Noise Control Engineering Strategies

Bryan Beamer, PhD, PE, CSP
Lieutenant, United States Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
Cincinnati, Ohio

Introduction

Thousands of pieces of equipment and machinery that produce hazardous noise levels are used in the manufacturing, construction and service industries in the United States of America. Often management of noise hazards has relied on providing hearing protection to workers, implementing hearing conservation programs, and training workers on the proper use and wear of hearing protection. To be effective, this strategy requires high levels of interaction and coordination from workers, supervisors and safety professionals. Furthermore, the worker's primary workplace responsibilities and activities may distract them from consistent and proper hearing protection use. Although engineering controls are frequently a better solution, the reality is that cost-conscious employers are unlikely to have a noise-control expert on staff to facilitate implementing such measures.

The lack of effective noise controls may be a reason that noise-induced hearing loss is still one of the most prevalent occupational health concerns in the United States of America, with the Agriculture, Construction and Mining Industries most consistently leading in prevalence.[1,2] In fact, approximately 22 million workers are exposed to hazardous noise levels in the United States.[3] Exposures in the noisiest industries can be quite high due to equipment noise emissions. For instance, heavy equipment like piling equipment, road milling machines and drill rigs can create sound levels in excess of 110 dB(A), while other more common equipment like circular saws, loaders and leaf blowers can have sound power levels between 100 and 110 dB(A) as

---

* Disclaimer: The findings and conclusions in this report are those of the author and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

[1] Occupational Safety and Health Administration, "Occupational Noise Exposure," [Online]. Available: https://www.osha.gov/SLTC/noisehearingconservation/. [Accessed 3 March 2016].

[2] E. A. Masterson, J. A. Deddens, C. L. Themann, S. Bertke and G. M. Calvert, "Trends in Worker Hearing Loss by Industry Sector, 1981-2010," *American Journal of Industrial Medicine,* vol. 58, pp. 392-401, 2015.

[3] S. Tak, R. R. Davis and G. M. Calvert, "Exposure to Hazardous Workplace Noise and Use of Hearing Protection Devices Among US Workers - NHANES, 1999-2004," *American Journal of Industrial Medicine,* vol. 52, no. 5, pp. 358-371, 2009.

specified in EU Directive 200/14/EC.[4] Despite potentially dangerous noise emissions in the workplace, engineering controls for noise have not been universally adopted; some of the reasons for this are explored below.

Benefits and Challenges of Implementing Engineering Controls for Noise

Problems with Current, PPE-Centered System

As illustrated above, current strategies for protecting the hearing of the American worker, by far and large, are not fully effective. This point is further illustrated by the fact that hearing loss is the 3rd most common chronic physical condition after hypertension and arthritis and is more prevalent than diabetes, vision trouble or cancer. Also, hearing loss is the most common work-related illness. In fact, over 11% of the working population has hearing difficulty; 24% of worker hearing difficulty is attributable to occupational exposures, which include hazardous noise and ototoxic chemicals (chemicals causing damage to the inner ear).[5]

These problems stem from not considering engineering controls for noise in the American workplace, despite the fact that the preferred approach for hearing loss prevention is to eliminate hazardous noise at the source. In large measure, the focus on PPE-based strategies stems from the assumption that engineering controls for noise are complicated and cost-prohibitive to implement. Repercussions stemming from this misperception include:

- Pervasive and reflexive use of personal protective equipment (PPE) to protect workers' hearing – a strategy proven to be ineffective due to poorly chosen or incorrectly worn PPE.
- A critical gap in the understanding of the economic benefits of implementing noise engineering controls.
- Additional hazard exposure resulting from the poor communication that ensues from wearing PPE that reduces speech intelligibility.

Potential Benefits of Implementing Noise Control Engineering Strategies

A paradigm shift to the implementation of noise control engineering strategies has a great potential to better protect workers' hearing. Potential benefits include:

- Controlling noise at the source can eliminate the need for PPE, which historically has not been sufficient to protect workers' hearing.
- Implementing engineering controls can eliminate the need for hearing conservation Programs, thereby eliminating the associated administrative burden and expense.
- Preventing noise-induced hearing loss by noise prevention can lead to better situational awareness and improved communication.

[4] Roo, F.D., Gerretsen, E. and Borst, J., "Environmental impact of noise from mobile outdoor equipment," in 7th European Conference on Noise Control, EURONOISE 2008 and Acoustics '08, Paris, France, 2008.
[5] Masterson E.A., Tak S., Themann C.L., Wall D.K., Groenewold M.R., Deddens J.A., Calvert G.M., "Prevalence of hearing loss in the United States by industry". *American Journal of Industrial Medicine* 56:670-681 (2013)

- Implementing engineering controls for noise, where feasible, will help employers meet the OSHA requirement that noise controls be the first line of defense against excessive noise exposure.
- Ultimately, a shift from PPE-based strategies to engineering controls will result in reducing occupational hearing loss in the workplace.

Current Effective Strategies

There are simple, straight forward strategies to protecting workers from noise-induced hearing loss that do not rely on PPE. For instance, National Institute for Occupational Safety and Health (NIOSH) has been working with partners to develop and promote the Buy Quiet program and the Safe-in-Sound Excellence in Hearing Loss Prevention Award™.

Buy Quiet Program

Business owners are encouraged to create Buy Quiet programs as a first step in the effort to control noise emissions. Having information on the noise emission from tools, equipment or machinery is an important step. NIOSH developed a Power Tools Database that contains sound power levels, sound pressure levels, and vibrations data for a variety of common power tools that have been tested by researchers. This database also contains downloadable sound level recordings to help with purchasing decisions (visit http://wwwn.cdc.gov/niosh-sound-vibration/). As part of a national campaign, NIOSH launched a Buy Quiet web site to promote the initiative and educate employers and workers about Buy Quiet (visit http://www.cdc.gov/niosh/topics/buyquiet/). The website includes a video providing an overview of Buy Quiet and resources for construction company owners, employees, subcontractors, purchasers and suppliers of power tools and equipment, as well as for the general community. Similar materials are being completed focusing on the manufacturing industry.

The key elements of a model Buy Quiet program are:

A. An inventory of existing machinery and equipment with corresponding noise levels. This inventory is updated as quieter pieces of equipment are purchased to replace worn out, louder equipment. The inventory can also be used for facilitating, documenting, tracking, and promoting a company's Buy Quiet purchases.

U.S. manufacturers of equipment and machinery are required to provide noise level information for the products they market and sell.[6] An equipment purchaser uses the manufacturer's information to compare noise emission levels of differing models prior to purchase. How manufacturers make this information readily available to their customers is still being discussed, but one option includes an online database populated in a collaborative fashion by manufacturers. The motivation for manufacturers to include their products' noise level information would be to increase product visibility and competitive advantages as more and more purchasers demand quieter and easily accessible noise level information.

[6] U.S. Environmental Protection Agency, "Summary of the Noise Control Act," 1 June 2015. [Online]. Available: http://www2.epa.gov/laws-regulations/summary-noise-control-act. [Accessed 2 March 2016].

B. A Buy Quiet company policy or procedure. Company policy can be an easy and effective way for employers to show commitment to using the best available technology to protect the hearing and well-being of their employees. Three levels of increasing commitment are suggested so that any company can initiate a Buy Quiet Program that realistically reflects their time and monetary resources. These levels of commitment include:

- Low-Level: Commitment to purchasing replacement machinery that produces no greater noise levels than the original machinery.
- Mid-Level: Commitment to purchasing the most cost-beneficial piece of machinery available that produces less noise than the original machinery.
- High-Level: Commitment to purchasing the quietest piece of machinery available, regardless of price.

C. Educational materials and promotional tools. Employees, management, customers, and the community can be informed about the importance and benefits of Buy Quiet. NIOSH developed a series of posters for construction companies to communicate their organization's efforts and commitment to reducing noise levels in and around construction worksites (see Figure 1). These posters are available online for download and printing (visit http://www.cdc.gov/niosh/topics/buyquiet/posters.html).

D. Analysis of the Cost-Benefit of Buying Quiet. Calculation methods can be used to conduct a cost-benefit analysis comparing one piece of equipment to another. Factors that can influence this analysis may include initial costs, long-term maintenance and depreciation, as well as the cost of noise-induced hearing loss to the worker, company and society. In many cases, the quieter piece of equipment is the most inexpensive alternative when a thorough cost-benefit analysis is completed that considers:

- all life cycle costs of the machinery;
- possible worker's compensation claims;
- costs associated with a company's hearing conservation program;
- costs of healthcare (such as hearings aids); and
- possible lost productivity.

Conservative estimates suggest savings of $100 per decibel when purchasing quieter products.[7] The savings are applicable across a wide variety of machinery and equipment.

Safe-in-Sound Excellence in Hearing Loss Prevention Award™

Through the Safe-in-Sound Excellence in Hearing Loss Prevention Award™, created in partnership with the National Hearing Conservation Association (NHCA), organizations that document measurable achievements in occupational hearing loss prevention are recognized for their achievements. Often these achievements include examples of real-world, successful noise control strategies in the manufacturing, service and construction sectors. Not only does the Safe-in-Sound Excellence in Hearing Loss Prevention Award™ motivate companies to find innovative

[7] D. Nelson, "Adaptation of NASA buy-quiet process roadmap for construction firms.," U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Cincinnati, OH, 2011.

ways to protect their employees from workplace noise but also innovative results are promoted as part of the program's outreach (see winners and archives at www.safeinsound.us).

Future Research Possibilities

During 2016, NIOSH researchers from the Hearing Loss Prevention Team (HLPT) of the Division for Applied Research and Technology (DART) will be pursuing other research opportunities to protect workers' hearing by promoting Noise Control Engineering strategies in the Manufacturing, Service and Construction industries. This objective will not only be accomplished by developing and identifying noise control engineering strategies but also by assessing the economic feasibility/practicality of these strategies. Findings from these case studies would be disseminated to workers, managers, and safety professionals to demonstrate their generalizability and provide incentive for employers to apply similar techniques to control noisy equipment or operations.

The ultimate goal of generating and promoting case studies would be accomplished through the following functions:

- Creating noise profiles and analysis through field studies for the Construction, Manufacturing and Service Sectors.
- Identifying best practices and noise control engineering strategies at these sites.
- Studying the economic feasibility and practicality of recommended strategies.
- Testing engineering technologies in NIOSH laboratories.
- Generating straightforward, real-life case studies to maximize the motivation to implement noise control engineering strategies and best practices.
- Implementing an Intervention Mapping approach to develop and deliver theory-based and evidence-informed intervention programs.

While specific sites for study have not yet been selected, this project will target tasks typical to their industries. Furthermore, sites will be selected based on the need for noise engineering controls, the generalizability of interventions and the willingness of potential partners to participate in research. The initial list of sites is as follows:

- Construction Sector – Asphalt Milling and Commercial/Residential Construction
- Manufacturing Sector – Stone Countertop Manufacturing and Industrial Food Production
- Service Sector – Musician Industry and Landscaping

Partners who will potentially play a key role in identifying sites include the Center for the Protection of Workers' Rights (CPWR), the Ohio Bureau of Workers Compensation (OBWC), and the General Services Administration (GSA).

Conclusions

In summary, shifting the focus of hearing loss prevention strategies from PPE and Hearing Conservation Programs to engineering-based strategies for noise control has many benefits. For instance, effective noise control engineering strategies may be able to: eliminate the need for PPE, which historically has not been sufficient to protect workers' hearing; eliminate the need for

Hearing Conservation Programs, thereby eliminating the associated administrative burden and expense; help employers meet the OSHA requirement that noise controls be the first line of defense against excessive noise exposure; lead to better situational awareness and improved communication; and ultimately result in reducing occupational hearing loss in the workplace.

Simple strategies outlined in this report include the Buy Quiet initiative which focuses on eliminating noise hazards early in the design and manufacture of power tools and equipment, thus reducing the risk of occupational hearing loss, and also the Safe-in-Sound Excellence in Hearing Loss Prevention Award™ which promotes and highlights information on real-world successful noise control interventions. Ultimately, the HLPT of NIOSH is pursuing future research opportunities to protect workers' hearing by promoting noise control engineering strategies in the Manufacturing, Service and Construction industries. This research would culminate in the development and publication of case studies focusing on the economic feasibility and practicality of noise control engineering strategies to be disseminated directly to equipment users, safety professionals, and purchasing decision makers.

Bibliography

Nelson, D., "Adaptation of NASA buy-quiet process roadmap for construction firms.," U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Cincinnati, OH, 2011.

Daniell, W.E., et al., "Noise exposure and hearing loss prevention programmes after 20 years of regulations in the United States". *Occup. Environ. Med.* 63, 343–351 (2006)

Davies, H., S. Marion, and K. Teschke. "The impact of hearing conservation programs on incidence of noise-induced hearing loss in Canadian workers". *Am. J. Ind. Med.* 51, 923–931 (2008)

Fausti, S.A., et al. "Hearing health and care: the need for improved hearing loss prevention and hearing conservation practices". *J. Rehab. Res. Dev.* 42(S2), 45–62 (2005)

Groenewold M.R. et al. "Do hearing protectors protect hearing"? *Am J Ind Med.*, 57(9):1001-10 (2014)

Masterson E.A., et al. "Prevalence of hearing loss in the United States by industry". *American Journal of Industrial Medicine* 56:670-681 (2013)

Masterson, E. A., "Trends in worker hearing loss within the Manufacturing Sector: 1981-2010". *CAOHC Update*, 27(1), pp. 8-10 (2015)

Masterson, E.A. et al. "Trends in Worker Hearing Loss by Industry Sector, 1981-2010". *American Journal of Industrial Medicine*, vol. 58, pp. 392-401 (2015)

Meinke, D.K. and T.C. Morata. "Awarding and promoting excellence in hearing loss prevention". *Int. J. Audiol.* 51(S1), 63–70 (2012)

National Institute for Occupational Safety and Health. "Buy Quiet Partners and Promoters," 27 March 2014. [Online]. Available: http://www.cdc.gov/niosh/topics/buyquiet/partners.html. [Accessed 2 March 2016].

_____. "Criteria for a Recommended Standard," U.S. Department of Health and Human Services, Cincinnati, OH (1998)

_____."Noise and Hearing Loss Prevention," 15 August 2013. [Online]. Available: http://www.cdc.gov/niosh/topics/noise/about.html. [Accessed 2 March 2016].

Occupational Safety and Health Administration, "Occupational Noise Exposure," [Online]. Available: https://www.osha.gov/SLTC/noisehearingconservation/. [Accessed 2 March 2016].

Roo, F.D., E. Gerretsen, and J. Borst. "Environmental impact of noise from mobile outdoor equipment," in 7th European Conference on Noise Control, EURONOISE 2008 and Acoustics '08, Paris, France, 2008.

Suter, A.H., "The hearing conservation amendment: 25 years later". *Noise Health*. 11, 2–7 (2009)

Tak S. and G.M. Calvert. "Hearing difficulty attributable to employment by industry and occupation: An analysis of the National Health Interview Survey - United States, 1997 to 2003". *Journal of Occupational and Environmental Medicine* 50(1):46-56 (2008)

Tak, S., R.R. Davis and G.M. Calvert. "Exposure to Hazardous Workplace Noise and Use of Hearing Protection Devices Among US Workers - NHANES, 1999-2004". *American Journal of Industrial Medicine*, vol. 52, no. 5, pp. 358-371 (2009)

The Institute of Noise Control Engineering of the USA, "Technical Activities". [Online]. Available: http://www.inceusa.org/about/technical. [Accessed 2 March 2016].

U.S. Environmental Protection Agency, "Summary of the Noise Control Act," 1 June 2015. [Online]. Available: http://www2.epa.gov/laws-regulations/summary-noise-control-act. [Accessed 2 March 2016].

Verbeek, J.H. et al. "Interventions to prevent occupational noise-induced hearing loss". *Cochrane Database Syst.* Rev. 10, CD006396 (2012)