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Rating the Performance of Active Noise Cancellation Devices

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Hazardous noise exposure can be a threat to the human auditory system; one that some workers contend with every day of their working career. The noise exposures vary in level, duration, and spectra. When engineering and administrative controls do not adequately protect workers, hearing protection devices (HPDs) must be used to reduce noise exposures. HPDs come in all shapes and sizes and can be worn in the ear (earplugs and canal caps), around the ear (earmuffs and headsets), or in combination. HPDs are provided to reduce the level of hazardous noise; this reduction can be achieved with passive HPDs or with HPDs that have built-in active noise cancellation (ANC), sometimes called active noise reduction technology. Devices with ANC technology are designed to increase the level of protection by actively reducing the level of low-frequency noise (typically at 500 Hz and below). ANC technology works by detecting noise under the HPD and generating an equal, but opposite phase signal to actively cancel the level of noise at the ear.

This technology is beneficial in enhancing attenuation in the low-frequency range where passive HPD capabilities are sometimes limited. ANC can improve attenuation for workers in environments with high levels of low-frequency noise, such as rotary wing aircraft, propeller aircraft, power generation, wood finishing, and newspaper press facilities (Karplus & Bonvallet, 1958).

When HPDs are being selected for workers who need them, certain factors should be considered: the type of noise that the workers are exposed to, appropriateness for that particular noise environment, cost, logistics, comfort, and maintenance. Performance ratings can indicate which HPD is appropriate for a specific noise environment. Currently, the Noise Reduction Rating (NRR) is the only rating required by law in the United States (US) (EPA, 1979). NRR only describes the passive performance HPDs, which in the case of ANC devices, means when the electronics are turned off. This single number rating does not provide frequency specific information to the user and it was designed to be applied directly to C-weighted noise level measurements. The US scientific community has developed new performance ratings, described in detail in ANSI S12.68, that provide more accurate ratings for a variety of HPDs, including those with ANC technology.

For a study of ANC performance in HPDs, four ANC headsets were selected for this study: Bose® A20®, Telex Stratus HeliXT, Pilot DNCXL PA1779T, and Sennheiser HMEC250. These circumaural headsets were commercially available and were commercially purchased at similar price points. Noise attenuation performance measurements were collected at Wright-Patterson Air Force Base in Dayton, Ohio. Ten persons (five males and five females) volunteered for this study. They ranged in age from 18 to 24 years old. All subjects had hearing threshold levels of 15 dB or better from 125 to 8000 Hz.

Passive noise attenuation measurements were conducted in accordance with ANSI S12.6-2008, Method A. These psychoacoustic, real-ear-attenuation at threshold (REAT) measurement involved two separate fittings of the headset for each subject. Mean REAT data were calculated for each subject. Active insertion-loss measurements using microphone-in-real-ear (MIRE) were conducted in accordance with ANSI S12.42-2010. These objective measurements involved three separate fittings of the headset for each subject. One-third octave-band noise level data from 100 to 10,000 Hz were collected with the ANC headset powered both on and off. Median active insertion-loss data, across the frequency bands, were calculated for each subject. Total attenuation data were calculated per subject by combining the mean REAT for each octave band with the median MIRE data from the third octave bands adjacent to and centered on the REAT frequencies as described in ANSI S12.42. The total noise attenuation data (from here on out called “active” data) and passive attenuation data were then analyzed by the methods described in ANSI S12.68-2007 (2012). The octave-band method of computing a protection rating is potentially the most accurate approach for estimating a user’s noise exposure. This method requires measured octave-band noise spectra data from the actual noise environment. The attenuation data are then directly applied, per octave band, to the measured noise levels.

Two new methods described in ANSI S12.68 are the Noise Level Reduction Statistic for use with A-Weighting (NRS_A) and Noise Level Reduction Statistic, Graphical (NRS_G). The NRS_A rating can be simply subtracted from the measured A-weighted noise level to estimate the level of sound at the ear under the hearing protector. Proposed as a replacement to the well-known NRR, the NRS_A rating offers several advantages in comparison (EPA, 2009). The NRR was developed to be subtracted from C-weighted noise levels. If the NRR is subtracted from A-weighted noise levels, a 7-dB spectral adjustment must be applied. Using NRS_A values eliminates the need for the 7-dB adjustment factor. Another advantage of the NRS_A rating is that it shows a range of protection indicating the level of protection that can be achieved for an entire population. This range reflects the variation across the subjects in the test panel, providing insight into how hard/easy the device may be to fit). The majority (90%) of users will achieve the performance specified by the lower protection value in the range, only the most motivated proficient users (10%) are

able to achieve the higher value. A narrow range of NRS_A values for HPDs indicates lower variability in performance. The use of NRS_A is not recommended when the noise level exceeds 100 dBA or when the noise environment has high levels of low-frequency noise content (spectral balance greater than 5 dB).

The NRS_G rating requires measurement of both the C- and A-weighted noise levels, and this additional information about the noise spectrum is used to more precisely estimate the range of protection provided. To approximate the response of the human auditory system, A-weighted noise measurements give less weight to low frequencies relative to mid-high frequencies. C-weighted noise measurements do not differentially weight low frequencies, therefore, the difference between C- and A-weighted noise levels describe the low frequency content of the noise. For example, if the C-weighted noise was measured at 100 dB and the A-weighted noise was measured at 94 dB then the difference between the two weighted levels would be 6 dB. The NRS_G ratings also report a range of protection for the using population similar to NRS_A ratings.

The study results are shown in Figures 1 to 4. Each figure includes a picture of the headset as well as the NRS_A and NRS_G ratings. The x-axis is the difference between the C- and A-weighted noise levels, essentially a measure of spectral balance between high and low frequency content. The greater the value on the x-axis, the greater the low-frequency content in the noise spectrum. The y-axis is the level of protection provided by the ANC headset in dB. The ratings for passive attenuation data are displayed in red for NRS_G and as a dashed red line for NRS_A . The ratings for active attenuation data are displayed in blue for NRS_G and as a solid blue line for NRS_A .

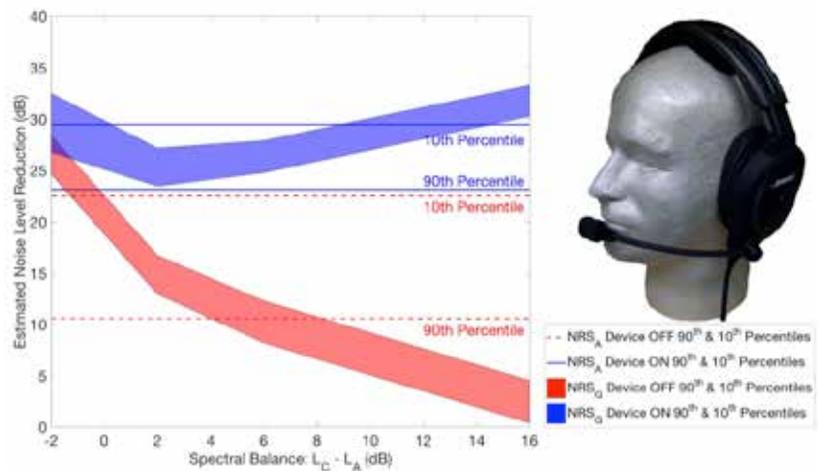


Figure 1. Bose® A20® headset active and passive noise reduction estimates as a function of spectral balance, in terms of NRS_A and NRS_G for the 90th (lower values) and 10th (upper values) percentiles.

Regardless of the noise environment, the noise reduction remained fairly consistent for the Bose® A20® with ANC powered on. When the headset was powered off, the passive noise reduction decreased as the amount of low frequency content in the noise environment increased. The NRS_G ratings show the large differences in protection provided by the Bose® A20® when the ANC headset was powered on and off. The NRS_A and NRS_G ratings also show the clear benefit of the ANC technology when powered on. The range of performance, for a community of users, was fairly small (approximately 5 dB or less) when comparing the 90% and 10% NRS_G values (Figure 1).

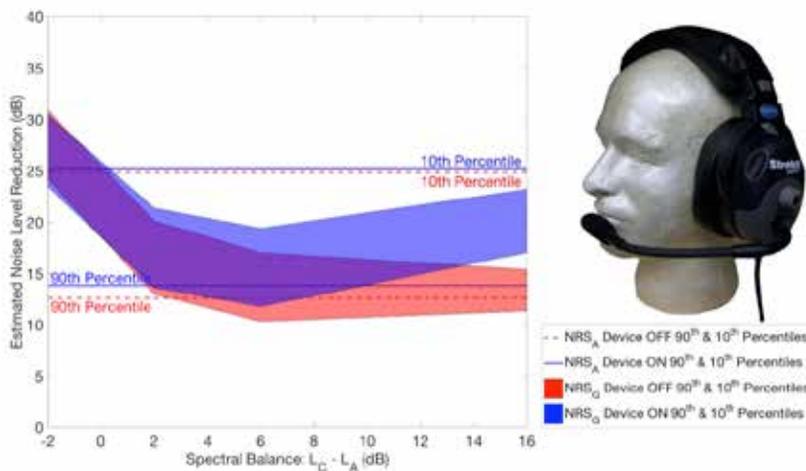


Figure 2. Telex Stratus HeliXT headset active and passive noise reduction estimates as a function of spectral balance, in terms of NRS_A and NRS_G for the 90th (lower values) and 10th (upper values) percentiles.

The performance measurements and ratings for the Telex Stratus HeliXT headset reveal a different result when compared to those of the Bose® A20®. The NRS_G ratings show the difference in protection provided when the ANC headset was powered on and off are nonexistent for spectral balance values below 5 dB, and even when the spectral balance exceeded 10 the ANC advantages are small. Therefore, the benefit from ANC is minimal. When ANC was powered off, passive attenuation only (shown in red), the NRS_G ratings remained relatively constant for noises where the spectral balance exceeded 2 (Figure 2). The NRS_A ratings show almost no benefit to having ANC technology built into the Telex Stratus HeliXT headset. Regardless of whether the device was powered on or off, the level of protection was similar.

The Pilot PA1779T headset provided moderate levels of attenuation on the basis of both NRS_A and NRS_G ratings (Figure 3). The range of performance was wide, however, in comparison to the other headsets, with a difference upwards of 10 dB between the 90% and 10% NRS_G values. The wider range suggests that the protection performance of the headset possibly differs due to variability in user fit.

The Sennheiser HMEC250 headset had the lowest NRS_A ratings of the four headsets for both the passive and active conditions. The NRS_G passive attenuation decreased considerably as the amount of low frequency content increased. When ANC was powered on, the level of protection remained consistent at approximately 10 dB when the C- and A-weighted differences were 2 dB and above for the NRS_G ratings. There was overlap in performance when the spectral balance was between -2 and 2, a finding similar to many other ANC headsets. The NRS_A ratings show no benefit to having ANC technology built into the Sennheiser HMEC250 headset.

The ratings offer users (or persons in charge of selecting HPDs for a community of users) greater information with which to make a purchasing decision. This information is important in selecting an HPD that adequately protects those exposed to hazardous noise without overprotecting the persons who will be using the device. Attenuation data can also

be used in a cost-benefit analysis when exposures are known. For example, consider workers who are exposed to a noise environment similar to the NIOSH #45 noise source from Table A.1 of ANSI S12.68. This particular noise environment

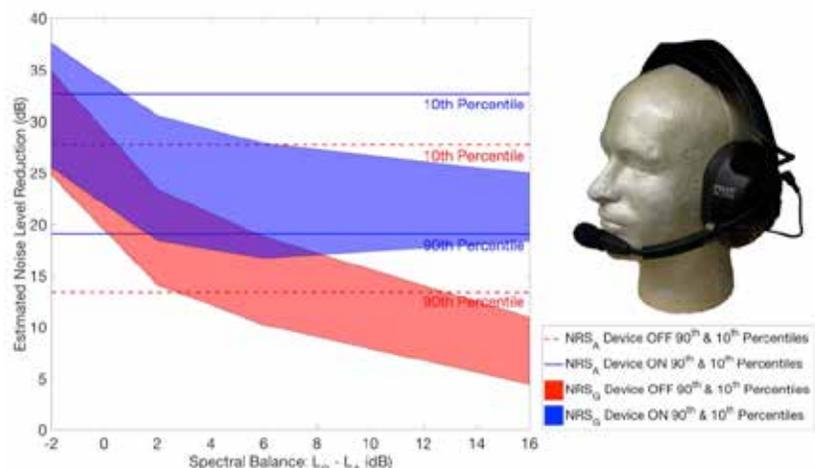


Figure 3. Pilot PA1779T headset active and passive noise reduction estimates as a function of spectral balance, in terms of NRS_A and NRS_G for the 90th (lower values) and 10th (upper values) percentiles.

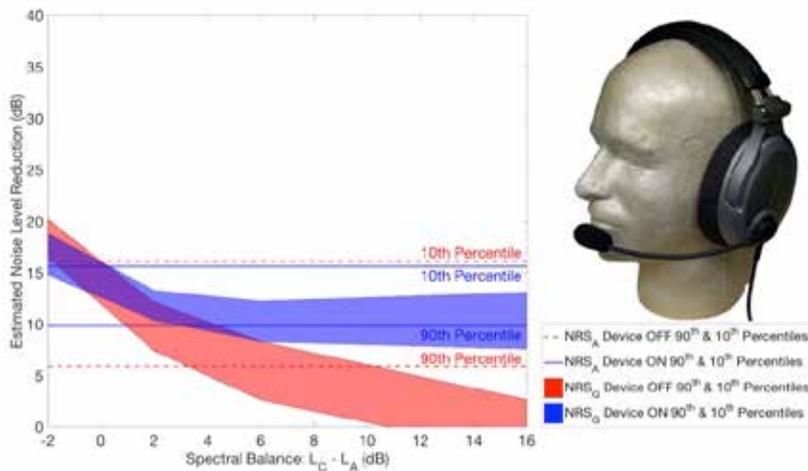


Figure 4. Sennheiser HMEC250 headset active and passive noise reduction estimates as a function of spectral balance, in terms of NRS_A and NRS_G for the 90th (lower values) and 10th (upper values) percentiles.

has an A-weighted noise level of 95 dB and spectral balance of 6 dB (Table 1). According to the NRS_G data for the Pilot PA1779T headset, the range of estimated noise levels under the hearing protection device will be 67–78 dBA with the headset powered on and 76–85 dBA with the headset powered off for 90% and the remaining 10% of the user population, respectively. According to the NRS_A data for the Pilot PA1779T headset, the range of estimated noise levels under the hearing protection device will be 63–76 dBA with the headset powered on and 68–82 dBA with the headset powered off. In this example, NRS_G provides a more conservative estimate

of protection for a particular noise exposure when compared with NRS_A . NRS_A , the most simplified method, may be most appropriate when workers are exposed to noises with a spectral balance between -1 and 5. NRS_G is a more accurate rating than NRS_A because of the additional spectral information in the form of C-A values used in its application, yet it is relatively simple to apply. The octave-band method is still considered the most accurate way to estimate the level under the HPD, but NRS_G provides a good approximation of the octave-band method.

In summary, the results of this study demonstrate how important test data are to understanding the attenuation performance of an HPD. Devices with ANC technology are no exception. The results show how variable the results can be for devices using the same technology. For a lower-attenuation headset, the application may be better suited to a lower noise-exposure environment, whereas a high-attenuation, isolating headset is better suited to an environment with higher noise levels. The consumer needs both passive and active performance ratings to choose the HPD appropriate for a particular noise exposure. NRS_A and NRS_G ratings provide new metrics that can be used in the estimating of the level of A-weighted noise at the ear under the HPD.

Active Noise Cancellation	Rating Method	NRSA Rating (dB)		Estimated Noise Level Reduction (dB)		Estimated Exposure Level (dBA)	
		90 %	10 %	90 %	10 %	90%	10%
On	NRS_G	n/a	n/a	17	28	78	67
Off	NRS_G	n/a	n/a	10	19	85	76
On	NRS_A	19	32	n/a	n/a	76	63
Off	NRS_A	13	27	n/a	n/a	82	68

Table 1. The estimated noise reductions and predicted effective sound pressure levels for the Pilot PA1779T headset when worn in a noise with a sound level of 101 dBC/95 dBA that has a spectral balance of 6 dB (i.e., C – A). The NRS_A rating, or the Estimated Noise Level Reduction computed from the spectral balance and NRS_G values, is subtracted from A-weighted sound levels experienced when hearing protection is worn in the noises indicated.

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NHCA Annual Conference News

by Rachel Bouserhal
NHCA Program Chair

42nd NHCA Annual Conference

All of us want some of the same things in life: joy, good health, and of course happy ears. NHCA conference attendees, presenters and exhibitors are working together so we can have *Happy Ears for Many Years!*

Please earmark February 15-17, 2018, to attend the 42nd NHCA Annual Conference, Happy Ears for Many Years, held at the Caribe Royale All-Suite Hotel and Convention Center in Orlando, Florida. The conference will feature workshops, podium presentations, poster sessions, plenty of exhibitors and round table discussions. **NEW** for 2018 are panel discussions! See the Program Chair Task Force report in Spectrum and visit the NHCA website for conference updates (<http://www.hearingconservation.org/>).

Call for papers is open for 2018 conference attendees!

If you have research you want to share with your fellow hearing health enthusiasts, workshops that will teach us all a thing or two, and/or posters showing off your results and presentation skills, now is the time to get started. NHCA wants to see them all! Deadline for submissions is August 11, 2017. Looking forward to hearing from you!



43rd NHCA Annual Conference. In 2019, the annual conference will be held in Dallas, Texas.

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