Sound Source™

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How NRR Is Calculated

When I compare the values in the attenuation charts with the NRR on the package, the NRR is much lower than the average attenuation. How is the NRR calculated?

It is quite an ambitious calculation to measure a hearing protector's attenuation at a variety of frequencies on a few test subjects in the laboratory, input these values into a formula and derive a single-number rating that can be applied universally to all users in all noise settings. If you have studied the attenuation charts on boxes of hearing protectors, you can see the Noise Reduction Rating (NRR) is not simply a mathematical average of the attenuation values. In 1979, the U.S. Environmental Protection Agency[1] standardized the NRR formula that we still use today to rate hearing protectors. Here are the significant steps used in calculating the NRR, and an explanation of why each step is important:

Table 1. **Howard Leight® Max® Single-Use Earplug Attenuation | NRR 33 dB** *Testing according to ANSI S3.19-1974, R1979*

Frequency in Hz	125	250	500	1000	2000	3150	4000	6300	8000
Mean Attenuation dB	40.9	43.0	44.8	38.9	37.2	47.4	48.5	47.7	47.8
Standard Deviation dB	3.5	3.9	3.8	2.8	2.7	4.5	3.1	4.4	3.9

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Laboratory Testing: At least ten subjects are tested with properly-fitted hearing protectors (called "occluded ear") and tested again without hearing protectors (called "open ear"), across a range of test frequencies. The difference between the open ear and occluded hearing tests gives us the attenuation of the hearing protector. Each subject is tested three times, meaning there are at least thirty attenuation measurements at each frequency. The variability in these measurements (the "Standard Deviation") is calculated and the thirty attenuation values are then averaged to give us the "Mean Attenuation in dB" at each frequency. These Mean Attenuation values, as well as the Standard Deviations, appear in the attenuation chart on each box or bulk package of hearing protectors distributed in the U.S.

Standard Deviation: To account for individual variation in fitting hearing protectors out in the real world (remember, the laboratory only tested a minimum of ten subjects), a correction factor of two standard deviations is subtracted from each attenuation value. By subtracting two standard deviations, we can generalize the results from a small sample of ten subjects to a larger population: for a population which is properly fitted with the HPD in the same manner as the laboratory subjects, 98% of the population would be expected to achieve these same attenuation values in the lab.

Subtraction from Hypothetical Noise: To account for some differences between the laboratory test sounds and real-world noise, the adjusted attenuation values (mean minus two standard deviations) are subtracted from "hypothetical noise levels" – some standardized noise levels at each frequency band. This step is critical so that we might apply the final NRR to a hearing protector user, and not a laboratory microphone which detects sound differently than a human ear.

Logarithmic Addition: In this step, we combine all the adjusted attenuated levels into a single number. Attenuation values are measured in decibels, which are logarithmic numbers. (From math class, you may recall logarithms are related to the exponent of a number, or the power to which a number is raised.) Logarithms cannot just be added mathematically (80 dB plus 80 dB does not equal 160 dB). They are added in a special way that accounts for the exponents.

Correction Factor: Finally, a 3 dB correction is built into the NRR calculation to account for the fact that not all noise spectra are the same. The assumed noise spectrum used in the NRR calculation may be quite different than the actual spectrum in the workplace, so this 3 dB correction is a cushion for "spectral uncertainty." (Note: There is an additional 7 dB correction factor used in applying the NRR to A-weighted noise measurements, also for "spectral uncertainty." See Sound Source #4 "A- and C-Weighted Measurements.")

The result of this lengthy calculation is the NRR. The NRR is significantly lower than the average attenuation across all frequencies because the NRR contains corrections and cushions to make it applicable to a broader population. While it is not a perfect real-world measure of attenuation, the NRR is the most standardized method currently in use for describing a hearing protector's attenuation in a single number. The NRR estimates the amount of protection achievable by 98% of users in a laboratory setting when hearing protectors are properly fitted.

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Footnote:

[1] The EPA labeling standard is defined in Code of Federal Regulations (CFR) 40, Part 211, Subpart B – Hearing Protective Devices.