E·A·R®

E•A•RCAL℠ Laboratory

To: Users and specifiers of personal stereo systems

From: Elliott H. Berger

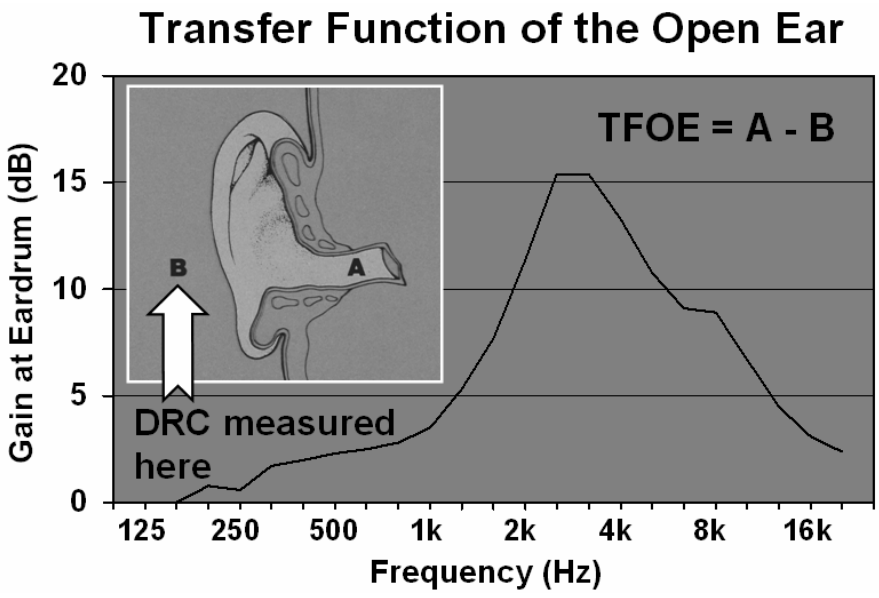
Date: February 8, 2008

Re: Why can't I measure sound exposures from MP3 players (iPod or equivalent) or from a Peltor Worktunes® style earmuff, with a simple microphone?

A common mistake made in the characterization of noise risk from earphones is to measure the output of an in-the-ear earphone or a headset either by using a microphone and placing it next to the driver, or by putting the earphone on a standardized coupler and measuring the levels accordingly. The reason this yields inaccurate data is that this type of measurement does not correspond with the manner in which data have historically been acquired for purposes of relating hearing loss to noise exposure. Such relationships, called damage-risk criteria (DRC) are based on numerous occupational noise studies in which sound levels were measured in the workplace by positioning a sound level meter microphone in the sound field, in the absence of the listener, in the position that would have been occupied by the worker. Sometimes the mic was positioned near the worker's head, but not in the ear. These are commonly referred to as diffuse-field measurements.

Diffuse-field measurements were taken back in the 1950s and 60s (when the studies that are the basis of today's standards and regulations were conducted) because that is what the technology supported.

The head and earcanal amplify sound, i.e. depending upon the frequency, the sound pressure levels at the eardrum are from approximately 0 – 15 dB greater than in the diffuse field that created them. This natural amplification of the ear is part of what improves our ability to detect quiet sounds. The amplification is called the transfer function of the open ear (TFOE), as illustrated in the chart. Whenever a measurement is taken in a specified acoustic test fixture, coupler, or in a real ear using a probe microphone, TFOE must be accounted for by subtracting it from the measured values. If a mic is simply positioned next to the earphone, then a different correction is needed.



Unfortunately the correction factor cannot be specified without having "calibrated" the particular mic-earphone-geometry that was used for the measurement.

Since TFOE is frequency dependent, another variable is the spectrum of the test sound itself. If you select just any source of music or speech, the results will not be reproducible. For example, at one extreme, if the test sound was all at or near the frequency of 2500 Hz, the overestimation would be about 15 dB as can be seen in the chart, but if the test sound had all or most of its energy at 125 Hz, the TFOE correction would be 0 dB. Today there is a standard that is becoming accepted, IEC 60268-1 that specifies an average speech/music spectrum consisting of random noise passed through a filter with uniform response from 125 to 1250 Hz, and a roll off above and below those frequencies.

Standards also exist that describe how to routinely and reliably measure the output of earphones by applying the above procedures with a test fixture (ISO 11904-2), or via a group of test subjects (with microphone-in-real-ear technology, MIRE, ISO 11904-1). European standard prEN352-8 discusses how to use a MIRE method in a test approval scheme wherein four samples are tested on eight subjects, and the mean plus one standard deviation is limited to 82 dBA equivalent diffuse field (EDF). Such statistical limits of course suggest that any one sample tested by a consumer, could fall outside the specified range, albeit with low likelihood. At this time, there are no U. S. standards that describe such measurements or requirements.

The ISO and EN documents specify, or course, how to correct the measurements to estimate the EDF values that are needed to compare to the damage-risk criteria that are commonly recommended or enforced. In the absence of such an approach, errors of from 5 to 15 dB overestimation in the hazardousness of earphones are likely. Without test data on the specific measurement that was employed, a correction factor cannot be properly identified.

References

European Standard prEN 352-8, Final Draft (2007). “Hearing protectors – Safety requirements and testing – Part 8: Entertainment audio ear-muffs,” Belgium.

ISO (2002). “Acoustics – Determination of sound immission from sound sources placed close to the ear – Part 1: Technique using a microphone in a real ear (MIRE technique),” ISO 11904-1, Switzerland.

ISO (2004). “Acoustics – Determination of sound immission from sound sources placed close to the ear – Part 2: Technique using a manikin,” ISO 11904-2, Switzerland.