



POSITION STATEMENT

PREVENTING NOISE-INDUCED OCCUPATIONAL HEARING LOSS

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PURPOSE AND SCOPE

This position statement addresses the issues relevant to audiologists engaged in preventing occupational noise-induced hearing loss. Audiologists' roles and responsibilities as overseers for hearing loss prevention programs (American Academy of Audiology, 1997) and essential qualities of best practices for preventing noise-induced occupational hearing loss are outlined. This document is not intended to address community or recreational noise, nor is it designed to be a how-to guide that specifies the details inherent to a hearing loss prevention program.

STATEMENT OF BELIEFS

No one needs to lose his or her hearing in order to earn a living. Noise-induced hearing loss is preventable.

BACKGROUND

The average, otherwise healthy, person will have essentially normal hearing at least up to age 60 if his or her unprotected ears are not exposed to high noise levels (i.e., levels above 85 dBA). According to the American National Standards Institute (Annex A of ANSI S3.44 B1996 at age 60, the median material hearing impairment is only 17 dB and 12 dB for males and females, respectively (ANSI, 1996). Aging alone should not prevent the average person from enjoying normal hearing throughout all or most of his or her working career. Unfortunately, this is not the case for those who are occupationally exposed to high noise levels.

Estimates suggest that there are upwards of 5 million, perhaps as many as 30 million Americans occupationally exposed to noise levels greater than 85 dBA (NIDCD, 1999; Berger et al., 2000). At present exposure limits, (OSHA, 1983) one in four of these workers will develop a permanent hearing loss as a result of trying to earn a living (Prince, et al., 1997). Many of these workers, perhaps a majority, will also develop tinnitus in addition to a hearing loss. In his review of the problem, Dobie (1993) described data from one Swiss study in which NIHL was a factor in 18% of all hearing loss cases. According to the National Institutes of Health, approximately one third of all hearing loss can be attributed to noise exposure, and "occupational hearing loss is the most common cause of noise-induced hearing loss" (NIH, 1990, pp. 3-4). The impact of hearing impairment on occupational safety and health was underscored by a recent

finding that sensory impairment - particularly hearing loss - is associated with a substantially increased risk of occupational injury (Zwerling, et al., 1997). The need for hearing loss prevention extends beyond the obvious practical desire to preserve hearing and/or limit the economic impact of hearing loss. Hearing health is clearly intertwined with a healthy, safe workplace.

ROLE OF THE AUDIOLOGIST

Although an appropriately certified technician may perform air conduction threshold tests in support of an occupational hearing loss prevention program, OSHA (CFR 29, 1910.95, 1993) specifies that only audiologists or physicians may be responsible for the audiometric monitoring program. This includes responsibility for the quality and appropriate performance of audiometric monitoring tests, as well as reviewing problem audiograms to determine whether there is a need for further evaluation.

The American Academy of Audiology promotes the audiologist as the principal advocate for and supervisor of programs that manage the hearing health of people exposed to hazardous noise.

The audiologist designs, implements, and coordinates occupational and community hearing loss prevention programs. This includes identification and amelioration of noise-hazardous conditions, identification of hearing loss, recommendation and counseling for use of hearing protection, employee education, and the training and supervision of non-audiologists performing monitoring audiometry in the occupational setting (American Academy of Audiology Scope of Practice Statement, 1997).

There are numerous regulations that attempt to address the problem of hazardous noise exposure and noise-induced hearing loss in the United States. A factory worker in the manufacturing sector is covered by a different regulation than a carpenter in the construction sector; a coal miner is covered by a different regulation than a truck driver; an Army soldier is covered by a different regulation than a Navy sailor. However, hazardous noise exposure transcends standards and regulations. A 95 dBA exposure to a logger in Oregon is equally harmful to hearing as a 95 dBA exposure to an agricultural worker in Florida. The fact that hearing damage risk may vary somewhat as a function of race or gender (ANSI S3.44-1996) does not negate the fact that noise can and does harm the hearing of workers regardless of their age, race or gender.

Audiologists must know what particular regulation is relevant to a given individual or group and must be capable of implementing a program that complies with the appropriate regulation. The American Academy of Audiology promotes the proper care of the noise-exposed patient which incorporates best practices for preventing noise-induced hearing loss.

BEST PRACTICES FOR PREVENTING NOISE-INDUCED OCCUPATIONAL HEARING LOSS

Audiologists must play a leading role in helping workers keep the hearing they had when they entered the workforce. Best practice would call for audiologists to be pro-active about the problem and think in terms of hearing loss prevention rather than hearing conservation. Preventing noise-induced hearing loss requires that every facet of the problem be addressed. An effective hearing loss prevention program (HLPP) involves a comprehensive effort consisting of the following elements: (1) performing initial and annual audits of the work environment, labor and management needs, and HLPP procedures; (2) assessment of noise exposures; (3) engineering and administrative control of noise exposures; (4) audiometric evaluation and monitoring of hearing; (5) appropriate use of personal hearing protection devices; (6) education and motivation; (7) record keeping; and (8) program evaluation for effectiveness (NIOSH, 1996). But even when a comprehensive program is in place, noise-induced hearing loss can and does occur (Ohlin, 2000). Unless best practices have been adopted, people exposed to hazardous noise are at risk of unnecessary hearing loss.

The best way to prevent noise-induced hearing loss is to eliminate the hazard. Audiologists need to have a sufficient understanding of acoustics to know when to engage the services of an acoustical engineer. When engineering and administrative controls have not eliminated the hazard, best practices mandate six components for hearing loss prevention. Each component is described below.

1. The noise hazard must be realistically defined. The American Academy of Audiology promotes the use of a 3-dB exchange rate (Suter, 1992) in conjunction with an 85 dBA permissible exposure limit (PEL) (NIOSH, 1998). This constitutes the best practice for defining a noise hazard. Thus, any daily noise exposure should be controlled so that an individual's occupational exposure would be less than the combination of exposure level (L) and duration (T), as calculated by the following equation:

Equation 1
$$T \text{ (min)} = 480/2^{(L-85)/3}$$

Furthermore, when the daily exposure consists of periods of different noise levels, the daily dose (D) should not equal or exceed 100, as calculated according to the following equation:

Equation 2
$$D = [C_1/T_1 + C_2/T_2 + \dots + C_n/T_n]$$

where

C_n = total time of exposure at a specified noise level, and

T_n = exposure duration for which noise at this level becomes hazardous.

When using equation 1, above (i.e., an 85 dB PEL with a 3-dB exchange rate), and when using A-weighting with Aslow@ exponential averaging to measure continuous-type

noise, the American Academy of Audiology recognizes a ceiling limit of 129 dB for 1 second. Exposure to continuous-type sounds above this limit, even for brief instances of less than 1 second are considered hazardous. For impulsive-type sounds, exposures that exceed 140 dBC, peak SPL for any duration (no matter how brief) should be considered hazardous. Impulsive-type sounds are generally considered more hazardous than continuous-type sounds. Therefore, the American Academy of Audiology concurs with the ANSI S3.44 (1996) provision that a 5-dB “penalty” may be added to time-weighted averages derived from exposures to impulsive sounds.

2. Annual monitoring air conduction audiometry must be performed with methodology appropriate to the goal of accurately measuring hearing threshold levels. Best practice dictates that anyone exposed to hazardous noise should have a baseline as well as annual monitoring hearing tests.

A. Audiometric tests should be performed by an audiologist, physician, or technician with appropriate credentials. If audiometric tests are performed by a technician, all tests must be conducted under the supervision of an audiologist or physician.

B. All audiometry is to be conducted with audiometers that meet the specifications of and are maintained and used in accordance with the American National Standard Specifications for Audiometers (ANSI S3.6-1996, 1996b).

C. Audiometric tests must be conducted in a test space where background noise levels do not interfere with valid measures of hearing thresholds. Ambient noise levels should conform to all requirements of the American National Standard Maximum Permissible Ambient Noise Levels for Audiometric Test Rooms (ANSI S3.1-1999).

D. At a minimum, audiometry should consist of pure-tone air-conduction threshold testing of each ear at 500, 1000, 2000, 3000, 4000, and 6000 Hz. To enhance the decision about probable etiology, testing at 8000 Hz is strongly recommended.

E. (1) Baseline air conduction audiogram should be obtained within 6 months of employment unless exposures are expected to periodically equal or exceed a time-weighted average (TWA) of 100 dBA, in which case a baseline should be obtained within 30 days. All baseline tests must be preceded by 12 hours of effective quiet. Hearing protectors should not be used as a substitute for quiet.

(2) Subsequent hearing thresholds measured during annual monitoring may show improvement or decrements in hearing. When and how such changes warrant revising the baseline audiogram is subject to many considerations. The National Hearing Conservation Association has developed a *Professional Guide for Audiometric Baseline Revision* (NHCA, 2001). The American Academy of Audiology endorses this guide for use within the context of administering a hearing conservation program that is compliant with the OSHA Hearing Conservation Amendment (CFR 1910.95).

F. A monitoring air conduction audiogram should be obtained annually. If feasible, these should be scheduled well into a work shift so that temporary changes in hearing due to insufficient noise controls or inadequate use of hearing protection can be observed. The results should be compared immediately with baseline hearing levels. The availability of audiometric database management systems makes such comparisons

feasible, and also makes it possible to provide patients with timely feedback regarding the presence or absence of hearing changes. This is significant because timely feedback is an important factor in promoting increased use of hearing protectors (Zohar, Cohen, and Azar, 1980).

G. A confirmation hearing test to determine the presence/absence of a significant change in hearing threshold should be obtained within 30 days of a monitoring audiogram that detects a significant change.

3. Protocols capable of identifying meaningful changes in hearing should be employed. The purpose for monitoring audiometry is to provide timely detection of significant changes from baseline hearing threshold levels. The American Academy of Audiology finds that the current OSHA method for identifying Standard Threshold Shifts (STS) does not constitute the best practice for identifying meaningful changes in hearing. OSHA (1983) uses the term Standard Threshold Shift (STS) to describe significant changes from baseline hearing levels. The OSHA Standard (paragraph (g) (10)) defines STS as, "a change in hearing threshold relative to the baseline audiogram of an average of 10 dB or more at 2000, 3000, and 4000 Hz in either ear" (OSHA, 1983,). OSHA also permits the use of age corrections when computing threshold changes. Age corrections may be both suitable and useful for risk analyses of group data. However, age correction of individual audiograms before checking for threshold shifts is counterproductive to detecting temporary changes in hearing before they become permanent (Merry and Franks, 1995). "Many professionals feel that if intervention for threshold shifts is delayed until after age-corrected STS has occurred, then significant hearing changes will not receive needed follow-up attention" (NHCA, 2001).

Consider the example of a 40-year old male who had baseline HTLs of 0 dB and presents with current thresholds of 5 dB at 2000 Hz, 10 dB at 3000 Hz, and 40 dB at 4000 Hz. After applying the age correction, the average threshold change would be less than 10 dB. Even though this patient exhibited significant changes in hearing, he would have "passed" his hearing test; he would not have been identified as having an STS, and no intervention would have been applied to prevent additional hearing loss.

Royster (1992, 1996) studied 8 criteria for detecting significant threshold shifts and applied each criterion to 15 different industrial hearing conservation databases. Royster demonstrated that the OSHA STS criterion identified true positives only 57% of the time. By comparison, the 15-dB TWICE method (a 15 dB shift at any test frequency affirmed by an immediate retest) identified true positives 71% of the time. When a 15-dB TWICE method has identified a suspected STS, a confirmation hearing test should be performed within 30 days. to determine whether the STS was a temporary or permanent threshold shift. This test should be performed when the patient has been in a quiet environment for at least 12 hours immediately prior to the test. If the confirmation test demonstrates a persistent STS, the change likely represents a permanent threshold shift. When an STS is confirmed, the audiologist should follow appropriate guidelines (e.g., 29

CFR 1910.95) for disposition of persons identified as having an STS, including (1) counseling the employee and notifying his/her employer, (2) retraining the worker to ensure he/she can properly use personal hearing protection, and (3) referring the worker for follow-up clinical audiological evaluation or otological examination, as appropriate. Additionally, the audiologist should determine if the hearing change must be recorded on an OSHA Log 300 per 29 CFR 1904.10.

The STS should function as a sentinel for identifying significant changes in hearing. Therefore, the American Academy of Audiology recognizes the 15-dB TWICE method, followed within 30 days by a confirmation audiogram as the best practice for identifying significant noise-induced threshold shifts.

4. Educational methods and materials should be tailored to the specific audience. The goal of education and training is not just to inform, but also to motivate. The success or failure of a hearing loss prevention program, including employee buy-in, depends upon effective education and training (Berger, 2001). Education and training must be relevant to a person's specific needs if hearing health behaviors are to be influenced positively (Stephenson, 1996). For example, individual feedback can be given either to encourage workers to adopt better hearing loss prevention behaviors or to affirm existing behaviors, depending on the presence or absence of an STS. Workers may know loud noise can damage hearing, but they may be ill-informed about the hearing hazard inherent to the specific tools they use or the environment in which they must work. The hearing loss prevention program audit can provide opportunities to find out what particular hearing hazards are present and what resources labor and management are willing to bring to bear to address these hazards. Education and training can be tailored to address specific attitudes, beliefs, and behavioral intentions labor and management have about hearing loss prevention. In other words, education and training must consist of more than showing a film and passing out a pamphlet or it will be ineffective. Through effective training, individuals can become motivated to adopt hearing loss prevention behaviors (Berger, 2000). This means education and training content must be framed within the context of the needs of each audience. Dynamic, relevant training will imbue workers with a sense of personal control over their hearing health, lead to the development of intrinsic motivation to adopt positive hearing health

behaviors, and diminish reliance on ineffective systems based on external rewards and punishment (Merry and Franks, 1995).

5. The attenuation ratings for hearing protectors must be based on methods that yield realistic estimates of the amount of protection provided as a device would be worn. The American Academy of Audiology endorses the use of the subject fit procedure, Method B, of ANSI S12.6-1997 to describe the amount of attenuation a personal hearing protection device (HPD) can be expected to provide as it would actually be worn.

Research has demonstrated that the amount of noise reduction provided by an HPD as it is actually worn bears little relationship to the noise reduction rating (NRR) shown on the HPD's label (Berger, Franks, and Lindgren, 1996). Additionally, the NRR was intended to be used with C-weighted sound measures. Royster (1995) described how the subject fit method can be used to derive a noise reduction rating (NRR_{SF}) that addresses both of these issues. The NRR_{SF} provides both a simple, realistic estimate of the protection a user can expect to receive, as well as a measure designed to be used with A-weighted sound levels (Berger, 2000).

6. Hearing protector devices (HPDs) should be individually fit, or, at a minimum, fit in small groups. Failure to fit hearing protectors properly and to wear them consistently is probably the leading cause of occupational noise-induced hearing loss (Sweeney, et al., 2000). Studies show that hearing protectors use/non-use is determined by removing barriers to their use and by imparting users with skills needed to select and wear the right hearing protector for his/her needs (Lusk, et al., 1994; Lusk, et al., 1995). Audiologists can ensure that hearing protectors they recommend address barriers to their use by taking care of the 4-C's: comfort, convenience, cost, and communication. There are hundreds of hearing protectors available (NIOSH, 1994). There is an HPD that meets every attenuation need, that can accommodate every ear size and shape, and a device for every price range. There is a large variety of hearing protector devices designed to enable users to communicate and/or hear important sounds. Without proper instruction in how to fit and use hearing protectors, people will get only a fraction of the available hearing protection (Berger, 2000). Each person who must be exposed to hazardous noise should receive individual or small group instruction on how to fit and use personal hearing protector devices.

CLOSING STATEMENT

Occupational hearing loss impacts everyone in our society. It is so commonplace that it often is viewed as a normal part of aging (Suter, 2000). The prevalence of occupational hearing loss does not diminish its impact on those who suffer its effects, on their family members, or on society. In fact, "preventing noise-induced hearing loss would probably do more to reduce the societal burden of hearing loss than medical and surgical treatment of all other ear diseases combined" (Dobie, 1993, p. 1). The American Academy of Audiology supports audiologists leading the efforts to prevent occupational hearing loss through comprehensive hearing loss prevention programs.

REFERENCES

American Academy of Audiology Scope of Practice Position Statement (1997). *Audiology Today*, 9(2), 12-13.

ANSI (1996). American National Standard: Determination of occupational noise exposure and estimation of noise-induced hearing impairment. New York: American National Standards Institute, Inc., ANSI S3.44-1996.

ANSI (1996). American National Standard: Specification for Audiometers. New York: American National Standards Institute, Inc., ANSI S3.6-1996.

ANSI (1997). American National Standard: Methods for measuring the real-ear attenuation of hearing protectors. New York: American National Standards Institute, Inc., ANSI S12.6-1997.

ANSI (1999). American National Standard: Maximum Permissible Ambient Noise Levels for Audiometric Test Rooms. New York: American National Standards Institute, Inc., ANSI S3.1 1999.

Berger, EH (2000). Hearing protection devices. In: Berger, EH, Royster, LH, Roster, J.D., Driscoll, DP, and Layne, M, Eds. The Noise Manual. Fairfax, VA. American Industrial Hygiene Association, pp. 429-432.

Berger, EH (2001). The ardent hearing conservationist. *Spectrum Suppl.* 1,18, pp. 17-18. Note - this may also be accessed directly at the following internet site: <http://www.aearo.com/html/industrial/tech01.asp#noise>

Berger EH, Franks JR, Lindgren F (1996). International review of field studies of hearing protector attenuation. In: Axelsson A, Borchgrevink H, Hamernik RP, Hellstrom P, Henderson D, Sanvi RJ, Eds. Scientific Basis of Noise-Induced Hearing Loss. New York: Thieme Medical Publishers, Inc., pp. 361-377.

Dobie RA (1993) *Medical-Legal Evaluation of Hearing Loss*. New York: Van Nostrand Reinhold, Inc., p.1.

Lusk SL, Ronis DL, and Baer LM (1995). A comparison of multiple indicators: Observations, supervisor report, and self-report as measures of workers' hearing protection use. *Eval Health Prof* 18(1):51-63.

Lusk SL, Ronis DL, Kerr MJ, and Atwood JR (1994). Test of the health promotion model as a causal model of workers' use of hearing protection.

Nursing Res 43(3):151-157.

Merry CJ and Franks JR (1995). Historical assessment and future directions in the prevention of occupational hearing loss. In: Morata TC and Dunn DE, eds. Occupational Medicine: State of the Art Reviews - Occupational hearing loss. New York: Hanley and Belfus, Inc., pp.669-682.

NHCA (2001). National Hearing Conservation Association Professional Guide for Audiometric Baseline Revision. *Spectrum Suppl. 2*, volume 1.

National Institutes of Health (1990). Noise and Hearing Loss. NIH Consensus Development Conference Consensus Statement 1990, Jan 22-24; 8 (1).

National Institute for Occupational Safety and Health (1994). The NIOSH compendium of hearing protection devices, 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 95-105.

National Institute for Occupational Safety and Health (1996). Preventing occupational hearing loss - a practical guide, 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 96-110.

National Institute for Occupational Safety and Health (1998). Revised Criteria for a recommended standard - Occupational noise exposure, 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 98-126.

National Institute on Deafness and Other Communication Disorders (1994). Annual Report. (need more detail in reference)

National Institute on Deafness and Other Communication Disorders (1999). Noise-Induced Hearing Loss. NIH Pub. No. 97-4233.

Occupational Safety and Health Administration (1983). Occupational Noise Exposure Standard. 29 CFR Chapter XVII, Part 1910.95.

Ohlin, D. (2000). Cost effectiveness of hearing loss prevention programs. Proceedings of North Atlantic Treaty Organization Research And Technology Organization, RTO Lecture Series 219, June, 2000.

Prince MM, Stayner LT, Smith RJ, Gilbert SJ (1997). A re-examination of risk estimates from the NIOSH Occupational Noise and Hearing Survey. *J Acous Soc Am* 101(2):950-963.

Royster, J (1992). Evaluation of different criteria for significant threshold shift in occupational hearing conservation programs. Raleigh, NC: Environmental Noise Consultants, Inc., NTIS No. PB93-159143.

Royster, J (1996). Evaluation of additional criteria for significant threshold shift in occupational hearing conservation programs. Raleigh, NC: Environmental Noise Consultants, Inc., NTIS No. PB97-104392.

Royster, L (1995). In search of a meaningful measure of hearing protector effectiveness. *Spectrum* 12(2), p. 1 and 6-13.

Stephenson MR (1996). Empowering the worker to prevent hearing loss: the roll of education and training. Proceedings of National Hearing Conservation Conference XXI. Milwaukee, WI, February, 1996.

Suter AH (1992). The relationship of the exchange rate to noise-induced hearing loss. Cincinnati, OH: Alice Suter and Associates, NTIS No. PB93-118610.

Suter AH (2000). The handicap resulting from noise-induced hearing loss. Paper presented at the National Conference on Preventing Hearing Loss in Construction, Washington, DC, March, 2000.

Sweeney MH., Fosbroke D, Goldenhar L, Jackson L, Linch K, Lushniak B, Merry C, Schneider S, and Stephenson M (2000). Health Consequences of Working in Construction. In ME Rinker Sr. Lecture Series, Richard Coble (Ed.), Occupational Health and Safety in the U.S. Construction Industry, Philadelphia: Taylor and Francis.

Zohar, D, Cohen, A, and Azar, N. (1980). Promoting increased use of ear protectors in noise through information feedback, *Human Factors*, Feb. 22 (1):69-79.

Zwerling, C, Whitten PS, Davis CS, and Sprince NL (1997). Occupational Injuries Among Workers With Disabilities, *Journal of the American Medical Association*, 278(24):2163-2166.

Task Force Members

Mark R. Stephenson, Chair
CDC/NIOSH
4676 Columbia Parkway, M/S C-27
Cincinnati, OH 45226-1998
Work Phone: 513.533.8144 Email: mos9@cdc.gov

Elliott H. Berger
E·A·R
7911 Zionsville Rd.
Indianapolis, IN 46268
Work Phone: 317.692.3031
Email: eberger@compuserve.com

Lee D. Hager
James, Anderson & Associates, Inc.
P.O. Box 23113
Lansing, MI 48909
Work Phone: 517.349.7870
Email: LeeHager@safe-at-work.com

(The late) Daniel L. Johnson
Interactive Acoustics
4719 Mile High Drive
Provo, UT 84604
Work Phone: 801.224.6386
E-mail: daniel@interactiveacoustics .com

James E. Lankford
Professor Emeritus, Northern Ill. Univ.
325 Joanne Lane
DeKalb, IL 60115
Phone: 815.753.9123
E-mail: jelank@wpo.cso.niu.edu

Deanna K. Meinke
Associates in Acoustics, Inc.
1112 73rd Street
Greeley, CO 80634-97044
Work Phone: 970.346.1065
E-mail: mountainear@mindspring.com

Nancy B. Nadler
League for the Hard of Hearing
71 West 23rd Street
New York, NY 10010
Work Phone: 917.305.7700
Email: NNFOG@aol.com

Doug Ohlin
USACHPPM, 5158 Blackhawk Rd.
ATTN: MCHB-TS-CHC
Aberdeen Proving Ground, MD 21010-5403
Work Phone: 410.436.3797
Email: Douglas.Ohlin@APG.AMEDD.ARMY.MIL

Carol Merry Stephenson
CDC/NIOSH
4676 Columbia Parkway, M/S C-10
Cincinnati, OH 45226-1998
Work Phone: 513.533.8581 Email: cem3@cdc.gov