How Hearing Protection Affects the Perception of Speech and Warning Signals

Workers’ Resistance to Hearing Protection

Hearing conservation professionals, such as industrial hygienists and audiologists, have struggled for years with workers’ resistance to wearing hearing protectors. One of the most frequently-cited objections by workers is that they feel they are unable to hear speech and warning signals when they are wearing these devices. Hearing conservationists then explain to workers that hearing protectors reduce the sound level of both speech and background noise by the same amount, and therefore, the desired signal should be unaffected. In fact, the ability to communicate can actually be improved because hearing protectors can reduce overall noise levels to a point where the ear is not so stressed and less distortion is likely to occur. This improvement does often occur in high noise levels, over 90 dB(A) and especially over 100 dB(A).

For many workers, however, this benefit does not seem to be realized. Studies have shown that as many as one-half of the workers who wear hearing protection believe that the protectors “block” or partially block essential sounds. Part of the problem is that workers, especially when they are not used to wearing the devices, need some time to adjust to changes in the sounds of their machines and in other important signals. Although time and persistence sometimes help, the problem is often more complicated than it seems.

The Acoustics of the Problem

Hearing speech

If hearing protectors did indeed attenuate (reduce) all sounds by the same amount, then speech and warning sounds should be perceived as readily with or without protectors. Nearly all protectors, however, attenuate high frequency sounds more efficiently than low frequency sounds. This is especially true of ear muffs. Thus, the frequency spectrum is changed when one wears protectors, making high-pitched sounds more difficult to hear. This can make it difficult to understand speech communication because most of the meaning in speech is carried by consonants, which are higher in pitch and softer than vowels. The result is that one hears a person is speaking but (continued on next page)}
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cannot understand what is being said.

The problem is compounded by high-frequency hearing loss, which is very common among industrial workers. Both noise and the aging process tend to damage hearing for high-frequency sounds sooner and more severely than hearing for low-and middle-frequency sounds. For example, a worker who has been working unprotected in high levels of noise for a number of years will develop a hearing loss.

Then, when hearing protection is initiated, the device’s high-frequency attenuation may reduce the level of the consonant sounds to the point where speech is unintelligible or completely inaudible.

An interesting side effect of hearing protection stems from what is called the “occlusion effect,” which causes the wearer’s own voice to sound unusually loud. This effect occurs most often when ear plugs are inserted only superficially. The result is that hearing protection wearers tend to lower their voices, and others may have difficulty hearing their speech in a background of noise. Speech communication may be even more difficult when both parties in a conversation are wearing hearing protectors. These types of problems are alleviated when both communicators are able to see each other and use visual cues, such as lip reading and gesturing.

Hearing Warning Signals

When workers wear hearing protectors, they also complain they cannot hear non-verbal warning signals, such as sirens, buzzers or the sounds of machinery malfunctioning. In some cases, warning signal perception will be unaffected or even improved by the use of hearing protectors if the warning signal is loud enough, if its acoustical characteristics are sufficiently different from the background noise, and if it is not affected by the high-frequency attenuation of the hearing protector. Otherwise, studies have shown that workers wearing protectors do tend to have difficulty hearing warning signals, especially when they have some amount of hearing loss.

Another effect has not received very much attention: hearing protectors can adversely affect the ability to localize sound (i.e. to determine the location of a sound signal). Both plugs and muffs can cause difficulty determining whether a signal is coming from ahead or behind. Ear muffs can also cause confusion between left and right sound sources and can drastically impede the ability to localize a sound in the vertical plane. This can mean extra problems for a person, such as a construction worker, who must watch out for falling objects or for the approach of potentially dangerous equipment.

We have to remember, however, that both the noise in the workers’ environment and the hearing loss the noise can produce will also adversely affect workers’ abilities to hear and understand speech, to hear and correctly diagnose mechanical problems, to hear warning signals and to localize the sounds of danger. Failure to reduce the offending noise or to protect workers adequately with hearing protectors can cause a handicapping hearing loss, which in turn, will exacerbate the problems we are trying to avoid.

So those who issue and those who wear hearing protectors are walking a fine line. Fortunately, there are solutions to these problems.

Solutions

1. The most effective solution is always to control the noise at the source or in the worker’s environment so that the risk of hearing loss will be minimized and the use of hearing protectors will not be necessary. This solution, however, is not always possible.

2. Workers need to be carefully trained in fitting and using hearing protection. When an ear plug is fitted properly it is likely to attenuate somewhat more evenly across the frequency spectrum instead of attenuating only high frequencies. Also, workers need to be told that their machines may sound different when they wear hearing protectors, and they need to be encouraged to get used to the new sound. A training program should include practice in communicating while wearing hearing protection. Workers should also be encouraged to keep their voice levels from dropping and to use visual cues whenever possible.

3. Those who purchase hearing protectors and fit workers with them need to be sensitive to workers’ complaints about the interference with speech and warning signals and should be careful not to select a protector with too much attenuation. For example, why select a protector with an NRR of 35 dB when only 15 dB of attenuation is needed?
4. Warning signals should be tailored to the noise environment in which they are to be used. Acoustic signals can be replaced with flashing lights or other visual signals; a frequency spectrum can be changed so as not to be masked either by the noise environment or by the hearing protector’s attenuation. It may be helpful to consult an acoustical engineer or an industrial hygienist well-versed in acoustics for this solution.

5. In situations where speech communication is essential, the use of electronic communication systems should be given serious consideration. Cordless, as well as corded systems, are now available and ear plugs can be worn successfully under head phones if more attenuation is needed. One helpful technology that is just emerging is the noise-canceling headset, which reduces low-frequency sounds considerably more than high-frequency sounds. When worn in combination with conventional ear plugs, the resulting attenuation can be very effective, yet allow much of the high-frequency sound energy to be audible.

For Further Reading