AMERICAN COLLEGE OF OCCUPATIONAL AND ENVIRONMENTAL MEDICINE

ACOEM Evidence-based Statement **October 27, 2002**

Noise-induced Hearing Loss

Since the publication in 1989 of an earlier position statement by the American College of Occupational and Environmental Medicine (ACOEM),[1] noise-induced hearing loss remains one of the most prevalent occupational conditions, partly due to the fact that noise is one of the most pervasive occupational hazards found in a wide range of industries. ACOEM believes that occupational clinicians need to become increasingly proficient in the early detection and prevention of noise-induced hearing loss. This requires clarification of current best practices, as well as additional research into certain aspects of noise-induced hearing loss that remain poorly understood.

Based on current knowledge, and to promote improved surveillance and research for this condition, ACOEM proposes the following update of previous position statements regarding the distinguishing features of occupational noise-induced hearing loss.

Definition
Occupational noise-induced hearing loss, as opposed to occupational acoustic trauma, is hearing loss that develops slowly over a long period of time (several years) as the result of exposure to continuous or intermittent loud noise. Occupational acoustic trauma is a sudden change in hearing as a result of a single exposure to a sudden burst of sound, such as an explosive blast. The diagnosis of noise-induced hearing loss is made clinically by a medical professional and should include a study of the noise exposure history.

Characteristics
The principal characteristics of occupational noise-induced hearing loss are as follows:

- It is always sensorineural, affecting hair cells in the inner ear.
- Since most noise exposures are symmetric, the hearing loss is typically bilateral.
- Typically, the first sign of hearing loss due to noise exposure is a “notching” of the audiogram at 3000, 4000, or 6000 Hz, with recovery at 8000 Hertz (Hz).[2] The exact location of the notch depends on multiple factors including the frequency of the damaging noise and the length of the ear canal. Therefore, in early noise-induced hearing loss, the average hearing thresholds at 500, 1000, and 2000 Hz are better than the average at 3000, 4000, and 6000, and the hearing level at 8000 Hz is usually better than the deepest part of the “notch.” This “notching” is in contrast to age-related hearing loss, which also produces high frequency hearing loss, but in a down-sloping pattern without recovery at 8000 Hz.[3]
- Noise exposure alone usually does not produce a loss greater than 75 decibels (dB) in high frequencies, and 40 dB in lower frequencies. However, individuals with superimposed age-related losses may have hearing threshold levels in excess of these values.
- The rate of hearing loss due to chronic noise exposure is greatest during the first 10-15 years of exposure, and decreases as the hearing threshold increases. This is in contrast to age-related loss, which accelerates over time.
- Most scientific evidence indicates that previously noise-exposed ears are not more sensitive to future noise exposure and that hearing loss due to noise does not progress (in excess of what would be expected from the addition of age-related threshold shifts) once the exposure to noise is discontinued.[4]
- In obtaining a history of noise exposure, the clinician should keep in mind that the risk of noise-induced hearing loss is considered to increase significantly with chronic exposures above 85 dBA for an 8-hour time-weighted average (TWA). In general, continuous noise exposure over the years is more damaging than interrupted exposure to noise which permits the ear to have a rest period. However, short exposures to very

high levels of noise in occupations such as construction or firefighting may produce significant loss,[5,6] and measures to estimate the health effects of such intermittent noise are lacking. When the noise exposure history indicates the use of hearing protective devices, the clinician should also keep in mind that the real world attenuation provided by hearing protectors may vary widely between individuals.[7]

The Occupational Physician as Professional Supervisor of a Hearing Conservation Program
ACOEM believes that occupational physicians can play a critical role in the prevention of noise-induced hearing loss by serving as professional supervisors of hearing conservation programs. The Council on Accreditation of Occupational Hearing Conservation (CAOHC) offers a course for professional supervisors.

The responsibilities of such a supervisor include supervision of an audiometric technician, review of problem audiograms and determination of whether there is a need for additional evaluation, determining the work-relatedness of a threshold shift, revision of an audiometric baseline, and evaluation of the effectiveness of the hearing conservation program.[8] The professional supervisor should be an advocate for the "hearing health" of noise-exposed persons, and work to ensure that noise exposures are minimized both at work and during recreational activities, through avoidance of excessive noise and proper use of hearing protection when necessary.

Additional Considerations in the Evaluation of the Worker with Suspected Noise-induced Hearing Loss
Clinicians evaluating cases of possible noise-induced hearing loss should keep in mind the following clinical concerns:

- While noise-induced hearing loss is typically bilateral, asymmetric sources of noise such as sirens or gunshots can produce asymmetric loss. When evaluating cases of asymmetric loss, referral to rule out a retro-cochlear lesion is first warranted before attributing the loss to noise.

- Co-exposure to ototoxic agents such as solvents, heavy metals, and tobacco smoke may act in synergy with noise to cause hearing loss.[9] However, the role of such cofactors – as well as the role of cardiovascular disease, diabetes, and neurodegenerative diseases – remains poorly understood. Individual susceptibility to the auditory effects of noise varies widely, but the biological basis for this also remains unclear.[10]

- Over a period of years of prolonged noise exposure, hearing loss due to noise expands to involve additional frequencies. This, together with the effects of aging, may reduce the prominence of the "notch." Therefore, in older individuals, the effects of noise may be difficult to distinguish from presbycusis without access to previous audiograms.[11]

- Individuals with noise-induced hearing loss may experience significant morbidity due to hearing loss, concomitant tinnitus, and impaired speech discrimination. On the job, such hearing loss can impact worker communication and safety. Other conditions associated with hearing loss may be depression, social isolation,[12] and increased risk of accidents.[13] Workers with evidence of hearing loss require an individualized approach that takes into account the need to communicate safely and effectively, and the need for protection from additional damage due to noise.

- Since the loss of hearing due to noise is not reversible, early detection and intervention is critical to improving prevention of this condition. A 10 dB confirmed threshold shift from baseline in pure tone average at 2000, 3000, and 4000 Hz (OSHA standard threshold shift), while not necessarily resulting in significant impairment, is an important early indicator of permanent hearing loss. Therefore, individuals in hearing conservation programs who exhibit such 10 dB threshold shifts on serial audiometric testing should be carefully evaluated and counseled regarding avoidance of noise and correct use of personal hearing protection.

- Age correction of audiograms is a method of age standardization allowing comparisons of hearing loss rates between populations. Applying age correction to the surveillance audiograms of a noise-exposed population results in fewer confirmed 10 dB shifts being reported. Therefore, when applying age correction to the audiometric results of an individual who has experienced a threshold shift, the clinician should consider whether in that individual a preventable noise component of hearing loss is playing a role.

Research Priorities
In an effort to shed light on some of the gaps in the current knowledge, ACOEM proposes the establishment of a research agenda for noise-induced hearing loss, and recommends research be conducted in the following areas:

- the relationship between specific noise exposures and risk of hearing loss, including impact noise, fluctuating noise, and noise at different frequencies, in order to improve protective exposure guidelines for noise exposure;

- early indicators of hearing loss, including the use of emerging audiologic technology such as otoacoustic emissions;
- the role of cofactors in hearing loss, including solvents, metals, vibration, heat, and carbon monoxide;
- the biology of noise-induced hearing loss, including the role of antioxidant compounds in prevention and recovery and whether noise damage continues to progress after noise exposure stops;
- individual susceptibility to noise-induced hearing loss, including the molecular basis for such susceptibility;
- the relationship of noise-induced hearing loss to other medical conditions, including cardiovascular disease, diabetes, and neurodegenerative diseases including age-related hearing loss;
- the impact of noise-induced hearing loss on individuals and their families and the development of rehabilitation strategies to maximize function and minimize disability;
- the behavioral aspects of noise avoidance and protection, including the effectiveness of training programs for hearing loss prevention.

Evaluation of the Effectiveness of a Hearing Conservation Program
To date, there is no universally accepted method of evaluating the effectiveness of a hearing conservation program. Hearing conservation programs include aspects of administrative controls, engineering controls, audiometric surveillance, and training. Occupational physicians can actively participate with employers in improving all these aspects of hearing conservation programs through ongoing evaluation of program outcomes and processes.

Acknowledgements
This ACOEM statement was developed by the ACOEM Noise and Hearing Conservation Committee under the auspices of the Council on Scientific Affairs. It was peer-reviewed by the Committee and Council and approved by the ACOEM Board of Directors on October 27, 2002.

References

1. ACOM Noise and Hearing Conservation Committee. Occupational noise-induced hearing loss. *JOM*. 1989;31(12):996.
2. McBride DI, Williams S. Audiometric notch as a sign of noise induced hearing loss. *Occup Environ Med*. 2001;58(1):46-51.
3. Coles RR, Lutman ME, Buffin JT. Guidelines on the diagnosis of noise-induced hearing loss for medicolegal purposes. *Clini Otolaryngology Allied Sc*i. 2000;25(4):264-73.
4. Rosenhall U, Pedersen K, Svanborg A. Presbycusis and noise-induced hearing loss. *Ear & Hearing*. 1990;11(4):257-63.
5. Lusk SL, Kerr MJ, Kauffman SA. Use of hearing protection and perceptions of noise exposure and hearing loss among construction workers. *Amer Indust Hygiene Asso J.* 1998;59(7):466-70.
6. Tubbs RL. Noise and hearing loss in firefighting. *Occup Med*. 1995;10(4):843-56.
7. Berger EH, et al. Development of a new standard laboratory protocol for estimating the field attenuation of hearing protection devices. Part III. The validity of using subject-fit data. *J Acoustical Soc Amer*. 1998;103(2):665-72.
8. OSHA. 1910.95 CFR Occupational Noise Exposure: Hearing Conservation Amendment (Final Rule). *Fed Reg*. 1983;48:9738-9785.
9. Morata TC. Assessing occupational hearing loss: beyond noise exposures. *Scand Audiology*. Supplementum. 1998;48:111-6.
10. Ward WD. Endogenous factors related to susceptibility to damage from noise. *Occup Med*. 1995;10(3):561-75.

11. Consensus conference. Noise and hearing loss. *JAMA*. 1990;263(23):3185-90.

12. Hetu R, Getty L, Quoc HT. Impact of occupational hearing loss on the lives of workers. *Occup Med*. 1995;10(3):495-512.

13. Zwerling C, et al., Occupational injuries among older workers with visual, auditory, and other impairments. A validation study. *JOEM*. 1998;40(8):720-3.