The Limitations of Dual Hearing Protection

The notion of dual hearing protection seems a logical response for any worker exposed to high noise.

One might think, for example, that wearing an earmuff with a noise reduction rating (NRR) of 28 dB combined with an earplug having a NRR of 28 dB would provide a total attenuation of 56 dB. However, this logic does not hold true in "real world" situations given what we know about hearing protector attenuation and a phenomenon known as bone conduction.
Sound is normally channeled to cochlea in one of three ways, by air *conduction (*as in the standard pure-tone *air-conduction* hearing test), bone conduction or air/bone conduction combined.

The Inward propagation of sound energy via air conduction is an acoustical>mechanical>bioelectrical process. However, if noise levels are sufficiently high, sound may bypass the outer and middle ears to stimulate the cochlea directly via vibration, made possible due to the conductivity of the human skull and associated tissues.

The sound pressure level at which noise is transmitted to the cochlea directly via bone conduction may vary from person to person due to human variability of bone mass and tissue makeup. Clinically, air conduction signals introduced to one ear require sufficient intensity to "cross over" to the other ear and stimulate that ear via bone conduction. In real world industrial environments, risk of bone conduction transmission is presents, although damage to the cochlea is unlikely at noise levels at or below 85 dB.

High-level noise is heavily weighted; low to middle frequency acoustical energy is significant. Noise level attenuation provided by earplugs alone is lesser in the low to mid frequency range.[1] Given this knowledge, logic would follow that the earmuff-earplug combination would suffice in high noise environments.

The influence of bone conduction sound transmission, however, is often overlooked. Take for example OSHA's Permissible Exposure Limit (PEL) and its associated 5 dB exchange rates. With or without hearing protection, OSHA permits workers to receive a 90 dB noise dose over an 8 hour time period. As noise levels increase in 5 dB increments, PEL durations must decrease by half. Adhering to this rule, a noise exposure of 95 dB limits duration to that exposure to four hours. An increase to 100 dB limits exposure duration to 2 hours. An increase to 105 dB permits exposure at this level for one hour. *Knowing what we know about bone conduction transmission, even dually protected noise exposure at 105 dB in as little as one hour may cause irreversible damage to the inner ear simply by the effect of bone conduction transmission.*

[1] Elliott Berger, Earlog 13, Attenuation of Earplugs Worn in Combination With Earmuffs, Aero Company

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So what is a correct formula to use when fitting dual hearing protection? Currently, there is none. Fitting dual hearing protection is unfortunately a “flying by the seat of your pants” methodology. Elliott Berger states ”no easy rule of thumb could be devised to predict combined attenuation”[2]

In the end, it is documented that dual protection adds but only 5 to 10 dB of attenuation.[3] So what message can be taken these findings? When planning work activity, remember to take into account the benefits of dual hearing protection. When confronted with high-level noise exposure, take into account, however, the known limitations of dual protection.

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