

accounting for the variable use of hearing protection in each trade, were calculated and used to group subjects by trade-specific exposure level. Mixed effects models were used to estimate the change in hearing outcomes over time for each exposure group, while adjusting for age, gender, previous noise exposure, and baseline audiometry, and accounting for subject and ear. Small but significant exposure-related changes in DPOAEs, on the order of -0.5 dB per year at 90 dB exposure, were observed, especially at 4 kHz, with less clear but similar patterns observed at 3 kHz. Pure tone audiometric thresholds displayed only slight trends toward increased threshold levels with increasing exposure groups. The effect of using alternative approaches to noise exposure metrics are explored. The results indicate that construction apprentices in their first three years of work, with average noise exposures under 90 dBA, have measurable losses of hearing function. Despite numerous challenges in using DPOAEs for hearing surveillance in an industrial setting, they appear somewhat more sensitive to these early changes than are evident with standard pure tone audiometry.

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EFFECTIVENESS OF HEARING PROTECTION IN THE CONSTRUCTION INDUSTRY. R. Neitzel, N. Seixas, University of Washington, Seattle, WA.

Hearing conservation programs in the construction industry are rare, and, where present, often rely on workers' use of hearing protection devices (HPDs) to reduce exposures below 85 dBA. This reliance on HPDs for protection from high noise is problematic, as the degree of protection provided by an HPD depends on not only the HPD's attenuation level, but also the amount of exposure time during which the HPD is used. Noise exposure and HPD use data drawn from construction apprentices employed in nine construction trades were analyzed to assess HPD effectiveness. A combination of one-minute dosimetry noise levels and simultaneous self-reported HPD use was evaluated, as were occupational HPD use data collected by questionnaire as part of a longitudinal study of noise exposure and hearing loss in construction workers. Direct measurements of earplug attenuation were also made on workers using the FitCheck attenuation measurement system. The mean full-shift noise levels across more than 700 workshifts exceeded 85 dBA for all but one trade, and nearly one-third of all monitored minutes were above 85 dBA. Workers used HPDs less than one-quarter of the time they were needed (i.e., when exposure levels exceeded 85 dBA.) Workers who reported "always" using HPDs in high noise on questionnaires actually wore them only one-third of the time they were needed. Direct attenuation measurements showed that, on average, workers achieved more than 50% of the labeled Noise Reduction Rating of their earplug, but that the variability in achieved attenuation was large. Lastly, when the measured earplug

attenuation levels and use time data were combined, the effective protection afforded by HPDs was less than 3 dB on average. Overall, HPD use reduced overexposure situations for only 20% of the measured full-shift exposures. These results demonstrate the need for better hearing conservation efforts in the construction industry.

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ACTIVE CONTROL OF LONGWALL COAL MINING NOISE. J. Slagley, U.S. Air Force, Morgantown, WV; A. Rai, S. Guffey, Y. Luo, West Virginia University, Morgantown, WV.

A NIOSH study indicated that 90% of coal miners experience hearing loss by the age of 50, compared to a 10% rate of loss by age 51 for the non-exposed comparison population. Due to the high degree of mechanization and confined environments, noise levels at longwall mining faces routinely exceed 90 dBA. The two major sources of noise in a longwall face are: *machine noise* produced by the mining machines, and *background noise* produced by the breakage and movement of surrounding rock strata.

Eleven underground surveys were conducted on longwall coal mining faces. Noise sources which most contributed to the miners' dose were identified for interventions, with particular attention to those that could be reduced using active noise control techniques. The one selected for further analysis was the headgate operator, who is exposed by the stageloader/crusher, a machine which crushes the coal coming from the face and loads it onto a belt for removal from the mine.

Active noise control (ANC) experiments were conducted on a laboratory model of the stageloader/crusher using recorded underground stageloader noise. ANC achieved a reduction of 7–10 dB (5–7 dBA) overall, mostly at frequencies below 1000 Hz. For the next tests, the recorded stageloader noise was broadcast inside an inoperative stageloader/crusher and counteracted with active noise control. The ANC reduced the noise 3–5 dB (1–3 dBA). Important factors in the experiments included aspect ratio, cross-sectional area of the air space inside the machine, and change of coal height.

If practically implemented underground, the system potentially could reduce the workers' noise dose and associated hearing loss.

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EFFECTIVENESS OF ENGINEERING CONTROLS TO REDUCE OCCUPATIONAL NOISE EXPOSURE TO SAWMILL WORKERS. B. Takacs, D. Whiteman, K. Johnson, West Virginia University, Morgantown, WV.

West Virginia University Safety and Health Extension, WVUSHE, has had the opportunity to work with the sawmill industry in West Virginia through a small business outreach program. Initially, WVU was contacted to perform

baseline monitoring for sawmills without noise monitoring data and to conduct follow-up evaluation for sawmills having a hearing conservation program. OSHA enacted a state emphasis program in and around the time of these noise surveys that required sawmills to implement engineering controls aimed at achieving at least a 3-dBA reduction in sawmill worker exposures.

WVUSHE provided general written recommendations and technical assistance to sawmills participating in the outreach program. This podium session or poster will share results of noise monitoring which includes dosimetry and sound levels collected pre- and post-engineering control implementation. Also, the types of materials and designs that were used to achieve feasible engineering controls will be highlighted. Other positive outcomes such as improvements in air quality and worker comfort are noted. In some instances, control implementation had to be modified several times to achieve desired reduction levels and lessons learned during this process will be shared. Workers' use of hearing protection and results of audiometric testing will be discussed. Furthermore, this partnership demonstrates the utility of university—private industry working relationships aimed at improving worker health and comfort.

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IMPLEMENTING TASK-BASED EXPOSURE ASSESSMENT FOR NOISE.

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Purpose. More than 30 million U.S. workers are exposed to TWA noise levels > 85 dB, a level associated with significant hearing loss risk. The eight-hour TWA using dosimetry is the most common noise metric, but does not capture task level characteristics (e.g., high exposure tasks) nor the complexities of time-varying or impulsive noise exposures. Task-based (TB) strategies permit high-noise task identification, targeting of controls, and fuller noise characterization for development of damage-risk models that incorporate time-varying and impulsive noise aspects. Implementation of a TB strategy is described. **Methods.** NIOSH studied 364 workers at three manufacturing plants (60–85% workers exposed to > 85 dB.). One study's aim was to examine measurement variability in daily noise TWAs by conducting simultaneous dosimetry and TB sampling with three repeated measures per worker.

Department and job lists, layouts, job descriptions, and historical noise data were obtained from each plant. Jobs were selected based on homogeneity of tasks, higher noise exposures, impulsive noise exposures, and ≥ 5 workers per group. Observation and interviews of workers and supervisors were used to develop task lists. Dosimetry and TB samples were collected simultaneously with direct observation and task-tracking for the entire shift. Time-at-task was measured and also estimated using three

methods. **Results.** Standardized task-lists were developed for 26 job groups, with five to 23 tasks per job. Work-sampling analysis showed 15-minute sampling intervals were sufficient for analyzed tasks. Of 364 workers, 229 were directly observed during measurement (dosimetry and TB) and 135 had only dosimetry. Variability of time-at-task estimates depended on estimation method. **Conclusions.** Clear task definition is crucial to the success of a TB approach, yet workers, supervisors, and researchers defined tasks differently. Although a TB strategy improves the validity of the exposure assessment and guides control efforts, cost and personnel time are not insignificant relative to other approaches.

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EVALUATION OF NOISE EXPOSURE IN AN INDOOR SKATEPARK. F. Akbar-Khanzadeh, R. England, Medical College of Ohio, Toledo, OH.

Exposure to noise in recreational facilities is widely accepted, and health professionals are rarely called to assess its magnitude and possible harmful effects. Indoor skateparks in particular may generate excessive noise because of their confined structural nature, possibly exposing users and employees to unacceptable levels of noise. This study used real-time sound level meters (Quest Models 400 and 500) to examine the extent of noise exposure at an indoor skatepark with wooden ramps. Noise sources included the activities of up to 25–30 individuals using skateboards, rollerblades, and bicycles on the ramps. At the facility's front counter, where employees worked, minute-time-weighted average area noise exposure ranged from 50–95 dBA (mean \pm SD of 65 ± 9 dBA; $n = 88$) with peak noise levels ranging from 101–145 dB (131 ± 7 dB). A skateboarder and a bystander (at a distance of 2 meters from the skateboarder) wore personal noise dosimeters concurrently for an extended period of time. The skateboarder's minute-time-weighted average personal exposure ranged from 81–99 dBA (89 ± 3 dBA; $n = 32$) with peak noise levels ranging from 114–143 dB (131 ± 7 dB). The bystander's minute-time-weighted average personal exposure ranged from 73–85 dBA (81 ± 3 dBA; $n = 32$) with peak noise levels ranging from 111–128 dB (118 ± 5 dB). The users of this facility were mostly children (ages ranging up to 21 years) and some adults including two employees. The noise was dominantly impulsive. According to World Health Organization recommendations, the peak sound pressure attributed to hearing impairment from impulse sounds in children is 120 dB, and for adults is 140 dB. The results of this study indicate that noise exposure levels in this facility exceed recommended limits. In order to protect participants, bystanders, and employees, noise levels should be controlled accordingly.

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NOISE EXPOSURE AMONG EMPLOYEES WHO WORK IN DRINKING ESTABLISHMENTS THAT OFFER LIVE MUSIC.

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According to the U.S. Bureau of Labor Statistics, nationally, there are nearly 150,000 bartenders and nearly 80,000 waiters and waitresses who work in the job location category, drinking places: alcoholic beverages. Some "drinking places" offer some form of music as entertainment, many times in the form of live musicians. In venues where loud music is played, particularly live music, employees could be at risk for occupational noise exposure.

During the course of an environmental noise experiment, noise level samples were collected in and around a college drinking establishment. The establishment offered live music in the form of two five-person bands. The bands performed what would be classified as "rock and roll" music.

During a two-hour time frame, noise dosimeters were worn by two volunteers. These volunteers were stationed at specific locations within the establishment, but were free to move about the establishment. In addition, a hand-held sound meter set on the A-scale, slow response was used to collect samples from various specific locations within the establishment in 30-minute intervals.

The volunteer's dosimeters recorded averages 99.1 dB and 98.6 dB with maximum levels of 118.1 dB and 121.1 dB, respectively. Recorded sound levels from 10 feet from the stage averaged 100.53 dB (107.8 dB maximum), 30 feet from the stage, 97.35 dB (106.7 dB maximum), and at the front door, 50 feet from the stage, 88.17 dB (99.3 dB maximum). Individuals who worked as bartenders, waitstaff, and security at this establishment could possibly be exposed to levels above the OSHA permissible noise-exposure level and would likely qualify to be included in an OSHA required hearing conservation program.

Individuals who work in establishments that routinely offer loud live music as entertainment should be made aware of the hazards associated with excessive noise exposure.

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EXPOSURE ASSESSMENT OF A COMPLEX RF ENVIRONMENT. J. Cardarelli, W. Lotz, C. Dowell, M. Finley, CDC/NIOSH, Cincinnati, OH.

The National Institute for Occupational Safety and Health was asked to provide technical assistance to the Kentucky Labor Cabinet in monitoring radiofrequency (RF) field strengths on a building roof that housed multiple antennas with various transmitting frequencies. Employees of a window-washing company expressed concern about their exposures to RF while conducting preparation activities on the roof.

Some of the problems encountered were: (1) a previous RF survey neither provided spatial-average measurements nor approximate work locations of the window washers; (2) power levels and transmitter locations had changed over time; and (3) determining the appropriate exposure limits that apply to this occupation. The challenges were: (1) selecting and using the appropriate instruments to account for the different frequencies and power outputs; (2) reconstructing the power output conditions on the day of the suspected overexposure; (3) implementing an appropriate spatial-averaging technique; and (4) determining the appropriate measurement locations.

The problems and challenges were resolved by: (1) interviewing the window washers about their equipment, tasks, work duration, and locations while on the roof; (2) working with the Kentucky Labor Cabinet, the building management, and transmitter owners to gain access and adjust transmission power levels; and (3) using an instrument with a shaped-frequency response probe designed to mirror the appropriate standard.

The need to characterize and assess potential exposures to nonionizing radiation is becoming more important with the increased use and advancement of wireless technology and capabilities. This work illustrates that workers in occupations outside the traditional fields in nonionizing radiation are also exposed to RF hazards. It also demonstrates the need to account for their potential exposures and to develop training specific to their needs. Exposure assessors will also be informed of the latest technology used to assess complex RF environments.

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THE FREQUENCY ASPECT OF LOW FREQUENCY EMF MEASUREMENTS.

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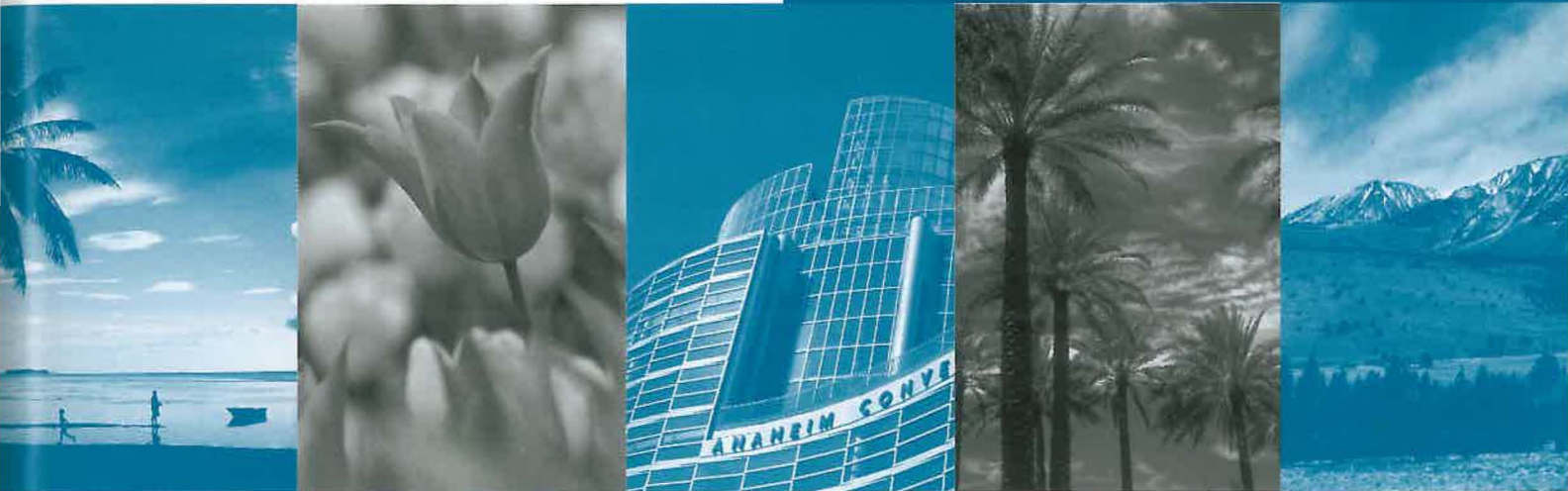
Low frequency electric and magnetic field measurements can range from the low field levels observed near video display terminals to the substantial magnetic fields often found near induction heating equipment. Asking the proper questions before making measurements is essential to an accurate determination of potential hazards. The frequency of the measured field may have a substantial impact on the measured values because of the variation in safety limits, the characteristics of the measurement instrument, and the harmonic content of the field.

Two case studies are reviewed as examples of the effect of frequency on the recorded data and its impact on interpretation of the results. The need to properly identify the frequencies present and understand the interrelationship between the field environment and the sensing instruments used to gather the data is demonstrated. Ultimately the observed data is used to evaluate compliance with the selected safety guideline.

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