PPE IV: Working On a Job Requiring Hearing Protection? Here's What You Need to Know!

Work hazards are minimized through engineering controls or eliminated altogether through safer methods or non-toxic materials. But sometimes, Personal Protective Equipment (PPE) must be worn as well. PPE can serve as an effective safety barrier as long as it is selected to protect the worker against the specific hazards (See "Job Hazard Analysis," *AIC News*, Vol. 39, No. 6, Nov. 2014, pp.13-16). PPE has to be properly maintained and worn because, if it fails, you are exposed to the full force of the hazard.

Wearing hearing protection devices may be required during noise-producing tasks to prevent temporary or permanent hearing loss. Certain noise sources relevant to collection care and exhibit-fabrication work are difficult to attenuate through engineering controls alone, including woodworking, machining, drilling, and use of compressed air.

Resources for Noise Source Reduction

This PPE series of articles is not directed at the details of acoustic engineering controls. A more detailed explanation of engineering control resources and toolkits for measuring and preventing occupational noise exposures can be found on OSHA Occupational Noise Exposure, (https://www.osha.gov/SLTC/noisehearingconservation/index.html, OSHA 2015a); NIOSH Noise and Hearing Loss Prevention, (http://www.cdc.gov/niosh/topics/noise/, NIOSH 2014a); NIOSH Document 96-110: Preventing Occupational Hearing Loss - A Practical Guide (http://www.cdc.gov/niosh/docs/96-110/, NIOSH 1996); and (just published) NIOSH pdf "Workplace Design Solutions," focusing on preventing hazardous noise and hearing loss during the project-design phase of processes and operations (http://bit.ly/ptdnoise, NIOSH 2015b).

OSHA=Occupational Safety and Health Administration; NIOSH=National Institute for Occupational Safety and Health

Hearing Conservation Program (HCP)

Hearing conservation programs strive to prevent initial occupational noise-induced hearing loss, preserve and protect remaining hearing, and equip workers with the knowledge and hearing protection devices (HPDs) necessary to safeguard themselves. If an employee's exposure exceeds an 8-hour time-weighted average (TWA) OSHA regulatory limit, employers are required to implement a Hearing Conservation Program (HCP) which provides free annual hearing exams, HPDs, training, and the implementation of an exposure monitoring program. Conservators will also need to measure noise levels from their tasks and equipment in order to properly select the correct HPD, and will also benefit when consulting with their physicians about having an audiometric test if noise exposure is a concern. This PPE article provides more details on measurement resources to help you conduct your job-hazard analysis.

Noise-Induced Hearing Loss (NIHL)

When sound waves enter the outer ear, the vibrations impact the eardrum and are transmitted to the middle and inner ear. The inner ear contains a snail-like structure (cochlea) filled with fluid and lined with cells containing microscopic hairs that move with the vibrations and convert the sound waves into nerve impulses that the brain converts into the sounds we hear. Short-term exposure to loud noise can temporarily impact these hairs, causing muffled hearing or a ringing in your ears (tinnitus), which may go away within a few minutes or hours after leaving the noisy area. Repeated, long-term exposure to high noise levels can destroy these cells, causing permanent hearing loss.

Diagram 1 shows a scale of sound levels (in decibels) of various real-world situations (OSHA 2015a). Noise may be a problem in your workplace if:

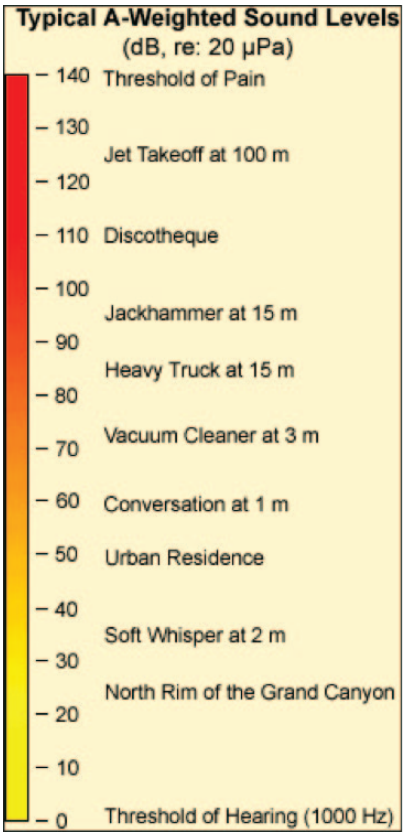


Diagram 1. A scale of sound levels (in decibels) of various real-world situations (OSHA 2015a).

- You hear ringing or humming in your ears when you leave work.
- You have to shout to be heard by a coworker an arm's length away.
- You experience temporary hearing loss when leaving work.

Exposure Limits

Noise is measured in units of sound pressure levels called decibels, using A-weighted sound levels (dBA). The A-weighted sound levels closely match the perception of loudness by the human ear. Decibels are measured on a logarithmic scale, which means that a small change in the number of decibels results in a huge change in the amount of noise and the potential damage to a person's hearing (OSHA 2015a).

OSHA sets legal limits on noise exposure in the workplace. NIOSH recommends a more conservative and protective limit to prevent hearing loss. Both based on a worker's TWA over an 8-hour day.

OSHA's Permissible Exposure Limit (PEL) is 90 dBA (8 hour max); permissible time is halved for every 5 dB increase of sound level: e.g., 95 dBA (4 hour max); 100 dBA (2 hour max).

NIOSH's Recommended Exposure Limit is 85 dBA for 8 hours, since significant noise-induced hearing loss has been shown to occur at levels less than the OSHA PEL. Further, NIOSH uses a stricter exchange rate: permissible time is halved for every 3 dB increase: e.g., 88 dBA (4 hour max); 94 dBA (1 hour max); 100 dBA (15 min. max). (NIOSH 1998)

Determining If Hearing Protection Is Needed

Sound Level Measurement (SLM) surveys are essential to determining NIHL risks. Noise dosimeters are used to measure employees' 8-hour TWA to determine if enrollment in the HCP is necessary. SLM surveys are also collected in potentially loud work environments in order to assign the appropriate HPD(s), each type of which is rated according to the noise reduction it can provide (see calculations in next section). SLMs greater than 85 dBA require HPDs. Noise surveys are best conducted by a qualified safety manager or industrial hygienist using calibrated professional equipment. Consultant listings can be found on the ASSE and AIHA websites listed at end of this article. Small businesses may qualify for free surveys via the OSHA On-site Consultation Program (OSHA 2015b). Rough estimates of noise levels may be determined through:

- Smart Phone Apps: NIOSH researchers (NIOSH 2014b) conducted a study of various smart phone apps and found that "certain sound measurement apps for Apple smartphones and tablets may be considered accurate and reliable to be used to assess occupational noise exposures. Android and Windows developers do not offer apps that meet the functionality needed for occupational noise assessments." (Kardous and Shaw, 2014).
- Online Interactives: You can roughly estimate your potential exposure using the OSHA Chart (Diagram 1) or the interactive NIOSH Noise Meter. (NIOSH 2013). This Flash application plays different sounds and sound intensities of everyday objects, and shows how long it takes before a particular sound level becomes dangerous to the human ear.

HPDs and Noise Reduction Ratings

Hearing protection devices (HPDs) act as acoustic barriers that reduce (attenuate) the amount of sound energy (expressed in decibels of sound pressure) transmitted through the ear canal to receptors in the inner ear. HPDs must attenuate noise levels below the regulatory limits. HPD attenuation is expressed as the Noise Reduction Rating (NRR), and is evaluated under laboratory conditions specified by the American National Standards Institute (ANSI S3.19-1974). The NRR is listed on the packaging of every HPD (required by USEPA 1979). Therefore, you will need to know the noise decibel levels to which you are exposed.

The NRR is a good comparison value of potential exposure reduction. However, since the NRR is a lab-tested rating, and variances will occur in the real world due to improper fitting and use, OSHA applies safety factors to arrive at a more conservative real-world NRR for that particular HPD.

Example: Noise level during your exhibit installation tasks (bracket making, metal and woodworking machinery) is 100 dBA. Your goal is to find an HPD that will reduce your noise exposure to below 85 dBA (difference of 15). But a listed NRR of 15 will not be able to achieve that because you must apply the following: listed NRR – 7dBA, then divided by 2:

Estimated Reduced Exposure (dBA) =
SLM (dBA) – (listed NRR – 7)/2* =

100 - (15 – 7)/2 = **88.5 dBA**

Using the same formula, an HPD with a listed NRR of 20 will provide the desired result:

100 – (20-7)/2 = 83.5 dBA

To ensure adequate protection at higher than 100 dBA noise levels, wearing a combination of muff over earplugs may be needed.

NIOSH's toolkit of online resources includes "The Hearing Protector Device Compendium" (http://www.cdc.gov/niosh/topics/noise/hpdcomp/). This searchable web tool was created to help workers and safety professionals select the most appropriate product for their unique environment. The tool identifies hearing protector devices by type (construction and materials), manufacturer, and noise exposure level, including the desired NRR (NIOSH 2015a).

Types of HDPs

EARPLUGS / INSERTS

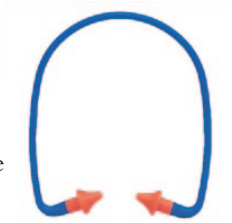
Earplugs, or inserts, are designed to fit into the ear canal and can be either pre-molded into a variety of shapes, custom-molded, or made of formable foam or silicone that expands to take the shape of the ear canal. Earplugs are available in passive or active types. Passive earplugs use mechanical methods to attenuate loud noise, such as foam or silicon inserts (no electronic attenuation). Active earplugs use electronic noise cancellation technology to attenuate loud noise while amplifying sounds in safe low ranges, such as normal conversation volumes. Active earplugs are passive earplugs with a microphone/speaker inside.

- **Pre-molded/Flanged/Reusable Earplugs:** Pre-molded earplugs come in a variety of shapes, some as multi-flanged inserts, made of soft foam or rubber/synthetic material, and are easy to insert into the ear canal. The main advantage is that they can be inserted without touching the portion that enters the canal, and do not need to be rolled/compressed. They are ideal for intermittent work where they need to be quickly inserted. The disadvantage is that they are subject to individual fit; even the same worker may require a different size for each ear. NRR range is typically 18 to 24.

- **Custom-Molded/Reusable Earplugs:** Custom-molded inserts, as the name implies, are created with a chemical mixture designed to be injected into the external canal and allowed to set by forming to the individual ear contours. Custom-molded inserts require the expertise of a trained and experienced fitter, are more expensive than other inserts, and, contrary to popular opinion, do not automatically guarantee better attenuation (Berger 2000). These HPDs can be obtained through a licensed audiologist or health care provider.

- **Formable Inserts/Compressible/Disposable Earplugs:** Formable inserts (typically expandable foam rods or silicone putty) can provide a better seal due to their expansion properties, but in order to accomplish this, the plug needs to be hand compressed, inserted properly, and held in place for a few moments to allow the material to fully expand and seal. Most reputable manufacturers have detailed descriptions of these procedures on the package. This insertion process definitely requires clean hands to prevent ear infections. NRR range is typically 22 to 33.

- **Banded/Reusable (Hearing Bands):** Banded earplugs are earplugs that are mounted on a plastic headband. They are usually equipped with pre-molded earplugs that do not need to be compressed, making them extremely useful for intermittent use. They are cooler than earmuffs and more convenient then standard earplugs. NRR range is typically 17 to 28.



EARMUFFS

Earmuffs (or "circumaural protectors") are devices designed to cover the external ear completely to provide an acoustical enclosure to the ear canal. Complete enclosure helmets are also available and commonly used in aircraft. Earmuffs are typically made of a rigid plastic ear covering, lined with foam or fluid-filled insert, and held in place by a taut headband. Earmuffs can also be fitted on hardhats and various helmets. Just as with earplugs, no one muff will be comfortable for all ear sizes. A muff too small will cause uncomfortable pressure on the earlobe. A muff too large will not provide a tight seal. The interior cup opening should be reasonably small as well, to increase attenuation and to allow the cup cushion to make a wider seal with the ear. Earmuffs are available in passive or active types. Passive earmuffs use mechanical methods to attenuate loud noise, such as foam or silicon inserts (no electronic attenuation). Active earmuffs use electronic noise cancellation technology to attenuate loud noise while amplifying sounds in safe low ranges, such as normal conversation volumes. Active earmuffs are passive earmuffs with a microphone/speaker inside. The NRR range for passive earmuffs is typically 18 to 31, and the NRR for active earmuffs is typically 19 to 30.

COMPARISONS

Earplugs are preferable for long periods of wear (less pressure on the head), preferable in hot weather (less sweat problems) and cold (easily fit under hats), and are easier to store and carry. However, earplugs are more prone to be worn incorrectly because they are more dependent on individual comfort and fit.

Earmuffs are preferable for multiple removals/intermittent use, and offer more reliable protection with fewer restrictions due to fit and comfort. However, earmuffs can interfere with glasses and other headgear (Berger 2000). A good one-page comparison fact sheet is available for download from Yale University's Environmental Health and Safety website at http://ehs.yale.edu/sites/default/files/noiseposter.pdf.

SELECTION FACTORS TO CONSIDER

- Knowledge of the sound pressure levels to which the worker is exposed (a noise survey by a safety professional or using a sound level meter will be required).
- Proper sizing to ensure the device has the ability to form an airtight seal inside or over the ear.
- Convenience of muffs versus plugs in work situations requiring intermittent use and frequent removal (although many plugs can be purchased with connecting straps).
- Sanitation concerns (formable plugs require direct handling; pre-molded can be inserted without touching the part inserted into the ear canal).
- Temperature and humidity (muffs can be more uncomfortable in hot, humid environs).
- Importance of audibility and ability to communicate verbal warning signals.
- Personal comfort.

Inspection and Cleaning

Reusable plugs and muffs should be inspected periodically for rough edges, damage, or loose headbands, and replaced accordingly. Earmuff headband tension must remain taut or the result will be a significant loss of attenuation.

Earplugs that are of non-porous, cleanable material will need to be washed after each use and as a general sanitation rule, should never be shared among workers. Earplugs that are porous (compressible foam) should be disposed after each use to minimize the risk of ear infections. Earmuffs should likewise be cleaned as needed, taking care to carefully dry any exposed interior acoustic foam.

Training and Proper Use

HPDs are effective only if the devices are worn properly and consistently. For example, formable/disposable earplugs must be compressed/rolled, inserted while lifting up/back the earlobe to open the canal, and then held in the ear canal for a moment to allow expansion. All HPDs come with comprehensive instructions for donning and cleaning. Be sure to read and practice! Everyone's ear canals are different and you may need to try a few different types (foam vs rubber flanged) to be sure they fit snugly. Be sure to wash your hands before handling and inserting any HPD.

One of the barriers to workers not wearing HPDs is that they are not available when and where they are needed. Studies show that installing boxes or storage areas for proper muffs or plugs near the noise-producing equipment or work area cues workers to use them (Acutan 2015).

More information on how workers can protect themselves from NIHL on the job can be found on this NIOSH podcast (live streaming or MP3 download) at http://bit.ly/nihlpodcast.

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Questions about health and safety? Contact us at HealthandSafety@conservation-us.org

Don't forget to sign up for a Respirator Fit Test appointment at the annual meeting in Montreal! You must attend the lecture first, and have your annual physical completed by the meeting. Forms are available on the Health and Safety webpage, and you can register for the fit test lecture and appointment online at www.conservation-us.org/add-ticketed-events.

People

Robert (Bob) J. Hotes, AIA, NCARB, LEED AP BD+C, recently joined EYP Architecture and Engineering as Senior Historic Preservation Expert., Prior to joining EYP's Washington, DC, office, Hotes most recently led the Philadelphia office of Klein and Hoffman, Inc. as Restoration Architecture Group Leader and associate at the firm. He previously served as senior associate and senior preservation architect at Philadelphia's John Milner Architects, Inc. and RMJM/Hillier Architecture.

Julie Lauffenburger has been appointed as the Dorothy Wagner Wallis Director of Conservation and Technical Research at the Walters Art Museum, where she will oversee a team of seven full-time conservators, a conservation scientist, and numerous fellows and intern. She joined the Walters as an Andrew W. Mellon Fellow in 1991 and has been a departmental objects conservator since 1999. In 2015, she served as conservator and curator for the *Gold of the Ancient Americas* exhibition. Lauffenburger is also an associate editor for the *Journal of the American Institute for the Conservation of Historic and Artistic Works* and has lectured and published numerous scholarly essays and articles in her field.

Lois Olcott Price, recently retired from the Winterthur Museum in November as Director of Conservation. She continues as Adjunct Senior Conservator working on occasional projects at Winterthur and as a faculty member for WUDPAC. Aside from a more flexible schedule, she looks forward to continuing to teach workshops on the history and preservation of architectural/design/technical drawings, pursuing a few research projects and continuing as chair of the Advisory Council for the Iraqi Institute for the Conservation of Antiquities & Heritage. She can be reached at loprice@yahoo.com.

Melissa Swanson, a recent graduate of the Historic Preservation Masters of Science program at Columbia University, is now working for the Naval History and Heritage Command in Richmond, VA, at their new conservation and collections management facility. Her interests are outdoor sculpture, historic preservation, and materials conservation, and her master's thesis was on the performance of alkoxysilane stone consolidants.

Ariel O'Connor has recently been appointed Objects Conservator at the Smithsonian American Art Museum (SAAM) Lunder Conservation Center in Washington, DC. Prior to this position, she held appointments as Objects Conservator at the Smithsonian National Air and Space Museum and an Assistant Objects Conservator at the Walters Art Museum. She holds a M.A. and C.A.S. in Art Conservation from SUNY Buffalo State in 2009.