} * (L_C - L_A - 2\text{ dB})\right).$$

If this difference is ≥ 2 dB, the PER is calculated using the equation:

$$PNRx = Mx - \left(\frac{Mx - Lx}{8} * (L_C - L_A - 2\text{ dB})\right),$$

For example, if (L_C - L_A) = -1, then PER = 15.5 - ((20.1-15.5)/4 ∗ (-1-2)) = 17.3, using the HML values from Table A.4.5.

3. **Subtract PNR_X from the A-weighted noise level.** The PNR*x* is then subtracted from the total A-weighted noise level to give the effective A-weighted level at the ear under the protector (L_{Ax}):

$$L_{Ax} = L_A - PNRx.$$

For example if L_A = 104 dB, then, L_{A84} = 104 dB - 17.3 dB = 86.7 dB.

Method for Calculating and Using the Assumed Protection Values (APV_{fx})

Assumed Protective Values (APV_{fx}) are a measure of hearing protector attenuation by frequency (f). The APV_{fx} is used in calculating other hearing-protector related values, such as the Single-Number Rating (SNR; see *Calculating SNR*) and the High Medium Low rating (HML; see *Calculating HML*). It may also be used alone as a direct estimate of noise reduction at a particular frequency band when the octave-band levels of the noise are known.

Calculating the APV_{fx}:
The APV_{fx} is computed by subtracting a multiple of the standard deviation of the attenuations from the mean attenuation for each frequency band. The standard deviation multiplier (α) is chosen based on the desired protection performance level (x). Table 1 gives the values for various protection performance levels. Once a protection performance level is selected, the APV is so designated by the subscripted x. For example, $APV_{500(84\%)}$ designates the APV at the 500 Hz octave band for a protector performance level of 84%.

Table 2 illustrates the calculation of the APV_{fx} for a protector performance level of 84%.

Using the APV_{fx}:
The APV_{fx} may be used as a direct estimate of the noise exposure level at a particular frequency band when the octave-band noise levels are known. The APV is applied by subtracting it from the corresponding octave-band noise level of the noise from which protection is being sought. For example, if the octave-band level for a noise is 92 dB SPL at 500 Hz and the $APV_{500(84\%)}$ is13 dB, then the protected level would be equal to the difference value of 79 dB SPL. The differences may also be log summed across frequency to provide a prediction of overall effective noise exposure level under the hearing protector.

In the example in Table 2, the APV_{f84} values for a hearing protector are calculated; that is, the protection performance, α, of 84% (1 standard deviation) is selected. These APV_{f84} values then can be used alone (as described above) or utilized in calculations for the SNR (see *Calculating SNR*) and HML (see *Calculating HML*).

Table 1.
Values of α for various protection performances, x

Protection performance x in %	Value of α
75	0.67
80	0.84
84	1.00
85	1.04
90	1.28
95	1.64
98	2.00

Table 2.
Calculations of APV_{f84}. All values are in decibels.

	Octave-band center							
freq. (f) in Hz	63	125	250	500	1000	2000	4000	8000
Mean attenuation in dB, m_f	7.4	10.0	14.4	19.6	22.8	28.6	38.8	34.1
Standard deviation in dB, s_f	3.3	3.6	3.6	4.6	4.0	6.2	7.4	5.2
$\alpha * s_f$, $\alpha = 1.00$	3.3	3.6	3.6	4.6	4.0	6.2	7.4	5.2
$APV_{f84} = m_f - \alpha s_f$, in dB	4.1	6.4	10.8	15.0	18.8	22.4	31.4	28.9

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