

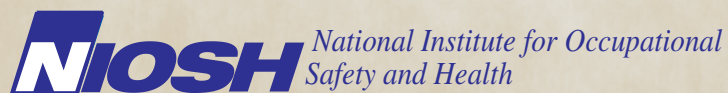


Noise Exposures and Hearing Loss Assessments among Animal Shelter Workers

Chandran Achutan, Ph.D.

Health Hazard Evaluation Report
HETA 2007-0068-3042
Louisiana Society for the Prevention of Cruelty to
Animals
Algiers, Louisiana
May 2007

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention



The employer shall post a copy of this report for a period of 30 calendar days at or near the workplace(s) of affected employees. The employer shall take steps to insure that the posted determinations are not altered, defaced, or covered by other material during such period. [37 FR 23640, November 7, 1972, as amended at 45 FR 2653, January 14, 1980].

CONTENTS

REPORT

Contents	
Abbreviations	ii
Highlights of the NIOSH Health Hazard Evaluation.....	iii
Summary	iv
Introduction.....	1
Assessment.....	3
Results & Discussion.....	4
Conclusions	7
Recommendations.....	7
References	8

APPENDIX

Appendix: Evaluation Criteria	10
-------------------------------------	----

ACKNOWLEDGMENTS

Acknowledgements and Availability of Report.....	13
--	----

ABBREVIATIONS

AL	Action Level
CAOHC	Council for Accreditation in Occupational Hearing Conservation
CFR	Code of Federal Regulations
dB	Decibels
dba	Decibels, A-weighted scale
HHE	Health hazard evaluation
HL	Hearing level
HPD	Hearing protection device(s)
Hz	Hertz
kHz	Kilohertz
LA/SPCA	Louisiana Society for the Prevention of Cruelty to Animals
MSDS	Material safety data sheet
NAICS	North American Industry Classification System
NIHL	Noise-induced hearing loss
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PEL	Permissible exposure limit
REL	Recommended exposure limit
SLM	Sound level meter
STS	Standard threshold shift
TWA	Time-weighted average

HIGHLIGHTS OF THE NIOSH HEALTH HAZARD EVALUATION

In December 2006, NIOSH investigators received a management request from the LA/SPCA to evaluate noise exposures and potential hearing loss among workers in the kennel area. Between December 2006 and February 2007, noise assessments and hearing tests were conducted on LA/SPCA employees.

What NIOSH Did

- We measured personal noise exposures for kennel workers, veterinary staff, and client care workers.
- We tested hearing levels of all LA/SPCA employees.

What NIOSH Found

- Noise levels exceeded the NIOSH REL on 16 occasions and exceeded the OSHA AL on five occasions.
- Three of 33 employees including two kennel workers, had hearing loss.
- Employees were wearing back braces in case they had to lift heavy animals.

What LA/SPCA Managers Can Do

- Enroll employees in a hearing loss prevention program.
- Require the use of ear plugs or ear muffs in the kennel area.
- Maintain ear muffs by making sure they are clean and by replacing the cushions every 6 months or sooner if necessary.
- Institute a comprehensive lifting program. Do not require employees to wear back braces.
- Train employees on the hazards associated with the chemicals they use.

What LA/SPCA Employees Can Do

- Wear hearing protectors when working in the kennel area.
- Wear goggles when using SX-64™ to clean kennel cages.
- Always wear gloves (example nitrile) when cleaning dog and cat cages, and wash hands after cleaning the cages.

Kennel workers at LA/SPCA were exposed to excessive noise levels. Some of the LA/SPCA employees have hearing loss but it is not possible to determine whether this is related to noise exposures in the kennel. To prevent further hearing loss, workers should be enrolled in a hearing loss prevention program, and provided with HPD.

On December 1, 2006, NIOSH received a management request for an HHE from the LA/SPCA in Algiers, Louisiana. The HHE request asked NIOSH to assess the noise levels experienced by workers in the kennel area from barking dogs. On December 16–17, 2006, a NIOSH investigator measured noise exposure levels for workers in the kennel area. NIOSH investigators returned to the facility on February 6–8, 2007, to conduct hearing tests on all LA/SPCA employees.

Thirteen kennel workers, two veterinary staff, and three client care workers provided 22 personal noise dosimetry measures over the 2-day evaluation. One of the measures collected on a kennel worker was invalid because of equipment malfunction. Sixteen of the 21 measures exceeded the daily allowable noise dose of 100% as calculated by the NIOSH criterion. Five measures also exceeded the OSHA AL. The OSHA PEL was not exceeded. Hearing tests were performed on 33 employees. Three employees showed some degree of hearing loss (> 25 decibel hearing loss) at one or more test frequencies in one or both ears on the NIOSH-administered audiogram. Twenty-one employees with normal hearing showed notches (hearing levels worsen over test frequencies before improving in the highest frequencies, forming a “notch” configuration) in one or both ears between 3000–6000 Hz, indicating early signs of hearing loss.

In addition to noise, the NIOSH investigator observed other hazards. Kennel workers without gloves and without proper eye protection (safety goggles) were cleaning cages. A constituent of one of the disinfectants used to clean the cages is a known eye irritant. In addition, kennel workers were required to wear back braces in case there was a need to lift heavy animals; NIOSH has determined back braces to be ineffective in preventing back injury.

Recommendations include establishing a hearing loss prevention program, wearing HPD when entering the kennel area, and using personal protective equipment when cleaning animal cages.

Keywords: NAICS 813312 (Environment, Conservation and Wildlife Organizations), noise, dose, hearing loss, dog, notch, audiometric testing, back braces

On December 1, 2006, NIOSH received a management request for an HHE from LA/SPCA in Algiers, Louisiana. The HHE request asked NIOSH to assess employee exposure to noise from barking dogs. On December 16–17, 2006, a NIOSH investigator measured noise exposure levels for workers in the kennel area. NIOSH investigators returned to the facility on February 6–8, 2007, to conduct hearing tests on all LA/SPCA employees.

Noise Exposures to Domestic Animal Handlers

Veterinary hospital workers, animal shelter employees, workers at facilities that board animals, and police officers with canine partners are potentially exposed to excessive occupational noise levels from barking dogs. However, few studies have examined noise exposures and the potential for hearing loss among these workers. One study measured noise levels as high as 108 dBA in veterinary establishments [Senn and Lewin 1975]. Another study in an outdoor animal shelter showed noise exposures in excess of the NIOSH REL for occupational noise [Achutan 2007]. This evaluation was conducted in the aftermath of Hurricane Katrina in St. Bernard Parish, Louisiana, and is not representative of typical veterinary staff noise exposure. Three recent HHEs on noise exposure and hearing loss assessments of employees at animal boarding facilities showed that kennel workers were exposed to noise levels up to ten times the NIOSH REL; some of these workers either had hearing loss or showed early signs of hearing loss [NIOSH 2007a,b,c]. Two studies examined noise exposures and hearing loss among canine police officers [Reid et al. 2004; NIOSH 2006]. Both studies found that police officers were exposed to excessive noise from canines, and some officers had hearing loss. The design of these studies did not enable investigators to determine whether observed hearing loss was associated with occupational noise exposures.

Louisiana Society for the Prevention of Cruelty to Animals

The LA/SPCA was chartered in 1888 with a mission to eliminate animal suffering and educate the public about animal care [LA/SPCA 2007]. In 2005, after Hurricane Katrina destroyed the LA/SPCA shelter on Japonica Street, New Orleans, the animals and the staff temporarily evacuated to the Houston SPCA. They subsequently moved to the Lamar-Dixon Exposition Center in Gonzales, Louisiana. In October 2005, LA/SPCA started operating from a former coffee warehouse in Algiers, Louisiana. The LA/SPCA expects to move into a new permanent facility in Algiers by the spring of 2007. At the time of the NIOSH evaluation, there were approximately 150 dogs at the facility. Although the warehouse could accommodate many more animals, the shelter limited the number of animals based on the number that could be accommodated at the new facility.

Facility Description

At the time of the NIOSH evaluation, the LA/SPCA was operating out of a 45,000-square foot warehouse in Algiers, Louisiana. The middle portion of the warehouse housed the majority of the dogs. The dogs were housed in cages in the adoption area, the healthy hold area, the quarantine area, and the isolation area. Dogs were housed in two types of cage configurations. One configuration was a cage with an opaque thick plastic panel covering three sides of the cage. The dimension of the cage could be modified depending on the size of the dog. The other configuration, called a “T” cage, was a 3-foot by 12-foot cage with a door in the middle. This door could be raised or lowered to allow the animal full access to the cage or partial access, such as when the cage was being cleaned.

The adoption area was open to the public and consisted of dogs deemed by the LA/SPCA to be healthy and non-aggressive. A behavior evaluator determined whether the animals were safe for adoption. These animals were also spayed or neutered. There were 46 regular cages arranged in 3 aisles or “runs” and 14 “T” cages arranged perpendicular to the regular cages.

The healthy holding, quarantine, and isolation areas were not accessible to the public unless accompanied by a staff member. These areas were blocked off from the adoption area by stacks of animal cages arranged three-deep, and by temporary fences. The healthy holding area housed animals brought in by the public or by animal control officers. Animals were held for 5–6 days to allow owners to claim their pets. After this period, animals were either put up for adoption or euthanized. The healthy holding area for dogs had 45 cages arranged in three runs.

The quarantine and isolation areas had 56 “T” cages placed in two runs. Dogs in the quarantine area were held on court order for aggression or because of owner cruelty. Sick animals at the LA/SPCA were moved to the cages in the isolation area, and were tended to by the veterinary staff.

On the south wall of the warehouse were three restrooms and seven other rooms. These rooms included a cat/kitten adoption room, a room for puppies and rabbits, a break room for staff, dishwashing/laundry/grooming room, a cat “healthy hold” room, a feral cat room, and a cat isolation room.

On the north wall of the warehouse were large shelves that held supplies such as food and litter. Adjacent to the shelves and behind some of the “T” cages was a veterinary clinic. The clinic was staffed by a veterinarian and three veterinary technicians. In front of the clinic and next to the isolation/quarantine cages were three tables placed in an “L” formation where the kennel supervisor did paper work.

Between the dog adoption cages and the start of the rooms on the south wall (close to the warehouse entrance) was a small office where three client care workers processed adoptions and received animals brought in by the public or by animal control officers. The client care staff also brought animals from the adoption area to prospective pet owners. Outside the warehouse in the parking lot were two trailers that housed the administrative staff, animal control staff, the behavior evaluator, and special events coordinators. The latter were the point of contact for members of the public wishing to volunteer at the LA/SPCA. Staff walked the dogs on a portion of the parking lot.

Kennel Work Activities

The 15 kennel workers reported to work between 6:00 a.m. and 8:30 a.m., and left work between 3:00 p.m. and 5:30 p.m. Workers got one 15-minute morning break, and an hour-long lunch break. The main kennel work activities were feeding the cats and dogs, cleaning cages, and walking the dogs. Workers typically worked in pairs. The two workers who came in at 6:00 a.m. started preparing food. The food was prepared on a cart in the warehouse and fed to the dogs in stainless steel feeding dishes. This took approximately one hour.

Dog excrement was scraped, scooped, and deposited in a trash can. Because there was a shortage of water at the warehouse, the dog cages were cleaned by spraying a disinfectant called SX-64™ and wiping the floors, cage, and the plastic panels with paper towels. After that, the floors were mopped using a mixture of bleach and water. Excess water from the floors was removed using a squeegee. The process was similar for the “T” cages, except that after the SX-64 is sprayed, the floor of the cage was mopped with the water/bleach solution, thus bypassing the wipe-down with paper towels. The cages were then lined with absorbent pads and a towel, and the drinking dish filled with fresh water. While one worker was preparing the cages, the cage occupant was taken for a walk by the other worker. The workers usually took turns cleaning the cages and walking the dogs. The cleaning of all the cages usually took about 5 hours.

Other activities included washing the feeding and drinking containers, laundering soiled cloths, bathing the dogs, cleaning floors of the facility, taking out the trash, and disinfecting the soiled scraper, mops, and squeegees in a container containing an aqueous bleach solution. In addition, the workers who left at 5:30 p.m. ensured that the animals had adequate food and water.

ASSESSMENT

Noise Assessment

On December 16–17, 2006, 18 employees who worked in the kennel area (13 kennel workers, two veterinary staff members, and three client care workers) contributed 22 full-shift, personal noise measures. Quest® Technologies (Oconomowoc, Wisconsin) Model Q-300 Noise

Dosimeters were worn by the kennel workers while they performed their daily activities. The noise dosimeters were attached to the wearer's belt and a small remote microphone was fastened to the wearer's shirt at a point midway between the ear and the outside of the shoulder. A windscreen provided by the dosimeter manufacturer was placed over the microphone during recordings. At the end of the workday, the dosimeter was removed and paused to stop data collection. The information stored in the dosimeters was downloaded to a personal computer for interpretation with QuestSuite for Windows® computer software. The dosimeters were calibrated before and after the measurement periods according to the manufacturer's instructions.

Hearing Loss Assessment

On February 6–8, 2007, hearing tests were performed on 33 LA/SPCA employees. All LA/SPCA employees were eligible for the hearing tests. Workers reported to a NIOSH mobile test facility prior to starting their work shift. Informed consent was obtained from participants before they completed a short questionnaire about work history and self assessment of their hearing ability.

A Tremetrics (Eden Prairie, Minnesota) Model AR 901 Hearing Booth and OSCAR 7 Electro-Acoustic Ear and Octave Monitor (Eden Prairie, Minnesota) provided an appropriate acoustic environment for testing. The booth was located inside the mobile test facility. The area was controlled for conversations and other extraneous noises during the tests. Hearing tests were collected with a Tremetrics Model HT Wizard Audiometer that had received a routine calibration check within the past year. Hearing tests were conducted by one of the investigators who had current certification from CAOHC. The audiometer tested the pure-tone frequencies of 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz in the computerized mode in each ear, left ear first.

Test results for each participant were interpreted immediately after testing and explained to the participant. In addition, each participant was sent a letter summarizing his or her results along with a copy of the audiometric test results.

The evaluation criteria for noise and a discussion of the health effects of noise are provided in the Appendix.

RESULTS & DISCUSSION

Noise Assessment

Of the 22 personal noise measures, one collected on a kennel worker was invalid because of equipment malfunction. Of the remaining 21 measures, 16 reached or exceeded the NIOSH REL. Of these, five reached or exceeded the OSHA AL. None exceeded the OSHA PEL. The full-shift TWA values for comparison with the NIOSH REL ranged from 82.2 dBA to 91.0 dBA. Table 1 summarizes these results.

RESULTS AND DISCUSSION (CONTINUED)

Table 1
Range of Personal Noise Dosimetry Measures from 18 LA/SPCA Employees in the Kennel Area

Job Title	Number of Measures	Percent Dose		
		OSHA AL	OSHA PEL	NIOSH REL
Kennel Workers	16	17.1–57.9*	4.4–37.3	52.5–398.4**
Veterinary Technicians	2	10.9–27.1	4.7–12.5	49.8–100.7***
Client Care Workers	3	6.3–15.4	1.4–6.7	23.6–60.3

* OSHA AL reached or exceeded 5 times

** NIOSH REL reached or exceeded 15 times

*** NIOSH REL reached once

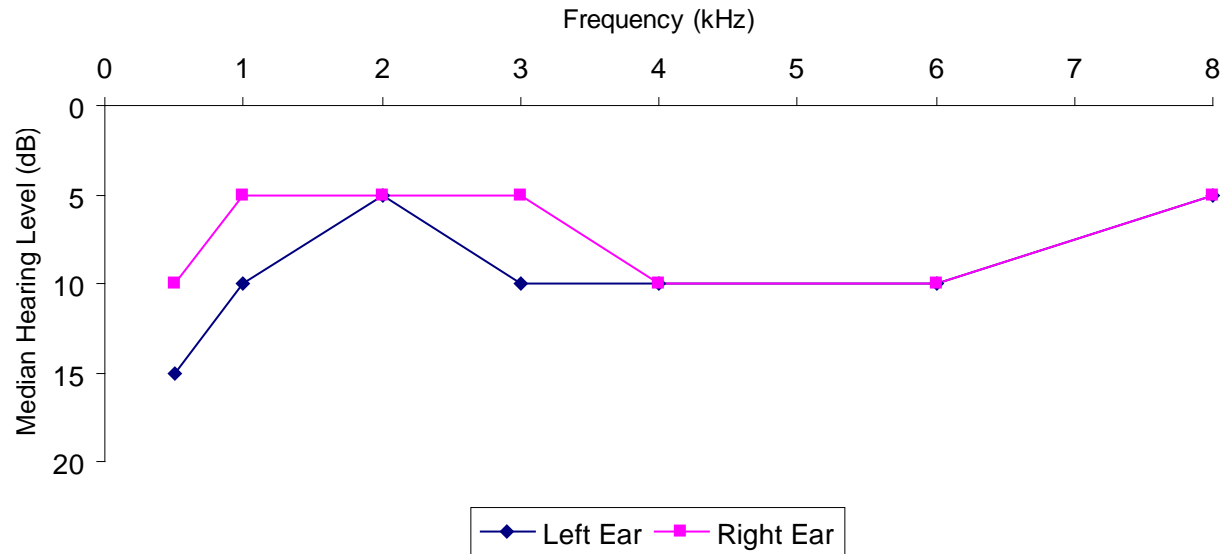
Personal noise levels exceeding the NIOSH REL were not surprising because (1) the barking of 150 dogs in a metal warehouse will result in noise reverberation, and (2) the shortage of water to the facility meant employees spent long hours cleaning the cages, thus increasing their duration of exposure. However, the personal noise levels at LA/SPCA were significantly lower (unpaired *t*-test, $p < 0.05$) when compared to those at the SPCA in Cincinnati, Ohio [NIOSH 2007c]. The two facilities were comparable with respect to kennel work activities but differed in facility design. Most of the dog cages at LA/SPCA were arranged so that dogs did not see each other, resulting in less barking. This was accomplished by hanging a thick plastic panel on three of four sides of the cage. In addition, unused cages, pallets, and other items were stacked in such a way as to restrict public access to certain areas. The panels and the stacked items absorbed or redirected sound from the dogs.

Hearing Loss Assessment

Hearing tests were given to 33 LA/SPCA employees. These included nine kennel workers, four client care workers, four veterinary staff, six animal control officers, one behavior evaluator, three special events coordinators, and six administrative employees. The mean age of the 33 employees was 35 years (range = 19–59). The mean age of the kennel workers was 25 years (range = 19–42). The median hearing levels and interquartile ranges for these employees are shown in Figure 1. The data showed considerable variability among individuals (as measured by the interquartile range). Three of the 33 workers showed hearing levels at one or more frequencies that exceeded 25 dB HL, indicating hearing loss. Two of the four were kennel workers. One employee had moderate to profound hearing loss in the right ear, and was advised to consult a physician. Twenty-one workers with normal hearing showed notches (hearing levels worsen over test frequencies before improving in the highest frequencies, forming a “notch” configuration) in one or both ears between 3000 and 6000 Hz indicating early signs of hearing loss. There were 46 notches in one or both ears of the 33 employees.

RESULTS AND DISCUSSION (CONTINUED)

Figure 1: Median Hearing Levels and Interquartile Ranges for 33 LA/SPCA Employees



Frequency (kHz)	Left Ear		Right Ear	
	25 th percentile	75 th percentile	25 th percentile	75 th percentile
0.5	10	20	5	15
1	0	10	0	5
2	0	10	0	10
3	5	10	0	10
4	5	15	0	15
6	5	20	5	20
8	0	15	0	15

Noise control strategies in dog kennels are complicated. Sound-absorbing materials such as spray-on foam and fibrous mineral wool, which are usually used in industry and other indoor settings to reduce noise exposures, are not appropriate in kennels because they are difficult to clean while maintaining dryness in order to avoid mold and mildew. One approach may be to use sound-absorbing material on surfaces that do not need to be cleaned routinely, such as ceilings. Acoustical ceiling tiles that are waterproof and washable can be installed to reduce noise [Carter 2007]. In addition, floors can be covered with rubber mats to absorb sound from the barking dogs and to reduce noise from feeding and drinking dishes hitting on hard (concrete and tile) surfaces. These approaches may offer some reduction in noise levels, but do not eliminate the direct noise path from the dog to the worker. The new LA/SPCA facility will have sound-absorbing baffles installed in the ceilings. A noise survey should be conducted after controls are in place to determine if personal noise exposures to workers are reduced.

RESULTS AND DISCUSSION (CONTINUED)

Other Observations

We observed kennel workers wearing back braces to protect their backs from injury in case they had to lift a heavy dog. Research has shown that back braces do not prevent back injury; a comprehensive program for lifting, including informing employees on the correct way to lift heavy objects would be more beneficial [NIOSH 1994].

The SX-64 chemical used to clean the dog cages contained quarternary ammonium compounds that are an eye irritant, per the chemical's MSDS. Therefore, employees should wear goggles when working with this chemical. An MSDS for every chemical used at the facility was filed in an area easily accessible to the kennel workers. However, employees were not trained in how to use the information in the MSDSs.

Some employees were observed not wearing gloves when cleaning dog cages. This can cause the spread of diseases when combined with poor personal hygiene.

CONCLUSIONS

This evaluation showed that kennel workers and some veterinary staff with the LA/SPCA were exposed to hazardous noise levels. In addition, three employees who participated in this evaluation showed hearing loss. However, because of the small sample size, inability to control for other sources of noise, and the relative youth of the workers with respect to time needed to develop hearing loss, it was not possible to determine whether the observed hearing loss was related to noise exposure at the kennel.

RECOMMENDATIONS

Based on the observations and findings of this evaluation, the following recommendations are offered to better protect the hearing of workers at the LA/SPCA.

1. Establish a hearing loss prevention program for the kennel workers and veterinary staff. The basic elements of the program should, at a minimum, meet the requirements for a hearing conservation program as outlined in the OSHA hearing conservation amendment [29 CFR 1910.95]. Other sources for defining effective hearing conservation programs are also available [Suter 2002; NIOSH 1996; Royster JD and Royster LH 1990].
2. Wear hearing protection devices (ear muffs or ear plugs) when working in the kennel areas. Train employees on the proper fit, selection, and maintenance of hearing protectors. For example, ear plugs should be deeply inserted into ear canals, and cushions on ear muffs should not be cracked or creased, and the head bands not sprung.

RECOMMENDATIONS (CONTINUED)

3. Develop a comprehensive lifting program for employees instead of the requirement that employees wear back braces.
4. Provide goggles to employees who are working with chemicals that cause eye irritation such as SX-64.
5. Train employees on how to use the information in the MSDSs as required by the OSHA Hazard Communication Standard [29 CFR 1910.1200].
6. Always wear gloves (for example nitrile or other suitable material based on the chemicals used) when cleaning animal cages and wash hands thoroughly after cleaning the cages.

REFERENCES

Achutan C [2007]. Occupational noise levels during emergency relief operations in the aftermath of Hurricane Katrina. *J Occup Environ Hyg* 4(4):D33-D35.

Carter T [2007]. Ask the builder: acoustical ceiling tiles — sound properties. [http://www.askthebuilder.com/B148_Acoustical_Ceiling_Tiles_Sound_Properties.shtml]. Date accessed: May 4, 2007.

CFR. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

Louisiana Society for the Prevention of Cruelty to Animals [2007]. [www.la-sPCA.org]. Date accessed: May 4, 2007.

NIOSH [1994]. Back belts: do they prevent injury? Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 94-127.

NIOSH [1996]. Preventing occupational hearing loss—a practical guide. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 96-110.

NIOSH [2006]. Health hazard evaluation report: Cincinnati Police Canine Unit, Cincinnati, OH. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH Report No. 2006-0223-3029.

NIOSH [2007a]. Health hazard evaluation report: Liberty Veterinary Hospital, Liberty Township, OH. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH Report No. 2006-0196-3036.

REFERENCES (CONTINUED)

NIOSH [2007b]. Health hazard evaluation report: Kenton County Animal Shelter, Covington, KY. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH Report No. 2006-0212-3035.

NIOSH [2007c]. Health hazard evaluation report: Society for the Prevention of Cruelty to Animals, Cincinnati, OH. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH Report No. 2006-0222-3037.

Reid A, Dick F, Semple S [2004]. Dog noise as a risk factor for hearing loss among police dog handlers. *Occup Med (London)* 54(8):535–539.

Royster JD, Royster LH [1990]. Hearing conservation programs: practical guidelines for success. Chelsea, MI: Lewis Publishers.

Senn CL, Lewin JD [1975]. Barking dogs as an environmental problem. *J Am Vet Med Assoc* 66 (11):1065–1068.

Suter AH [2002]. Hearing conservation manual. 4th ed. Milwaukee, WI: Council for Accreditation in Occupational Hearing Conservation.

APPENDIX: EVALUATION CRITERIA

The primary sources of evaluation criteria for noise in the workplace are: (1) the NIOSH REL [NIOSH 1992], and (2) the U.S. Department of Labor, OSHA PEL [29 CFR 1910.95]. Employers are encouraged to follow the more protective NIOSH REL, although they are required to adhere to the OSHA PEL for compliance purposes.

Noise-induced hearing loss is an irreversible, sensorineural condition that progresses with exposure. Although hearing ability declines with age (presbycusis) in all populations, exposure to noise produces hearing loss greater than that resulting from the natural aging process. This noise-induced loss is caused by damage to nerve cells of the inner ear (cochlea) and, unlike some conductive hearing disorders, cannot be treated medically [Ward et al. 2000]. While loss of hearing may result from a single exposure to a very brief impulse noise or explosion, such traumatic losses are rare. In most cases, NIHL is insidious. Typically, it begins to develop at 4000 or 6000 Hz (the hearing range is 20 Hz to 20000 Hz) and spreads to lower and higher frequencies. Often, material impairment has occurred before the condition is clearly recognized. Such impairment is usually severe enough to permanently affect a person's ability to hear and understand speech under everyday conditions. Although the primary frequencies of human speech range from 200 Hz to 2000 Hz, research has shown that the consonant sounds, which enable people to distinguish words such as "fish" from "fist," have still higher frequency components [Suter 1978].

The dBA is the preferred unit for measuring sound levels to assess worker noise exposures. The dBA scale is weighted to approximate the sensory response of the human ear to sound frequencies near the threshold of hearing. The decibel unit is dimensionless, and represents the logarithmic relationship of the measured sound pressure level to an arbitrary reference sound pressure (20 micropascals, the normal threshold of human hearing at a frequency of 1000 Hz). Decibel units are used because of the very large range of sound pressure levels which are audible to the human ear. Because the dBA scale is logarithmic, increases of 3 dBA, 10 dBA, and 20 dBA represent a doubling, tenfold increase, and hundred-fold increase of sound energy, respectively. It should be noted that noise exposures expressed in decibels cannot be averaged by taking the simple arithmetic mean.

The OSHA standard for occupational exposure to noise specifies a maximum PEL of 90 dBA for of 8 hours per day [29 CFR 1910.95]. The regulation, in calculating the PEL, uses a 5 decibel time/intensity trading relationship, or exchange rate. This means that a person may be exposed to noise levels of 95 dBA for no more than 4 hours, to 100 dBA for 2 hours, etc. Conversely, up to 16 hours exposure to 85 dBA is allowed by this exchange rate. The duration and sound level intensities can be combined in order to calculate a worker's daily noise dose according to the formula:

$$\text{Dose} = 100 \times (C_1/T_1 + C_2/T_2 + \dots + C_n/T_n)$$

where C_n indicates the total time of exposure at a specific noise level and T_n indicates the reference duration for that level as given in Table G-16a of the OSHA noise regulation. During any 24-hour period, a worker is allowed up to 100% of his daily noise dose. Doses greater than 100% exceed the OSHA PEL.

The OSHA regulation has an additional AL of 85 dBA; an employer shall administer a continuing, effective hearing conservation program when the 8-hour TWA value exceeds the AL. The program must include monitoring, employee notification, observation, audiometric testing, HPDs, training, and record keeping. All of these requirements are included in 29 CFR 1910.95, paragraphs (c) through (o). Finally, the OSHA noise standard states that when workers are exposed to noise levels in excess of the OSHA PEL of 90 dBA, feasible engineering or administrative controls shall be implemented to reduce the workers' exposure levels.

NIOSH, in its Criteria for a Recommended Standard, proposes exposure criteria of 85 dBA as a TWA for 8 hours, 5 dB less than the OSHA standard [NIOSH 1998]. The criteria also use a more conservative 3 dB time/intensity trading relationship in calculating exposure limits. Thus, a worker can be exposed to 85 dBA for 8 hours, but to no

APPENDIX: EVALUATION CRITERIA (CONTINUED)

more than 88 dBA for 4 hours or 91 dBA for 2 hours. The NIOSH REL for a 12-hour exposure is 83 dBA or less.

Audiometric evaluations of workers are conducted in quiet locations, preferably in a sound-attenuating chamber, by presenting pure tones of varying frequencies at threshold levels (i.e., the level of a sound that the person can just barely hear). Audiograms are displayed and stored as tables or charts of the HL at specified test frequencies [ANSI 1996]. Zero dB HL represents the hearing level of an average, young, normal-hearing individual. In OSHA-mandated hearing conservation programs, thresholds must be measured for pure-tone signals at the test frequencies of 500, 1000, 2000, 3000, 4000, and 6000 Hz. Each employee's annual audiogram is compared to his or her own baseline audiogram to determine the amount of STS that occurred between the two tests. Specifically, OSHA states that an STS has occurred if the average threshold values at 2000, 3000, and 4000 Hz have increased by 10 dB or more in either ear when comparing the annual audiogram to the baseline audiogram [29 CFR 1910.95]. The NIOSH recommended threshold shift criterion is a 15-dB shift at any frequency in either ear from 500–6000 Hz measured twice in succession [NIOSH 1998]. Practically, the criterion is met by immediately retesting an employee who exhibits a 15-dB shift from baseline on an annual test. If the 15-dB shift persists on the second test, a confirmatory follow-up test should be given within 30 days of the initial annual examination. Both of these threshold shift criteria require at least two audiometric tests. In cases where only one audiogram is available, a criterion has been proposed for single-frequency impairment determinations [Eagles et al. 1968]. It employs a lower fence (the amount of hearing loss necessary before a hearing handicap is said to exist) of 25 dB HL. With this criterion, any person who has a hearing level of 26 dB HL or greater at any single frequency is classified as having some degree of hearing loss. The degree of loss can range from mild (26–40 dB HL) to profound (>90 dB HL).

The audiogram profile is a plot of the hearing test frequencies (x-axis) versus the hearing threshold levels (y-axis). Hearing threshold levels are plotted in reverse (the highest hearing level up to 0 or -10 dB). For many workers, the audiogram profile tends to slope downward toward the high frequencies with an improvement at the audiogram's highest frequencies, forming a "notch" [Suter 2002]. A notch in an individual with normal hearing may indicate the early onset of hearing loss. Although there is no universal criterion to define what constitutes a "notch," several mathematical models that attempt to identify notches are presented in the scientific literature [Dobie and Rabinowitz 2002; Niskar et al. 2001; Cooper and Owen 1976]. The relative strength and weaknesses of these models have also been reviewed [Rabinowitz and Dobie 2003]. For this evaluation, a notch is defined as the frequency where the hearing level is preceded by an improvement of at least 10 dB at the previous test frequency and followed by an improvement of at least 5 dB at the next. The notch from occupational noise exposures can occur between 3000 and 6000 Hz, depending on the frequency spectrum of the noise, and the anatomy of the individual's ear [ACOM 1989; Osguthorpe and Klein 2001]. It is generally accepted that a notch at 4000 Hz is indicative of occupational hearing loss [Prince et al. 1997]. Some researchers have argued that the notch at 6000 Hz may not be a good marker for occupational hearing loss because it is widely seen in young adults and others with little documented occupational noise exposure [McBride and Williams 2001]. An individual may have notches at different frequencies in one or both ears [Suter 2002].

References

ACOM [1989]. Occupational noise-induced hearing loss. ACOM Noise and Hearing Conservation Committee. *J Occup Med* 31:996.

ANSI [1996]. American national standard specification for audiometers. Melville, NY: Acoustical Society of America, American National Standards Institute, ANSI S3.6-1996.

CFR. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

APPENDIX: EVALUATION CRITERIA (CONTINUED)

Cooper JC, Owen JH [1976]. Audiologic profile of noise-induced hearing loss. *Arch Otolaryngol* 102:148–150.

Dobie RA, Rabinowitz PM [2002]. Change in audiometric configuration helps to determine whether a standard threshold shift is work-related. *Spectrum* 19(Suppl 1):17.

Eagles EL, Hardy WG, Catlin FI [1968]. *Human Communication: The public health aspects of hearing, language, and speech disorders (NINDB monograph #7)*. Washington, D.C. Government Printing Office, USPHS Publication 1745.

McBride DI, Williams S [2001]. Audiometric notch as a sign of noise induced hearing loss. *Occup Environ Med* 58:46–51.

NIOSH [1992]. *Recommendations for occupational safety and health: compendium of policy documents and statements*. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

NIOSH [1998]. *Criteria for a recommended standard: occupational noise exposure (revised criteria 1998)*. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 98-126.

Niskar AS, Kieszak SM, Holmes AE, Esteban E, Rubin C, Brody DJ [2001]. Estimated prevalence of noise-induced hearing threshold shifts among children 6 to 19 years of age: The Third National Health and Nutrition Examination Survey, 1988-1994, United States. *Pediatrics* 108(1):40–43.

Osguthorpe JD, Klein AJ [2001]. Occupational hearing conservation. *Clin Audiol* 24(2):403–414.

Prince M, Stayner L, Smith R, Gilbert S [1997]. A re-examination of risk estimates from the NIOSH occupational noise and hearing survey (ONHS). *J Acous Soc Am* 101:950–963.

Rabinowitz PM, Dobie RA [2003]. Use of the audiometric configuration to determine whether hearing loss is noise-induced: can “notch criteria” help? *NHCA Spectrum* 20(1):8–11.

Suter AH [1978]. *The ability of mildly hearing-impaired individuals to discriminate speech in noise*. Washington, DC: U.S. Environmental Protection Agency, Joint EPA/USAF study, EPA 550/9-78-100, AMRL-TR-78-4.

Suter AH [2002]. *Hearing conservation manual*. 4th ed. Milwaukee, WI: Council for Accreditation in Occupational Hearing Conservation.

Ward WD, Royster LH, Royster JD [2000]. *Anatomy & physiology of the ear: normal and damaged hearing*. In: Berger EH, Royster LH, Royster JD, Driscoll DP, Layne M, eds. *The noise manual*. 5th ed. Fairfax, VA: American Industrial Hygiene Association, pp 101–122.

ACKNOWLEDGEMENTS AND AVAILABILITY OF REPORT

The Hazard Evaluation and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employers or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

This report was prepared by Chandran Achutan of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Donnie Booher, Judith Eisenberg, and Kevin L. Dunn of DSHEFS. Desktop publishing was performed by Robin Smith and Donna Pfirman. Editorial assistance was provided by Ellen Galloway.

Copies of this report have been sent to employee and management representatives at the Louisiana Society for the Prevention of Cruelty to Animals; and the OSHA Regional Office. This report is not copyrighted and may be freely reproduced. The report may be viewed and printed from the following internet address: <http://www.cdc.gov/niosh/hhe>. Copies may be purchased from the National Technical Information Service at 5825 Port Royal Road, Springfield, Virginia 22161.

NIOSH [2007]. Health Hazard Evaluation Report: Noise Exposures and Hearing Loss Assessments among Animal Shelter Workers, Louisiana Society for the Prevention of Cruelty to Animals, Algiers, Louisiana: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH HETA No. 2007-0068-3042.



**Delivering on the Nation's promise:
Safety and health at work for all people
through research and prevention.**

To receive NIOSH documents or information about occupational safety and health topics contact NIOSH at:

1-800-35-NIOSH (1-800-356-4674)

Fax: 1-513-533-8573

E-mail: pubstaf@cdc.gov
or visit the NIOSH web site at:
<http://www.cdc.gov/niosh>

SAFER • HEALTHIER • PEOPLE™