Sound Source

Volume 1/Issue 4 February 2005

A– AND C–WEIGHTED NOISE MEASUREMENTS

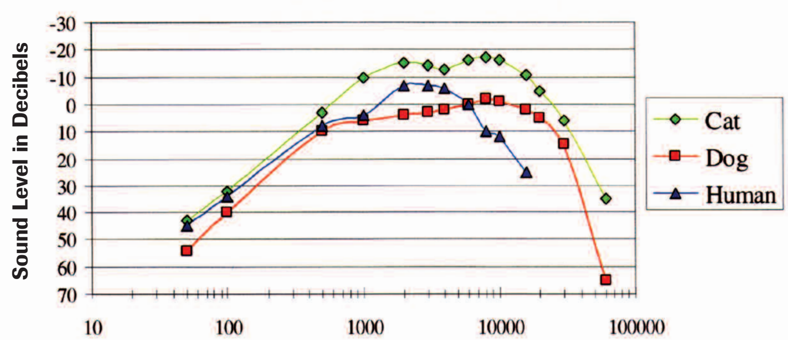
Hearing protector literature makes reference to A-weighted and C-weighted noise measurements. What are A-weightings and C-weightings?

The A-weightings and C-weightings refer to different sensitivity scales for noise measurement. For example, we've heard it said that animals have better hearing sensitivity than humans. This increased sensitivity is true not only for the ***intensity*** of a sound (a cat can hear sounds that are much quieter than humans can hear), but also for the ***frequency*** of a sound (a high-pitched dog whistle is easily heard by a dog, but is beyond the frequency range perceived by humans, even though it is quite loud). So hearing sensitivity must be measured not only in *intensity*, but also in terms of *frequency*.

To display these measurements of hearing sensitivity, we use a scale showing frequency on the horizontal axis (measured in hertz), and intensity on the vertical axis (measured in decibels). The curves in Figure 1, for example, show the measured hearing sensitivity for a cat and dog compared with a human.

Note in this figure that humans have hearing that is most sensitive for soft tones in the mid-to high frequencies of the chart, but less sensitive in the low frequencies; that is, hearing for soft tones "drops off" in the lows. Researchers in the 1930s discovered that this loudness sensitivity curve for soft tones was not the same for loud tones. In fact, at very loud tones, the sensitivity of the human ear has difficulty distinguishing differences in loudness between a low-frequency 80 Hz tone and a high-frequency 4,000 Hz tone – to the human ear, they sound about equally loud. Thus, in high noise levels, the loudness sensitivity of the ear is quite "flat."

Figure 1. **Hearing Sensitivity at Threshold**



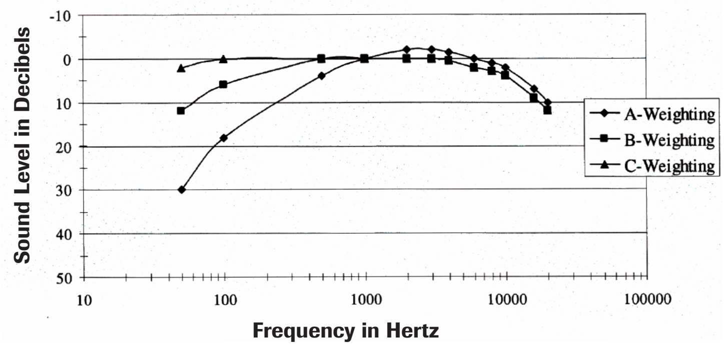
(Area under the lines represents sounds that are audible)

Bacou-Dalloz Hearing Safety Group
7828 Waterville Road, San Diego, CA 92154
Tech Support ph. 800/977-9177 • fax 619/661-8131
Cust Service ph. 800/430-5490 • fax 401/232-1110

In the development of sound level meters over the years, manufacturers have built in these different response curves (see Figure 2), and named them the A-, B-, and C-weighting scales:

The C-weighting scale was originally designed to be the best predictor of the ear's sensitivity to tones at high noise levels. Why, then, are noise measurements for hearing conservation almost always measured in dBA? Because the ear's loudness sensitivity for tones is not the same as the ears' damage risk for noise. Even though the low frequencies and high frequencies are perceived as being equally loud at high sound levels, much of the low frequency noise is actually being filtered out by the ear, making it less likely to cause damage. The A-weighting scale in a sound level meter replicates this filtering process of the human ear.

Figure 2. **A-, B- and C-Weighting Curves**



A-Weighting	Follows the frequency sensitivity of the human ear at low levels. This is the most commonly used weighting scale, as it also predicts quite well the damage risk of the ear. Sound level meters set to the A-weighting scale will filter out much of the low-frequency noise they measure, similar to the response of the human ear. Noise measurements made with the A-weighting scale are designated dBA.
B-Weighting	Follows the frequency sensitivity of the human ear at moderate levels, used in the past for predicting performance of loudspeakers and stereos, but not industrial noise.
C-Weighting	Follows the frequency sensitivity of the human ear at very high noise levels. The C-weighting scale is quite flat, and therefore includes much more of the low-frequency range of sounds than the A and B scales.

Several of hearing conservation's key documents (including OSHA's Hearing Conservation Amendment, and EPA's labeling requirements for hearing protectors) rely on dBC in determining noise exposures. Today, however, nearly all noise measurements for hearing conservation are measured in dBA, resulting in misapplications and errors when figuring attenuation from hearing protectors. OSHA has attempted to bridge the difference between C and A-weightings with the following advice:

If your industrial noise measurements are in dBC, subtract the NRR of the hearing protector from the dBC noise measure to determine the protected noise level for the worker.

EXAMPLE	**Noise Level**	**105 dBC**
	Hearing Protector	**25 NRR**
	Protected Noise Level	**80 dB**

If your industrial noise measurements are in dBA, subtract 7 from the NRR of the hearing protector as an error cushion for C-A differences, then subtract the resulting lower NRR from the dBA noise measure to determine the protected noise level for the worker.

EXAMPLE	**Noise Level**	**105 dBA**
	Hearing Protector	**25 NRR – 7 dB = 18 NRR**
	Protected Noise Level	**87 dB**

– Brad Witt, MA, CCC-A
Audiology & Regulatory Affairs Manager
Bacou-Dalloz™ Hearing Safety Group

Bacou-Dalloz