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Stopping Noise-Induced Hearing Loss in the Workplace

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Introduction

A quick quiz. Your facility has a continuous noise level of 100 decibels (dBA). Your worker wears an earplug with a Noise Reduction Rating of 30 dB. How much noise is reaching the eardrum of the worker?*

It's a question that strikes at the heart of hearing conservation efforts; yet most safety professionals have little idea how much protection is obtained by a noise-exposed worker.

Many well-intentioned managers follow best practice in offering hearing protectors and administering audiometric testing to noise-exposed workers. They are often surprised to find that their efforts simply document the progression of hearing loss, rather than prevent the loss. In the U.S. private sector, that liability grows now to an estimated $250 million annually, and the current military liability for NIHL and associated symptoms exceeds $1 billion annually.

Bad Assumptions

Employers invest the time and money to administer a regulatory-compliant Hearing Conservation Program (OSHA, MSHA, or some other regulatory authority), with the expectation that their compliance inoculates them from a compensation claim for hearing loss. But regulations are firmly entrenched in lagging indicators of hearing loss, like audiometric testing and the protector's Noise Reduction Rating. The hearing losses continue occurring, the high expectations are dashed, and claims for noise-induced hearing loss continue unabated -- or worse yet, climb higher. The following bad assumptions underlie many of these false expectations.

1. Providing hearing protection prevents hearing loss.

Many safety managers falsely assume that proper use of hearing protection is fairly intuitive ("just put it in your ear"). They provide little or no training in how to use protection properly, perhaps generously assuming that workers will read the manufacturer's instructions on the packaging.

A comprehensive study of hearing protector use in United Kingdom revealed that when Hearing Conservation training had been provided by posters or leaflets, less that half of the "trained" workers could recall even basic aspects of the content.[1] But repeated studies show that if that same training is delivered individually (one-on-one or in very small groups), the worker's

recall of the content skyrockets, and the worker is significantly more likely to obtain higher levels of protection. Large group training seems to have little effect in proper usage of hearing protection; only individual training can be linked to high attenuation results.

2. Any earplug in the ear is blocking some noise.

While intuition suggests anything in the ear canal must be blocking some noise, physics indicates otherwise. An earplug just sitting in the bowl of the outer ear, without sealing the ear canal, often creates a resonance cavity in the ear canal, increasing the noise level by a few decibels (similar to cupping your hand around your ear to hear better). This is problematic for a safety manager who is trying to evaluate compliance by visual inspections. He/she might assume that any worker wearing an earplug must be protected to some extent, and focus more on the workers who are wearing no protection at all. In reality, a poorly-fit earplug offers no protection, just like the worker with no earplug.

3. Audiometric testing prevents hearing loss.

Hearing conservation regulations throughout the world rely upon periodic audiometric testing as the bellwether indicator to determine if efforts are succeeding. But a worker must suffer a measurable hearing loss before a cautionary flag is ever raised. Audiometric testing identifies the earliest significant decline in hearing more than a year after initial employment. Consider the timeline of a best-case scenario for a worker losing hearing due to workplace noise:

- **Initial:** new hire receives a baseline audiogram and begins work in a noisy job.
- **Initial + 12 months:** Workers receives first annual audiogram and a shift in hearing is detected.
- **Initial + 14 months:** After a 30-day retest and follow-up reports, the worker is notified that hearing has declined significantly. Safety manager may intervene by offering different (more protective, higher NRR?) earplugs.

Does that early identification resolve the problem? Typically not. Employers must wait another year or two for another annual audiogram to confirm whether any intervention measures (engineering/administrative controls, refitting/retraining with the same earplug, use of a different hearing protector, etc.) effectively stopped the progression of hearing loss. Like the proverbial canary carried by the miner to detect deadly gases in the mine, a worker's sense of hearing is placed in the position of being the lagging indicator to determine if noise exposures are hazardous. In reality, three to five years can easily pass before determining whether the new hearing protection is any better (or worse) than the original hearing protection.

Due to a liberal 90 dB permissible exposure limit (nearly every other country in the world uses the more protective 85 dB limit) and over-reliance upon audiometric testing in regulations, NIOSH estimates that compliance with OSHA's Hearing Conservation standard still allows 23% to 32% of the exposed population to suffer material hearing impairment over a working lifetime. Indeed, it's not uncommon to hear a safety manager lament, "We've got ten years of audiometric data that show what we're doing in our Hearing Conservation Program doesn't really work."

4. I can de-rate the Noise Reduction Rating to estimate real-world protection values.

Since the EPA promulgated in 1974 its Noise Reduction Rating (NRR) on all hearing protector packaging, numerous studies have shown that average attenuation achieved in the real world is sometimes far below the laboratory-generated NRR. This may be due to several critical factors: users in the real world might not receive proper training, or may adjust their protectors for comfort rather than protection. Some users may intentionally compromise their fit in order to optimize their ability to hear co-workers and machine noises more clearly.

In response to this real-world disparity, a number of agencies have proposed various NRR de-rating schemes to better predict performance of hearing protectors in the ears of users in the field. An earplug that carries an NRR of 30 dB on the package, for example, may be given "credit" for 23 dB, 15 dB, 11 dB, or 2 dB, depending upon which of the contradictory de-rating methods, found in the published recommendations from government agencies, is applied.

In a 2007 field study, the attenuation of earplugs worn by 100 noise-exposed workers at eight different companies was measured. Workers wore a variety of earplugs from several different manufacturers. One-third of the tested workers achieved real-world attenuation that was equal to or higher than the published NRR for their respective earplug. The middle third of workers achieved attenuation within 5 decibels below the NRR, and the bottom third of workers showed real-world attenuation anywhere from 5-30 decibels below the published NRR for their selected earplugs.

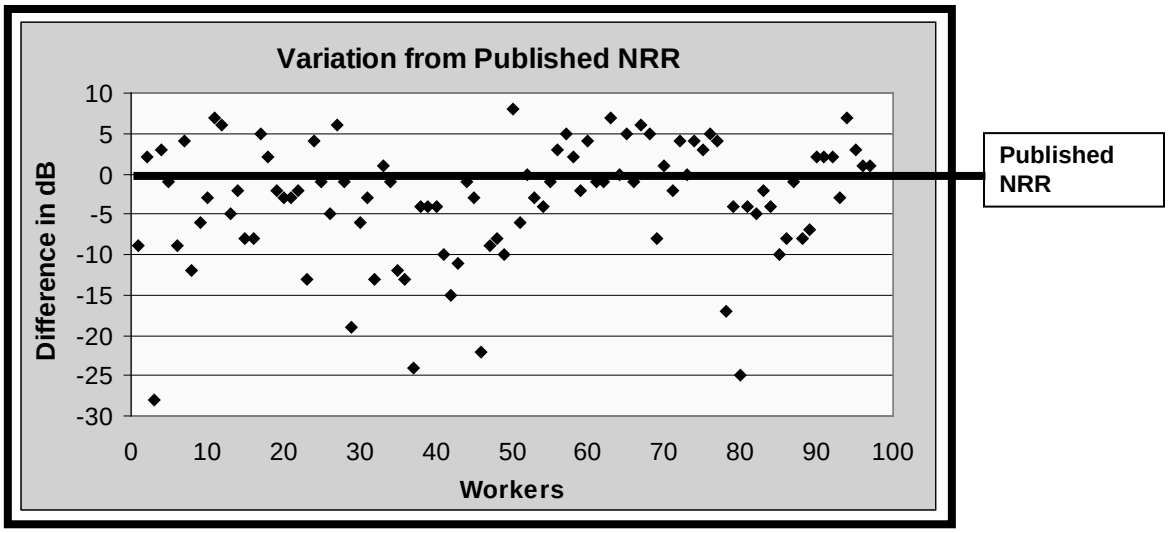

Figure 1. Real-world attenuation values from 100 noise-exposed workers at eight facilities. Solid line indicates the published NRR for the respective earplug used by the workers. Nearly one-third of workers achieved attenuation values higher than the published NRR. (From Howard Leight Acoustical Test Lab, San Diego, 2008).

Based on several real-world studies similar to this, one can see the futility of applying de-ratings to estimate protection levels. In the end, the performance of a hearing protector worn by

an individual in the workplace is completely impossible to predict using any laboratory rating method, with or without de-ratings.

5. It's impossible to measure how much protection a worker achieves in the real-world.

Instead of relying upon the laboratory population estimates of the NRR, a safety manager can now measure each worker's protection level on-site. At least five manufacturers currently offer fit-test systems for hearing protection, allowing a safety manager to document exactly how much protection a worker receives with a given protector. The result is a Personal Attenuation Rating (PAR). But that PAR is specific only to that earplug, that worker, and that particular fit. Fit-testing might not be feasible for some employers to administer on every noise-exposed worker in a facility, but it is certainly feasible for new hires, or workers demonstrating a significant threshold shift in their audiometric testing. OSHA regulations require these workers to be retrained and refit with appropriate protection, and fit-test systems allow employers to accomplish that very effectively.

Benefits of fit-testing of hearing protectors were highlighted in a recent Best Practices Bulletin published by an alliance of OSHA, NIOSH, and National Hearing Conservation Association (NHCA). The document (available from the website cited below[2]) endorses fit-testing as a best practice in a Hearing Conservation Program, and cites the major benefits, including employee training, refitting of workers with a threshold shift, and as being a helpful tool in selecting adequate hearing protectors for specific noise environments.

Lagging vs Leading Indicators of Hearing Loss

In a typical Hearing Conservation Program, it takes several years of audiometric testing to ascertain whether a worker has lost hearing due to workplace noise. And even after the determination of a significant threshold shift in hearing, the problem is not solved. It takes several more years of audiometric testing to determine if intervention has resolved the problem.

Leading indicators like fit-testing identify the workers most prone to hearing loss. Typically, fit-testing in a facility uncovers numerous workers who achieve sub-par protection, inevitably progressing toward a noise-induced hearing loss. Some fit-test systems provide on-screen training videos modeling the proper fitting techniques, and workers typically show an immediate improvement in attenuation when they are retested after this personal instruction. In other cases, better protection is achieved with a different earplug. In one field study of real-world fit, many workers achieved 20-30 decibels more protection simply by trying a different style of earplug.[3]

Fit-testing provides a momentary snapshot in time, valuable in training a worker in how to properly fit his hearing protection. It provides a user with valuable feedback to know what a properly fit earplug feels like and sounds like, but there is no guarantee the worker will continually wear the earplug with the same effectiveness demonstrated during the fit-test. To provide continuous real-time documentation while the worker is in noise, in-ear dosimetry can measure noise exposures under the hearing protectors.

Noise dosimetry is typically measured by clipping a microphone on the collar or hardhat of a noise-exposed worker. The resulting noise dose tells us the level of the ambient noise, but

tells nothing about the noise level reaching the eardrum of the worker, under the hearing protectors.

In-ear dosimetry uses dual miniature microphones, each inserted under the earplug or earmuff, to measure the noise dose at the eardrum. A worker with properly-fit protectors will have a safe noise dose (under 50%) at the end of the work shift. But if the worker has an inadequate fit, or removes the protectors repeatedly in high noise, the resulting noise dose at the end of the work shift will be excessive. This immediate feedback gives the worker (and the safety manager) the critical information to make immediate corrections. Using in-ear dosimetry, a worker knows before the end of his very first work shift whether hazardous noise is reaching the eardrum. If noise exposure is stopped at the eardrum, we have stopped the hearing loss.

Case Studies

Case #1

Committed to reducing its high rate of hearing shifts in its audiometric testing, one large multi-site manufacturer instituted fit-testing on over 1,500 production workers over multiple years. For their initial fit-test, workers were asked to use their usual earplugs (the ones they wore each day in production), fit in the usual manner with no assistance from the training team. Not surprisingly, 45% of the workers did not meet the minimum protection criterion set by the company (at least 15 decibels of protection in both ears), despite their participation in the company's long-standing Hearing Conservation Program. Those employees who did not pass the criterion on their first test received one-on-one fit-training, and in many cases, alternate earplugs were tried. The employees were then retested.

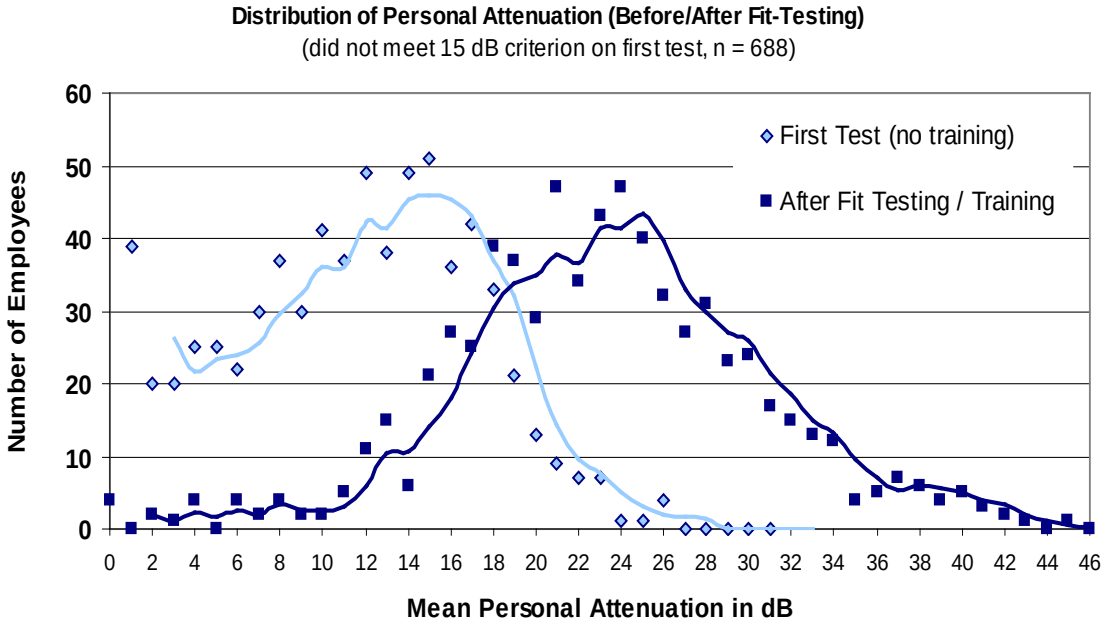

Figure 2. This distribution shows the number of employees who did not achieve the criterion 15 dB of protection on their first fit-test in both ears (n = 688), shown in left curve.

The right curve shows best results after training / refitting for these same workers. Mean personal attenuation improved significantly after training / refitting, from 11 dB to 23 dB as a group.

After individual fit-testing, retests confirmed the dramatic effect. Employees improved an average of 13 decibels in their protection levels, increasing average protection by 120% as a group. In a post-test survey, 84% of employees stated they were better able to fit their earplugs. And the post-test survey cards included many unsolicited comments from the workers: "I learned I've been using my earplugs wrong my whole career." "Just learned how to effectively roll the plug before insert." "I'll put a little more effort and get 'em deeper!" "Amazed at difference with proper fit."

Case #2

For one large smelter in the northwest, the OSHA-standard Hearing Conservation Program was not stopping hearing loss. "We've simply documented the progression of hearing loss," lamented one of the program managers. Despite all the components of a regulatory-compliant program in place, the liability for occupational hearing loss rose steadily year after year. Risk managers noted the dollar value of the pending liability for noise-induced hearing loss, and gathered to re-think the program.

The five-year trend line showed progressive hearing loss and claims activity among 46 of the highest noise-exposed workers. A program of in-ear dosimetry was instituted in 2005. Now, noise exposure at each worker's eardrum was defined as the bottom-line measure of exposures. In-ear dosimetry answers the question, how much noise is reaching the eardrum -- the only metric with direct potential to measure and prevent further progression of hearing loss.

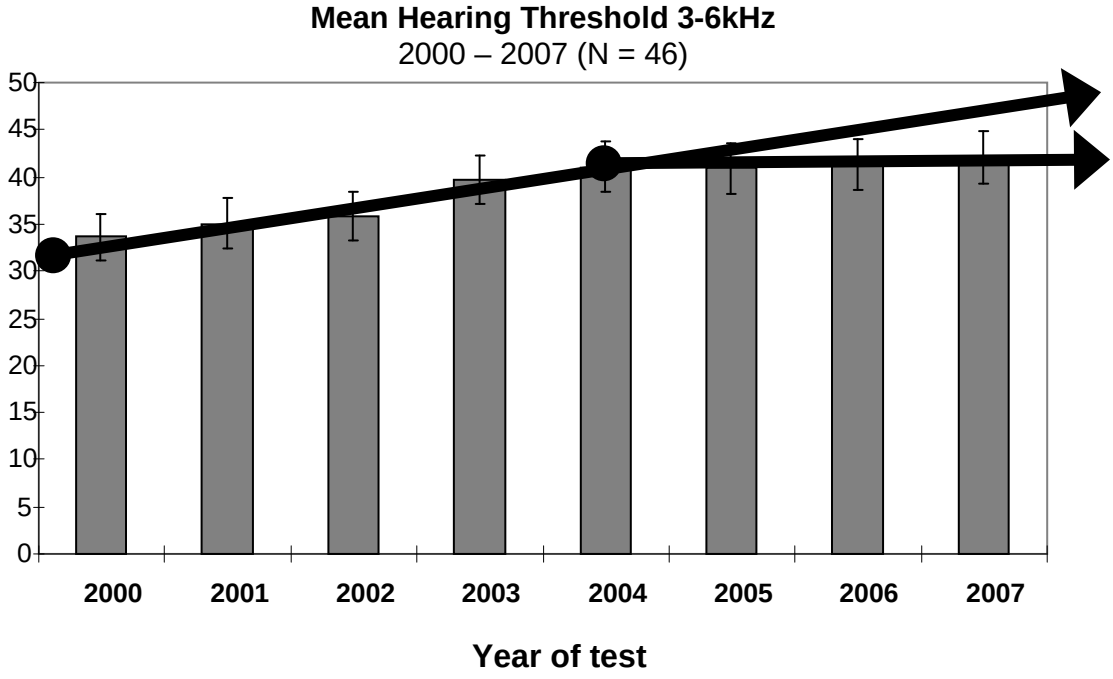

Figure 3. Mean hearing thresholds (in dB) of 46 high noise-exposed workers. Trend line before introduction of in-ear dosimetry shows continuing progression of loss. Trend line after introduction of in-ear dosimetry shows flat-line of hearing loss progression. (From K. Michael, 2009, used with permission)

The result of fitting high noise-exposed employees with in-ear dosimeters was impressive, and showed a flat-line of the trending hearing loss: no new hearing loss for these noise-exposed workers for succeeding years. Later analysis published by researchers at the Yale University School of Medicine confirmed no further progression of high-frequency hearing loss among 78 noise-exposed workers who were monitored.[4] And those who participated in the in-ear dosimetry program demonstrated significantly better protection than a control group of 234 workers, matched for age, duration of employment, initial hearing level, and similar noise levels in the facility.

Conclusion

Noise-induced hearing loss is not the automatic by-product of a noisy workplace. By implementing leading indicators in a Hearing Conservation Program, employers are empowered to prevent noise-induced hearing loss, rather than just documenting it through audiometric testing. And with best practices providing them a solid defense, employers can say with confidence, "We stopped hearing loss in our workplace."

*Wearing a 30 dB earplug, it is not uncommon for a worker in 100 dB of noise to receive anywhere from 60-103 dB of noise at the eardrum.

References

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2. Alliance Document published by OSHA and National Hearing Conservation Association, "Best Practices Bulletin - Emerging Trends: Individual Fit-Testing" (May 2008), available from: http://ohp.nasa.gov/topics/hear-cons/osha_alliance/AllianceRecommendationsForFitTesting_Final.pdf

3. Witt, B. "Fit Testing of Hearing Protectors." *Occupational Health & Safety*, 2 October 2007. http://ohsonline.com/articles/2007/10/fit-testing-of-hearing-protectors.aspx

4. Rabinowitz P., et al. "Effect of daily noise exposure monitoring on annual rates of hearing loss in industrial workers." *Occupational and Environmental Medicine*, published online 30 December 2010.