Evaluation of Noise Exposures in a City's Public Works Departments

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The employer is required to post a copy of this report for 30 days at or near the workplace(s) of affected employees. The employer must take steps to ensure that the posted report is not altered, defaced, or covered by other material.

The cover photo is a close-up image of sorbent tubes, which are used by the HHE Program to measure airborne exposures. This photo is an artistic representation that may not be related to this Health Hazard Evaluation. Photo by NIOSH.

Highlights of this Evaluation

The Health Hazard Evaluation Program received a request from a city manager concerning employees' noise exposures in several public works departments. We visited the city in March and June 2016.

What We Did

- We measured sound levels in the electric distribution, fire, operations, and water treatment departments.
- We measured 13 employees' noise exposures in the electric distribution, operations, parks and recreation, and water treatment departments.

What We Found

- High sound levels occurred when employees operated equipment such as chain saws, a wood chipper, a pothole patching truck, a sewer cleaning truck, lawn mowers, a front-end loader, and a hovercraft.
- Most employees in the electric distribution, operations, and parks and recreation departments were overexposed to noise.
- Employees in the water treatment department were not overexposed to noise.
- Some employees did not wear hearing protection when using noisy equipment or machinery.

We evaluated noise exposure in public works departments of a small city. We measured noise exposures above occupational noise exposure limits in the electric distribution, operations, and parks and recreation departments. Exposures were highest for employees using the chipper, the chainsaw, the pothole patcher, the sewer cleaning machine, lawn mowers, and hovercraft. We recommend starting a hearing conservation program that includes audiometric testing and providing hearing protection and training.

What the Employer Can Do

- Require employees in the electric distribution, operations, and parks and recreation departments to wear hearing protection when using noisy equipment and machinery.
- Require law enforcement officers using the firing range and fire fighters using the hovercraft to wear ear plugs and earmuffs.
- Start a hearing conservation program for employees in the electric distribution, operations, and parks and recreation departments.
- When hearing protection is required, supply a variety of device types, and make sure employees wear their hearing protection properly.
- Ask employees to report health symptoms they consider to be work related to their supervisor and health care provider.

What Employees Can Do

- Wear hearing protection when using noisy equipment and machinery to help prevent hearing loss.
- Wear ear plugs and earmuffs when working on the hovercraft and shooting firearms in the firing range.
- Report symptoms you believe to be work related to your supervisor.
- Tell your healthcare provider that you work in areas with high noise levels and about hearing problems you may have.

Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienists
AL	Action level
CFR	Code of Federal Regulations
dB	Decibels
dBA	Decibels, A-weighted
Hz	Hertz
NIHL	Noise-induced hearing loss
NIOSH	National Institute for Occupational Safety and Health
OEL	Occupational exposure limit
OSHA	Occupational Safety and Health Administration
PEL	Permissible exposure limit
REL	Recommended exposure limit
TLV	Threshold limit value
TWA	Time-weighted average
WEEL	Workplace environmental exposure limit

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Introduction

The Health Hazard Evaluation Program received a request from a municipal human resources director to evaluate noise exposures in the city's electric distribution, fire, operations, parks and recreation, and water treatment departments. We visited the city of about 10,000 residents in March 2016 and June 2016. After each visit, we sent letters to the human resources director and employee representative summarizing our activities. We also sent personal noise sampling results to employees who requested them.

Background

Public works department buildings were located throughout the city. Table 1 summarizes the departments and employee activities that we evaluated.

Table 1. City departments evaluated for noise

Department	Potential noise sources in the department
Electric distribution	Use of gasoline-powered equipment such as chain saws and a wood chipper
Operations	Operating a sewer cleaning truck, street sweeper, pothole patching machine, and truck-mounted sprayer used for mosquito control
Parks and recreation	Use of gasoline-powered riding lawn mowers
Water treatment	High-service pump room
Fire	Use of a hovercraft for search and recovery activities on a nearby river; testing fire-fighting equipment

The city did not have a written hearing conservation program but provided hearing protection to its public works employees for voluntary use.

Methods

The objectives of this evaluation were to (1) measure employees' noise exposures and sound levels, (2) determine whether a hearing conservation program was needed, and (3) identify possible noise control measures that could be implemented to decrease employees' noise exposures.

During our first site visit, we measured real-time, instantaneous sound levels using a Quest Technologies® Model 2400 Type II Sound Level Meter to identify tasks or equipment with potentially high noise levels. During our second site visit, we used Larson Davis Spark™ 706RC integrating noise dosimeters to measure full-shift time-weighted average (TWA) personal noise exposure on 13 employees in four departments. We placed the dosimeter microphone on the top of the employee's shoulder at the midpoint between the neck and edge of the shoulder.

Because the Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH) measure and calculate noise in

different ways, the noise dosimeters we used simultaneously collected data on three different settings. This allows us to compare noise measurements with the OSHA permissible exposure limit (PEL), the OSHA action level (AL), and the NIOSH recommended exposure limit (REL). These noise exposure limits are meant to be the amount of noise that most employees can be exposed to without substantial risk of hearing loss. We also used the sound level meter to take instantaneous noise measurements. Additional information on noise exposure limits and health effects is provided in Appendix A.

Results and Discussion

A summary of full-shift TWA personal dosimetry measurements are shown in Table 2. For an 8-hour work shift, the NIOSH REL is 85 decibels, A-weighted (dBA). The OSHA AL is 85 dBA, and the OSHA PEL is 90 dBA. Employers are required to keep noise exposures below OSHA limits. However, NIOSH considers its REL to be more protective. Using the NIOSH criteria, we found overexposures to noise in three of the four departments we evaluated. Employees in the electric distribution and operations departments had overexposures to noise above the OSHA AL. The only employee with noise exposure above the OSHA PEL was the wood chipper in the electric distribution department.

Electric Distribution Department

The two employees we sampled had noise exposures exceeding the NIOSH REL on both days we sampled. One employee operated a wood chipper, the other a gasoline-powered chain saw while suspended from a telescopic truck-mounted boom; both did these tasks for their full work shift on day 1. The chipper operator's exposure also exceeded the OSHA AL on both days and the OSHA PEL on 1 of the 2 days. The chipper operator's exposures were below both OSHA limits on both days. On the second day both employees stopped work mid-day because of the weather, thus reducing their noise exposures compared to a full work day. We saw the chipper operator standing within a few feet of the running chipper while waiting for the chainsaw operator to cut down branches. Remaining near the chipper while waiting for wood to feed into it exposed the operator to unnecessary noise. Both employees wore earmuffs (noise reduction rating, 22 dBA) attached to hard hats, leather gloves, and safety shoes while cutting and chipping tree branches. The chainsaw operator used a face shield that was attached to his hard hat for eye protection, while the chipper operator wore sunglasses without side shields. Using proper eye protection can keep foreign particles from entering and injuring the eye.

Table 2. Summary of TWA personal noise exposures, in dBA

Department and job tasks	Result based on NIOSH REL criterion	Result based on OSHA AL criterion	Result based on OSHA PEL criterion
Electric			
Wood chipper, day 1	94.0	87.9	87.5
Wood chipper, day 2*	98.2	94.0	93.7
Chainsaw operator, day 1	90.4	83.4	81.5
Chainsaw operator, day 2	92.1	84.6	83.3
Operations			
Pothole patching truck operator #1	91.6	87.8	85.6
Pothole patching truck operator #2	89.7	86.7	82.4
Sewer cleaning truck operator #1	90.8	86.6	84.1
Sewer cleaning truck operator #2	89.1	86.1	81.6
Front-end loader	87.5	82.0	75.1
Street-sweeping	84.8	83.1	68.6
Miscellaneous†	79.2	72.8	63.7
Mosquito-sprayer truck	79.3	74.5	59.9
Parks and recreation			
Lawnmower #1‡	90.3	88.9	87.7
Lawnmower #2	90.0	88.2	87.8
Lawnmower #3	89.0	87.2	86.1
Water treatment			
Operator #1, day 1	75.7	69.1	50.2
Operator #2, day 1	78.7	65.2	55.3
Operator #1, day 2	78.1	72.5	57.0
Occupational exposure limit (8-hour work shift)	85	85	90

*Dosimeter malfunctioned and ended measurements 2 hours before the end of the work shift.

†Dosimeter malfunctioned while sampling one employee on the second day of monitoring. Those results are not reported.

‡Employees only operated lawn mowers for 3 hours of the work shift.

Operations Department

Five of eight employees we sampled had noise exposure measurements exceeding the NIOSH REL. Four also exceeded the OSHA AL, but none exceeded the OSHA PEL. Most of the noise in the operations department occurred from using heavy machinery. For example, employees operating and using the sewer cleaning truck or the pothole patching truck were exposed to noise levels above the NIOSH REL and OSHA AL. During sewer cleaning, one employee remained in the cab to operate the truck while the other employee stood outside of the truck to manually operate the water and vacuum hoses. The truck operator, who did not wear hearing protection, had noise exposures slightly lower than the hose operator who reported wearing hearing protection intermittently, but did not wear hearing protection during our evaluation. Most of the noise during sewer cleaning came from the high-powered water

hose used to clean the sewers and the vacuum hose used to capture water and debris. During pothole patching, one employee manually operated the air nozzle and asphalt injection hose used to fill potholes. The other employee operated the dump truck and compacted the asphalt in the newly-filled potholes using a gasoline-powered tamper. Much of the noise during pothole patching came from the air nozzle, injection hose, and the tamper. We observed that the front-end loader operator remained inside the cab while loading and unloading mulch at the city's recycling center. While remaining in the cab reduced his noise exposure, the cab windows were not always kept rolled up, thus allowing some noise to enter.

Operations department employees involved in street sweeping, mosquito spraying, transporting and setting up traffic barricades, and driving a city dump trunk or pickup truck were not overexposed to noise during our evaluation. In many instances the employees could operate the machinery from inside their vehicle, thus avoiding direct exposure to the noise generated by the equipment such as the sweeper and truck-mounted sprayer. None of these employees wore hearing protection.

Use of hearing protection in the operations department varied with employee and task. Some employees always wore hearing protection, while others wore hearing protection only when they thought the task they were conducting was noisy or when it was convenient and comfortable to wear hearing protection. One of the operations department employees provided his own hearing protection because he found them to be more comfortable than those provided by the department.

Parks and Recreation Department

Two of three employees we sampled were exposed to noise exceeding the NIOSH REL, but none exceeded the OSHA AL or PEL. During our evaluation these two employees mowed for less than 3 hours because of a special event in the city. Employees informed us that they typically mowed up to a full 8-hour shift twice per week. If the employees had mowed for an 8-hour work shift, their TWA noise exposures would be approximately 89–91 dBA using NIOSH REL criteria, 86–88 dBA using OSHA AL criteria, and 87–89 dBA using OSHA PEL criteria. Because we were unable to sample during a normal full shift, we recommend conducting additional noise monitoring when employees are mowing for their full work shift to determine if their exposures exceed occupational exposure limits (OELs). One mower operator wore hearing aids and no hearing protection. This employee explained that he did not wear hearing protection because his hearing was already impaired, and he believed that hearing aids would provide adequate protection. Other mower operators wore earmuffs or ear plugs, but we were not able to determine if this hearing protection was consistently worn correctly because the areas being mowed were too large for us to observe.

Water Treatment Department

None of the water treatment department employees we tested were overexposed to noise during our evaluation. Although sound levels reached over 90 dBA in many areas of the water treatment plant, such as mechanical and pump rooms, employees spent very little time in these areas. Water treatment department employees generally worked inside offices, labs,

and other areas with low noise levels, occasionally entering the mechanical areas and pump rooms to adjust settings and conduct maintenance. Water treatment department employees did not use hearing protection during their routine work. However, we encourage the use of hearing protection when employees work in mechanical areas or pump rooms. The department had a set of earmuffs in the unoccupied water intake building for use when the alarm is activated and an employee needs to enter the water intake building while the alarm is still on. According to water department employees this event occurred infrequently.

Fire Department

Although we did not conduct full-shift noise monitoring in the fire station, we discussed noise concerns and hearing protection use with fire fighters. We also took sound level measurements at the fire station. Most high noise activities occurred during scheduled maintenance and routine testing of fire-fighting equipment. Noisy activities where hearing protection should be worn include refilling air tanks after a fire and during weekly checks of apparatus and equipment.

Fire fighters stated that hearing protection was not required. Recently, fire fighters used the hovercraft for a water rescue in a nearby river and did not wear hearing protection. A fire fighter participating in that rescue described temporary hearing loss and the symptoms of tinnitus (ringing in the ears) immediately following hovercraft operation for several hours. We measured noise levels of 115 dBA during test operation of the hovercraft. On the basis of these noise levels hearing protection should be required when operating the hovercraft. Because maximum noise levels are above 115 dBA during hovercraft use, dual hearing protection (i.e., both ear plugs and earmuffs) should be worn during hovercraft operation.

General Observations

Most departments tested their emergency generators every 2 weeks. During our testing of three generators, the noise levels near the generators reached 95–114 dBA. Employees conducting the testing wore hearing protection provided by the department. Employees only remained near the generators for the time needed to complete the test, typically less than 1 minute. This work practice does reduce unnecessary noise exposure. However, it is still recommended that employees wear hearing protection while working in and around the generators. Some department employees stated that the generators were scheduled to be replaced with remote-controlled generators in 2017. This change should further reduce employees' noise exposures during generator testing.

We learned from discussions with managers and employees that the types of hearing protectors and amount of training varied between departments. Because of the geographic separation of the departments, administering the hearing conservation program and associated training in the city's human resources department would make it easier to maintain uniform record-keeping and training.

Conclusions

Some public works employees in the electric distribution, operations, and parks and recreation departments were overexposed to noise. High noise exposures occurred while using gasoline-powered chain saws, the wood chipper, and riding lawn mowers. Operations department employees operating sewer cleaning and pothole patching equipment were also overexposed to noise. We did not measure full-shift noise exposures in the fire department, but we measured high noise levels during the testing of equipment. We did not measure noise exposures in the police department's shooting range, but past NIOSH health hazard evaluations in shooting ranges showed high noise levels requiring the use of dual hearing protection (ear plugs and muffs). Each city department had different types of hearing protection available, but voluntary use by employees was inconsistent. The city also did not have a hearing loss prevention program that included audiometric testing and training in the use of hearing protection and its role in protecting hearing.

Recommendations

On the basis of our findings, we recommend the actions listed below. We encourage the city to use an employee-employer health and safety committee or working group to discuss our recommendations and develop an action plan. Those involved in the work can best set priorities and assess the feasibility of our recommendations for the specific situation in the city's public works departments.

Our recommendations are based on an approach known as the hierarchy of controls. This approach groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install engineering controls to reduce exposure or shield employees. Until such controls are in place, or if they are not effective or feasible, administrative measures and personal protective equipment may be needed.

Engineering Controls

Engineering controls reduce employees' exposures by removing the hazard from the process or by placing a barrier between the hazard and the employee. Engineering controls protect employees effectively without placing primary responsibility of implementation on the employee.

1. Replace manually controlled generators with remote-controlled generators.
2. Identify and purchase equipment and machinery that generates the least noise when replacing or purchasing new equipment and machinery. More information can be found at https://www.cdc.gov/niosh/topics/buyquiet/.

Administrative Controls

The term administrative controls refers to employer-dictated work practices and policies to reduce or prevent hazardous exposures. Their effectiveness depends on employer commitment and employee acceptance. Regular monitoring and reinforcement are necessary to ensure that policies and procedures are followed consistently.

1. Implement a hearing loss prevention program for employees in departments that conduct high-noise tasks. The program should include annual audiometric testing, hearing protection, and training. More information on establishing a hearing loss prevention program can be found at http://www.cdc.gov/niosh/docs/98-126/pdfs/98-126.pdf, https://www.osha.gov/dts/osta/otm/new_noise/index.html, and http://www.osha.gov/Publications/osha3074.pdf.
2. Conduct hearing conservation training in departments with high noise exposure. Hearing conservation training should be uniform across departments and include information about noise hazards, how noise exposures affect hearing and health, and what protective measures should be used to prevent noise exposure and hearing loss.
3. Ask employees to report any symptoms they consider to be work related to their supervisor and their personal physician.

Personal Protective Equipment

Personal protective equipment is the least effective means for controlling hazardous exposures. Proper use of personal protective equipment requires a comprehensive program and a high level of employee involvement and commitment. The right personal protective equipment must be chosen for each hazard. Supporting programs such as training, change-out schedules, and medical assessment may be needed. Personal protective equipment should not be the sole method for controlling hazardous exposures. Rather, personal protective equipment should be used until effective engineering and administrative controls are in place.

1. Require employees to use hearing protection when operating the chainsaw, wood chipper, pothole patching truck, sewer cleaner, front-end loader, and lawn mower; and during any other high-noise tasks.
2. Require fire fighters to wear dual hearing protection (i.e., ear plugs and earmuffs) when operating the hovercraft. Additionally, fire fighters should wear hearing protection during weekly testing of equipment and apparatus that generates high noise levels.
3. Require law enforcement officers to wear dual hearing protection when shooting firearms in the firing range.
4. Provide hands-on training for employees on how to insert hearing protectors properly and the importance of proper hearing protector fit.
5. Conduct hearing protector fit testing to ensure that employees' hearing protection provides sufficient noise attenuation. Proper insertion of the hearing protection is critically important to ensure adequate noise attenuation. Hearing protection must attenuate noise levels to less than 85 dBA to provide adequate protection. Noise attenuation of insert-type hearing protection by individual users depends on the type of hearing protector, shape of the user's ear canal, how well the hearing protector fits, and proper insertion of the hearing protector. Several hearing protection manufacturers have developed methods for fit testing individual employees to determine the attenuation they actually receive from the hearing protectors they use.
6. Provide employees with proper eye protection and train them on its importance and use.

Appendix A: Occupational Exposure Limits and Health Effects

NIOSH investigators refer to mandatory (legally enforceable) and recommended OELs for chemical, physical, and biological agents when evaluating workplace hazards. OELs have been developed by federal agencies and safety and health organizations to prevent adverse health effects from workplace exposures. Generally, OELs suggest levels of exposure that most employees may be exposed to for up to 10 hours per day, 40 hours per week, for a working lifetime, without experiencing adverse health effects. However, not all employees will be protected if their exposures are maintained below these levels. Some may have adverse health effects because of individual susceptibility, a pre-existing medical condition, or a hypersensitivity (allergy). In addition, some hazardous substances act in combination with other exposures, with the general environment, or with medications or personal habits of the employee to produce adverse health effects. Most OELs address airborne exposures, but some substances can be absorbed directly through the skin and mucous membranes.

Most OELs are expressed as a TWA exposure. A TWA refers to the average exposure during a normal 8- to 10-hour workday. Some chemical substances and physical agents have recommended short-term exposure limit or ceiling values. Unless otherwise noted, the short-term exposure limit is a 15-minute TWA exposure. It should not be exceeded at any time during a workday. The ceiling limit should not be exceeded at any time.

In the United States, OELs have been established by federal agencies, professional organizations, state and local governments, and other entities. Some OELs are legally enforceable limits; others are recommendations.

- The U.S. Department of Labor OSHA PELs (29 CFR 1910 [general industry]; 29 CFR 1926 [construction industry]; and 29 CFR 1917 [maritime industry]) are legal limits. These limits are enforceable in workplaces covered under the Occupational Safety and Health Act of 1970.
- NIOSH RELs are recommendations based on a critical review of the scientific and technical information and the adequacy of methods to identify and control the hazard. NIOSH RELs are published in the *NIOSH Pocket Guide to Chemical Hazards* [NIOSH 2010]. NIOSH also recommends risk management practices (e.g., engineering controls, safe work practices, employee education/training, personal protective equipment, and exposure and medical monitoring) to minimize the risk of exposure and adverse health effects.
- Other OELs commonly used and cited in the United States include the threshold limit values (TLVs), which are recommended by the American Conference of Governmental Industrial Hygienists (ACGIH), a professional organization, and the Workplace Environmental Exposure Levels (WEELs), which are recommended by the American Industrial Hygiene Association, another professional organization. The TLVs and WEELs are developed by committee members of these associations from a review of the published, peer-reviewed literature. These OELs are not consensus standards. TLVs are considered voluntary exposure guidelines for use by industrial hygienists and others

trained in this discipline "to assist in the control of health hazards" [ACGIH 2016]. WEELs have been established for some chemicals "when no other legal or authoritative limits exist" [AIHA 2016].

Outside the United States, OELs have been established by various agencies and organizations and include legal and recommended limits. The Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (Institute for Occupational Safety and Health of the German Social Accident Insurance) maintains a database of international OELs from European Union member states, Canada (Québec), Japan, Switzerland, and the United States. The database, available at http://www.dguv.de/ifa/GESTIS/GESTIS-Internationale-Grenzwerte-für-chemische-Substanzen-limit-values-for-chemical-agents/index-2.jsp, contains international limits for more than 2,000 hazardous substances and is updated periodically.

OSHA requires an employer to furnish employees a place of employment free from recognized hazards that cause or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970 (Public Law 91–596, sec. 5(a)(1))]. This is true in the absence of a specific OEL. It also is important to keep in mind that OELs may not reflect current health-based information.

When multiple OELs exist for a substance or agent, NIOSH investigators generally encourage employers to use the lowest OEL when making risk assessment and risk management decisions. NIOSH investigators also encourage use of the hierarchy of controls approach to eliminate or minimize workplace hazards. This includes, in order of preference, the use of (1) substitution or elimination of the hazardous agent, (2) engineering controls (e.g., local exhaust ventilation, process enclosure, dilution ventilation), (3) administrative controls (e.g., limiting time of exposure, employee training, work practice changes, medical surveillance), and (4) personal protective equipment (e.g., respiratory protection, gloves, eye protection, hearing protection). Control banding, a qualitative risk assessment and risk management tool, is a complementary approach to protecting employee health. Control banding focuses on how broad categories of risk should be managed. Information on control banding is available at http://www.cdc.gov/niosh/topics/ctrlbanding/. This approach can be applied in situations where OELs have not been established or can be used to supplement existing OELs.

Noise

Noise-induced hearing loss (NIHL) is an irreversible condition that progresses with noise exposure. It is caused by damage to the nerve cells of the inner ear and, unlike some other types of hearing disorders, cannot be treated medically [Berger et al. 2003]. More than 22 million U.S. workers are estimated to be exposed to workplace noise levels above 85 dBA [Tak et al. 2009]. NIOSH estimates that workers exposed to an average daily noise level of 85 dBA over a 40-year working lifetime have an 8% excess risk of material hearing impairment. This excess risk increases to 25% for an average daily noise exposure of 90 dBA [NIOSH 1998]. NIOSH defines material hearing impairment as an average of the hearing threshold levels for both ears that exceeds 25 decibels (dB) at frequencies of 1,000 Hertz (Hz), 2,000 Hz, 3,000 Hz, and 4,000 Hz.

Although hearing ability commonly declines with age, exposure to excessive noise can increase the rate of hearing loss. In most cases, NIHL develops slowly from repeated exposure to noise over time, but the progression of hearing loss is typically the greatest during the first several years of noise exposure. NIHL can also result from short-duration exposures to high noise levels or even from a single exposure to an impulse noise or a continuous noise, depending on the intensity of the noise and the individual's susceptibility to NIHL [Berger et al. 2003]. Noise-exposed workers can develop substantial NIHL before it is clearly recognized. Even mild hearing losses can impair a person's ability to understand speech and hear many important sounds. In addition, some people with NIHL also develop tinnitus. Tinnitus is a condition in which a person perceives sound in one or both ears, but no external sound is present. Persons with tinnitus often describe hearing ringing, hissing, buzzing, whistling, clicking, or chirping like crickets. Tinnitus can be intermittent or continuous and the perceived volume can range from soft to loud. Currently, there is no cure for tinnitus.

The preferred unit for reporting of noise measurements is the dBA. A-weighting is used because it approximates the "equal loudness perception characteristics of human hearing for pure tones relative to a reference of 40 dB at a frequency of 1,000 Hz" and is considered to provide a better estimation of hearing loss risk than using unweighted or other weighting measurements [Berger 2003].

Employees exposed to noise should have baseline and yearly hearing tests to evaluate their hearing thresholds and determine whether their hearing has changed over time. Hearing testing should be done in a quiet location, such as an audiometric test booth where background noise does not interfere with accurate measurement of hearing thresholds. In workplace hearing conservation programs, hearing thresholds must be measured at 500 Hz, 1,000 Hz, 2,000 Hz, 3,000 Hz, 4,000 Hz, and 6,000 Hz. Additionally, NIOSH recommends testing at 8,000 Hz [NIOSH 1998]. The OSHA hearing conservation standard requires analysis of changes from baseline hearing thresholds to determine if the changes are substantial enough to meet OSHA criteria for a standard threshold shift. OSHA defines a standard threshold shift as a change in hearing threshold (relative to the baseline hearing test) of an average of 10 dB or more at 2,000 Hz, 3,000 Hz, and 4,000 Hz in either ear [29 CFR 1910.95]. If a standard threshold shift occurs, the company must determine if the hearing loss also meets the requirements to be recorded on the OSHA Form 300 Log of Work-Related Injuries and Illnesses [29 CFR 1904.1]. In contrast to OSHA, NIOSH defines a significant threshold shift as a change in the hearing threshold level of 15 dB or more (relative to the baseline hearing test) at any test frequency in either ear measured twice in succession [NIOSH 1998].

NIOSH has an REL for noise of 85 dBA, as an 8-hour TWA. For calculating exposure limits, NIOSH uses a 3-dB time/intensity trading relationship, or exchange rate. Using the NIOSH criterion, an employee can be exposed to 88 dBA for no more than 4 hours, 91 dBA for 2 hours, 94 dBA for 1 hour, 97 dBA for 0.5 hours, etc. Exposure to impulsive noise should never exceed 140 dBA. For extended work shifts NIOSH adjusts the REL to 84.5 dBA for a 9-hour shift, 84.0 dBA for a 10-hour shift, 83.6 dBA for an 11-hour shift, and 83.2 dBA for a 12-hour work shift. NIOSH recommends the use of hearing protection and implementation of

a hearing loss prevention program when noise exposures exceed the REL [NIOSH 1998].

The OSHA noise standard specifies a PEL of 90 dBA and an AL of 85 dBA, both as 8-hour TWAs. OSHA uses a less conservative 5-dB exchange rate for calculating the PEL and AL. Using the OSHA criterion, an employee may be exposed to noise levels of 95 dBA for no more than 4 hours, 100 dBA for 2 hours, 105 dBA for 1 hour, 110 dBA for 0.5 hours, etc. Exposure to impulsive or impact noise must not exceed 140 dB peak noise level. OSHA does not adjust the PEL for extended work shifts. However, the AL is adjusted to 84.1 dBA for a 9-hour shift, 83.4 dBA for a 10-hour shift, 82.7 dBA for an 11-hour shift, and 82.1 dBA for a 12-hour work shift. OSHA requires implementation of a hearing conservation program when noise exposures exceed the AL [29 CFR 1910.95].

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