



Hearing Conservation in Construction

New Perspectives on an Old Problem

By Donald J. Garvey

Occupational noise-induced hearing loss (NIHL) has been a major concern since the beginning of the industrial revolution. Several hundred years later, noise and hearing loss remain major concerns for the construction workforce, management and OSH professionals. One study of more than 1,300 noise measurements indicated that approximately 70% of the construction workers involved had a full-shift time-weighted average (TWA) exposure at or above the NIOSH recommended exposure limit (REL) of 85 dBA. About 10% of those workers had full-shift average exposures above the current OSHA construction permissible exposure limit (PEL) of 90 dBA (Neitzel, Stover & Seixas, 2011).

Noise levels of typical construction equipment can range from approximately 88 dBA for circular saws to 96 dBA for chipping guns to 102 dBA for jackhammers (ANSI/ASSE, 2013). In calculations made by the Center for Construction Research and Training (2013) using data from the 2010 National Health Interview Survey, 21% of construction workers self-reported some type of hearing problem. In addition, exposure to noise has been associated with increased pulse rate, high blood

pressure, muscle tension, sleeplessness and fatigue (Basner, Babisch, Davis, et al., 2014).

While hearing loss continues to be a problem for the construction industry, a significant amount of research provides insight as to why the problem persists, shortcomings in past efforts to control noise and new ideas to combat this problem. This article focuses on two areas of construction hearing conservation:

1) Use of hearing protection devices (HPDs). While engineering controls are the preferred method to prevent occupational exposure, HPDs are typically the control method implemented in construction. Accepting this for now, how can selection and wearing practices be improved to maximize use and actual effectiveness?

2) Training. What techniques and insights can be made training more impactful for workers and do more to encourage hearing-healthy attitudes and behaviors in the workforce?

While a discussion of engineering controls is beyond the scope of this article, such controls are a critical part of an effective hearing conservation program. Readers can find a brief review of information sources on engineering controls and a discussion of NIOSH's Buy Quiet program on p. 33.

Use of Hearing Protection Devices

On construction sites, HPDs are the most common method used to control noise exposures. Unfortunately, actual use, and more importantly effective use, of HPDs are typically poor. Low usage rates of HPDs are attributed to the transient nature of the workforce; the abstract, gradual and painless nature of NIHL; the lack of an immediate cause-effect loop; and the potential annoyance and discomfort caused some experience when wearing HPDs.

IN BRIEF

- Noise and hearing loss remain major concerns for the construction workforce, project owners and managers and OSH professionals.
- This article focuses on two areas of construction hearing conservation: use of hearing protection devices and training, both of which can boost use and promote consistent wearing of protective gear.

Donald J. Garvey, CSP, CIH, ARM, is a technical service specialist and construction industrial hygienist with 3M's Personal Safety Division in St. Paul, MN. Prior to 3M, he was a construction industrial hygienist for The St. Paul Companies. Garvey holds an M.S. in Environmental Health from the University of Washington. He is an AIHA Fellow and a past chair of its Construction Committee. Garvey is a professional member of ASSE's Northwest Chapter and a member of the Society's Construction Practice Specialty. He has published several articles in *Professional Safety* and is author of the industrial hygiene chapter in the second edition of ASSE's *Construction Safety Management and Engineering* textbook.

Effective use depends on both duration of use and actual attenuation achieved. Several studies have reported that construction workers, on average, use HPDs about 20% to 40% of the time that measured noise levels exceeded 85 dBA (Edelson, Neitzel, Meischke, et al., 2009; Neitzel & Seixas, 2005). In addition, the noise attenuation that most workers receive during actual use is significantly less than the manufacturer's published noise reduction rating (NRR) for the HPD used. However, individual results are highly variable and depend on proper HPD selection and use, with many wearers experiencing attenuation approaching the NRR and others experiencing much less (Edelson, et al., 2009; Neitzel & Seixas, 2005). Variable attenuation combined with actual usage time hinders accurate predictions of total noise protection achieved over the course of a work day. Using the formula:

$$R = 10 \times \log\{100/[100 - P(1 - 10^{-N/10})]\}$$

the realized attenuation (R) of an HPD with a nominal NRR (N) of 30 worn for 90% of a full 8-hour shift (P) in percent would be less than 10 dB (Arezes & Miguel, 2002). In a field study, actual user-attained attenuation levels combined with wear time produced realized net HPD protection levels of less than 3 dB (Neitzel & Seixas, 2005).

Many factors prompt low HPD use. For example:

- Lack of comfort. Several studies have recommended that comfort be given more emphasis than NRR. More comfort with subsequently greater worker acceptance (i.e., wear time) but less attenuation, may still give more overall protection versus high attenuation but less wear time (Arezes & Miguel, 2002; Neitzel, Meischke, Daniell, et al., 2008).

- Lack of availability on the job site. Convenience is critical. If HPDs are not readily available, workers are likely not to leave their job location to find them.

- Lack of training on proper HPD use. Training and the importance to workers of feeling that they can properly select and don HPDs is a critical factor in their decision to wear HPDs.

- Over attenuation. As noted, HPDs are often selected solely on the basis of high NRR. However, many TWA occupational noise exposures are 95 dBA or less (Franks, 1988). An HPD that delivers 10 dB of actual attenuation will cover many exposures and reduce noise exposure below 85 dBA. ANSI/ASSE A10.46 suggests that attenuation below 70 dBA is overprotection that may needlessly interfere with speech communication or warning signals and should be avoided. European Union guidelines (BS EN 458:2004) suggest an optimal "protected level" of 75 to 80 dBA, with an acceptable range of 70 to 85 dBA.

- Personal selection. In some cases, only one type of HPD is provided. Any single product may overprotect workers or be uncomfortable for some to wear. Ear canal size and shape varies significantly from person to person. A protector that fits well for one person with good attenuation may be uncomfortable and perform poorly for the next person.

- Safety climate and workers' perception of safety's priority in the workplace.

One recent development that can help address some of these areas is fit testing of hearing protection. Several manufacturers now provide methods to fit test earplugs. The two basic types of fit-testing methodology are:

- 1) Subjective. Results are based on the subject's response to a test signal.

- 2) Objective. Results are based on physical measurement of sound levels to calculate ear plug attenuation.

All field attenuation estimation systems yield a metric termed *personal attenuation rating* (PAR; Hager, 2011). Currently no standardized method exists for PAR calculation so inherent differences between test methods and conditions can yield different PARs. Still, fit testing can be a significant improvement in estimating a worker's expected protection from a specific HPD.

Hager (2011) identifies several benefits of fit testing that address many of the problems cited as factors in nonuse of HPDs.

- HPDs can be selected on a basis of both comfort and adequate protection, instead of protection alone. As noted, comfort is a critical factor in determining usage of HPDs. Fit testing can identify the most comfortable HPDs for a user that still provides adequate protection.

- Avoiding overprotection. Fit testing can help identify the HPD that provides the lowest, yet still sufficient noise attenuation, which may result in less interference with communication and warning signals.

- Wearer training and motivation. Fit testing can demonstrate to the wearer that s/he can successfully use an HPD and achieve an acceptable fit. For roll-down types of earplugs in particular, this can help the wearer understand the difference between proper and improper roll down and correct depth of insertion.

- Trainer training. Fit testing can help the trainer/HPD-dispensing person learn how to recognize good/poor fit and the effect on attenuation.

- Inventory management. Additional makes or models may need to be added to the inventory to provide an adequate selection (or conversely, while still providing a variety of options, perhaps not as many HPDs must be stocked as originally thought).

- Use when following up standard threshold shifts to show that the HPD used is appropriate for the individual's noise environment.

- Prioritize retraining for employees who may need additional help with obtaining and maintaining adequate attenuation.

- Documentation for audits or help in determining hearing loss etiology.

While construction is currently exempt from 29 CFR 1910.95(c), Hearing Conservation, safety professionals should be aware that OSHA has not accepted PAR as a method to comply with Appendix B of 29 CFR 1910.95. Contractors may want to consider that any PAR-based HPD selection also complies with Appendix B.

Two other areas that OSH professionals should consider to address potential barriers to HPD use include:

HPDs are the most common method used to control noise exposures on construction sites. Actual use, and more importantly effective use, of HPDs are typically poor.

- Compatibility with other safety equipment. Safety glass temple bars, welding helmets, faceshields and head protection all may interfere. Wells, Berger and Kieper (2013) reported that ear muff attenuation when worn with safety glasses may be reduced approximately 2 to 11 dB depending on temple bar design and ear muff cushion style (foam or liquid-filled). Therefore, OSH professionals should talk with PPE suppliers to identify gear that is designed to work together or is at least more compatible with each other.

- New styles and features. For example:

- 1) Stemmed foam earplugs can be used more easily with gloved hands and do not require the wearer to roll down or touch the part that inserts into the ear with their possibly dirty hands. Poor roll down is a common mistake.

- 2) Plugs with a design factor (e.g., flames printed on the plug or a plug in the shape of a wood screw).

- 3) Plugs with lanyards or other keeper devices that allow for easy retention and reinsertion.

OSH professionals must take a closer look at HPD selection, particularly earplugs, because more options are available. Multiple models with multiple features should be considered when selecting HPDs, not simply picking the first one in the catalog or the one with the highest NRR. To maximize actual wear time, comfort should be a greater consideration than simply getting the highest NRR. Fit testing can help address many other issues.

Hearing Conservation Training

Because noise exposure can be unpredictable and intermittent, construction workers must be able to recognize hazardous exposures and know how to protect themselves (Trabeau, Neitzel, Meischke, et al., 2008). Effective training is important, particularly for those just entering the trade. It is not uncommon for a 25-year-old construction carpenter who does not use hearing protection to have the hearing acuity of a 50-year-old nonoccupationally noise exposed person. While this is not a significant loss at this point, when that carpenter turns 50, the hearing loss may be 50 to 60 dB (Stephenson, 2001).

New construction workers have a critical need for effective hearing conservation program (HCP) training to reduce exposure and increase use of HPD before hearing damage can start. However, effective HCP training is rare (Neitzel, et al., 2008). Stephenson and Stephenson (2011) note that most HCP training focuses on presentation of knowledge such as the effects of noise, advantages/disadvantages of certain HPDs and HPD care. To be most effective, the training must also address motivational aspects to prompt a desired behavior change, namely consistent wearing of HPDs.

Thus, OSH trainers must develop a framework that delivers the information in a way that acknowledges workers' needs and concerns. One such framework is the Health Promotion Model (Pender, Walker, Sechrist, et al., 1990). The model's key idea is that a person's decision to take action is determined by the expected outcome of that decision and the person's evaluation of those outcomes (Ronis, Hong & Lusck, 2006).

Using the model, researchers identified five cognitive/perceptual factors that appear to influence HPD use (Lusk, Ronis & Hogan, 1997):

- 1) Self-efficacy. This refers to confidence in one's ability to perform a task, in this case to properly wear HPD. Even if the benefits outweigh the barriers, a person may not take action unless s/he believes s/he can successfully carry that action out.

- 2) Barriers. These are expected negative aspects of the behavior (e.g., wearing HPD).

- 3) Benefits. These are expected positive effects of the behavior.

- 4) Control of health. This refers to the extent of a person's perception of his/her ability to maintain personal health.

- 5) Value of use. This is the perceived importance of the outcome of using an HPD.

Studies indicate that a person's use of HPD in response to the risk of NIHL is strongly influenced by self-efficacy (Stephenson & Stephenson, 2011). Fit testing during training is one method a trainer can use to visually demonstrate to workers that they have selected an HPD that offers sufficient protection, can wear it properly and actually receive that desired level of protection. While PARs may vary depending on the fit test method, precision may be less important than the value of self-efficacy and motivation (Schultz, 2011).

Training should include a significant segment of hands-on activities and demonstrations to help workers develop a high level of skill mastery. Training should be conducted one on one or in small groups to allow interaction between each worker and the trainer. In addition, the trainer should be familiar with the work site so s/he can relate actual on-site exposures during training (Stephenson & Stephenson, 2011).

Perceived barriers to HPD use are another critical factor (Edelson, et al., 2009; Ronis, et al., 2006; Stephenson & Stephenson, 2011). For example, workers may perceive that HPDs:

- are time consuming to use;
- are uncomfortable to wear;
- make it difficult to hear speech or warning signals;
- are too complicated to use.

Workers may also underestimate the danger of their particular noise exposure.

OSH professionals should identify and address these barriers in ways specific to the audience. For example, carpenters may think that table saw noise is insignificant since it occurs only intermittently during the day. Training might address task-based noise monitoring of saw sound levels and durations on that particular job site compared to recommended exposure duration limits. Again, fit testing may help address barriers related to comfort or speech interference.

Other key considerations:

- Delivery format.** Murphy, Stephenson, Byrne, et al. (2011), compared video-based training, manufacturer's printed instructions and one-on-one training to determine the effects of training on attenuation achieved when an HPD is donned. Sub-

jects with no experience using HPDs received one training method, then donned the devices. Subjects were then tested to determine achieved noise reduction using ANSI/ASA S12.68.2007 methodology. Subjects in the video and printed materials groups showed similar performance in noise reduction achieved after donning HPDs. However, subjects in the one-on-one group showed an average of 5 to 8 dB increase in achieved attenuation versus the other two training method subjects.

Another study compared small group training to one-on-one training and to manufacturer's written instructions (Joseph, Punch, Stephenson, et al., 2007). These researchers found a similar increase in achieved attenuation over written instructions for both small group and one-on-one training. No significant difference was noted in achieved attenuation between the small group and one-on-one. Joseph, et al. (2007), concluded that small group training would be sufficient with one-on-one training required when a worker demonstrates a significant threshold shift. Both studies indicate that method of training can be the difference between achieving adequate and marginal protection.

•**Gain framing the behavior** (instead of loss framing). This entails emphasizing the gain to be realized by taking the desired action or exhibiting

the desired behavior. Gain framing would communicate that wearing HPDs prevents hearing loss, maintains health. Loss framing tells the worker what would be lost by not wearing hearing protection. Stephenson and Stephenson (2011) suggest that gain framed messages tend to better promote prevention behavior.

•**Industry-specific training.** To be most effective, trainers should use construction examples and graphics, and should ensure that text is written to ease comprehension (Neitzel, et al., 2008). It is also recommended that trainers use images instead of text in printed materials when possible. Photos must show the specific HPD and procedure to be used.

•**Management support.** Company leaders must support the use of engineering controls and HPDs; understand the need for effective hearing conservation training; and recognize the importance of preventing NIHL (Edelson, et al., 2009). When on site, company leaders must wear HPDs and encourage workers to do the same (Ronis, et al., 2006).

•**Use of noise indicators.** Noise indicators are small devices that workers wear on their clothing. These devices typically flash red when noise levels exceed a preset level such as 85 dBA. This notifies wearers that they are in a high noise area. One study that used noise indicators along with baseline

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Engineering Controls

While HPD use is the most common form of controlling noise exposure on construction sites, engineering controls are still preferred. Furthermore, OSHA requires employers to use such controls when feasible. Construction safety professionals should investigate all opportunities to utilize engineering controls, not only to protect workers, but also to simplify the HCP. By eliminating or reducing potential noise sources, these controls reduce reliance on HPDs.

Potential Engineering Controls

- Reduce vibration from surfaces (e.g., place sandbags on rebar when cutting, securely clamp a workpiece as close to the work area as possible when grinding).
- Use remote-operated equipment (e.g., rig-mounted hydraulic pavement breakers). This may also reduce other health hazards related to ergonomic and silica exposures.
- Use electrically powered equipment instead of diesel-powered and hydraulic-powered instead of pneumatic.
- Move workers away from noisy equipment (or vice versa). A 105 dBA noise source at a distance of 5 ft would be 102 dBA; at 20 ft, 90 dBA; and at 40 ft, 84 dBA depending on other sur-

rounding noise sources. During training, some trainers find it helpful to use a rotary grinder and sound level meter to demonstrate the noise reduction effect of changing the distance from noise sources or erecting a simple barrier between the worker and noise source (Neitzel, et al., 2008).

- Restrict or control access zones around high noise areas to limit the number of persons potentially exposed.
- Shut down equipment not in use.

Engineering Controls Resources

Construction OSH professionals can refer to multiple sources to learn more about utilizing these controls in their operations. For example:

- Workers' Compensation Board of British Columbia's Construction Noise publication (available at www.nonoise.org/resource/construc/bc.htm#7.5)
- WorkSafe Australia's Control Guide Management of Noise at Work (1991) (available at <http://bit.ly/1L8i98u>).
- Laborers Health and Safety Fund of North America Controlling Noise on Construction Sites (available at <http://bit.ly/1L8ihVD>)
- NIOSH's controls for noise exposure website (www.cdc.gov/niosh/topics/noisecontrol)

Buy Quiet

Buy quiet is the concept of including noise emission specifications when purchasing or renting equipment. Manufacturer-designed and built-in noise suppression is usually more effective and less expensive than retrofitting controls onto existing equipment. Quieter equipment may reduce the need for (or at least reliance on) HPDs to sufficiently protect workers. Reducing noise during the design or purchasing phase helps prevent NIHL for all the workers who may ultimately use that machinery. Quieter equipment can also help contractors respond to municipal or state ambient noise regulations during outdoor projects.

NIOSH (www.cdc.gov/niosh/topics/buyquiet) and NASA (<http://bit.ly/1TvjpPd>) provide information and suggestions for implementing a buy quiet program. NIOSH is developing a database that provides noise data to power tool buyer and users. The European Commission has an extensive database as well (<http://bit.ly/1N5w5Az>).



training and reinforcement toolbox talks showed a marked increase in use of HPDs compared to training alone. The noise indicators offered workers real-time information on noise levels and were a reminder to wear HPD (Seixas, Neitzel, Stover, et al., 2011).

Audiometric Testing

A full discussion of audiometric testing is also outside the scope of this article. However, audiometric testing can be a critical component of a hearing conservation program and is required in OSHA's general industry standard. Construction poses several challenges to audiometric testing that are not present in general industry (e.g., transient workforce with multiple employers, remote work sites). OSHA posed several questions in 2002 (<http://1.usa.gov/1P9ikOM>) that provide OSH professionals with a guide for examining the feasibility of creating a cost-effective, functional audiometric testing program for construction and other workforces.

Conclusion

Noise exposure and hearing loss in construction are not new topics. Multiple studies and presentations have sufficiently documented the issue. It is time to hear and listen to some new thoughts on how to address it. OSH professionals must be aware of ways to increase the effective use of HPDs and must consider training from the workers' side of the classroom. OSH professionals must learn what motivates workers and understand how to best communicate knowledge related to hearing protection. Finally, selecting effective controls and investing up front in quieter equipment should be considered. **PS**

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