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INTEGRATING NOISE MEASUREMENT AND NOISE CONTROL ENGINEERING INTO HEARING CONSERVATION TRAINING PROGRAMS

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INTRODUCTION

INCE Members and other noise control engineers possess a unique and critical tool. As experts in noise measurement and noise control, they could be the key to reducing the incidence of noise-related hearing loss, which is considered to be America's most common workplace disorder and the second most self-reported occupational illness or injury. Noise control engineers could potentially be the first to identify, and resolve, hazardous noise exposures before the body's auditory system is damaged. Moreover, this first-step action could potentially reduce or eliminate costs and personnel requirements related to Hearing Conservation Programs (HCPs), as well as the even greater costs of workers' compensation, lost work time, and communication errors due to noise-related hearing loss.

More than thirty million Americans are regularly exposed to hazardous noise levels, and ten million have suffered irreversible hearing damage. The causal relationship between noise exposure and hearing disorders clearly warrants aggressive action. Encouragingly, HCPs have been established in the past 30 years to reduce the prevalence of noise-related hearing loss. The National Institute of Occupational Safety and Health (NIOSH) recently declared noise-related hearing loss to be one of the eight most critical occupational diseases and injuries requiring research and development with the framework of the National Occupational Research Agenda. Discouragingly, many of these programs still have limited effectiveness because of incomplete education and participation. The purpose of this paper is to summarize some opportunities for noise control engineers to play a part in effective training programs in hearing conservation, as well as to provide tools that can be used in this training.

OVERVIEW OF OCCUPATIONAL HEARING CONSERVATION

Before discussing how training could improve the field of hearing conservation, it is appropriate to first review how HCPs are organized. While federal regulations mandate that such programs exist, program policies should aim for effective practices rather than merely satisfying minimum compliance with government regulations. Consequently, recommendations like those offered by NIOSH [1], which currently espouses a vision statement to eliminate noise induced hearing loss (not just reduce it), provide a useful outline for elements of an effective HCP.

Typically, elements of an HCP include:

1. *Noise measurement and monitoring – to identify if hazards exist*
2. *Noise control – to remove the hazard (through engineering) or remove the worker (administratively) from the noise*
3. *Personal hearing protective devices – used by individual workers to reduce their noise exposure*
4. *Monitoring audiometry – to monitor hearing levels among at-risk workers*
5. *Health education and discipline – to alert exposed workers of their risks and prompt supervisors to support hearing conservation efforts*
6. *Program monitoring - to determine program effectiveness, especially relevant in outcome measurements*

Each of these elements contributes to the overall effectiveness of the hearing conservation effort, yet noise measurement and control are obviously employed first and, therefore, can influence the remaining elements. More specifically, if a noise hazard can be identified and reduced to levels below a time-weighted average (TWA) of 85 dBA, there is little need for purchasing hearing protection, conducting monitoring audiometry, or conducting health education in a facility. Regulations of the Occupational Safety and Health Administration (OSHA) [2] and the Mine Safety and Health Administration (MSHA) [3] outline the regulatory aspects of hearing conservation. The scope of these programs is broad and cannot be accomplished by an individual representing a single discipline. Therefore, interdisciplinary approaches are employed to dovetail the contributions of professionals in engineering, medicine, safety, industrial hygiene and audiology.

At the basic, functional level, a "hearing conservationist" is the central individual who motivates, manages, and reviews the fabric of hearing conservation activities as a member of the occupational safety and health team. This individual may be one who works in only one specific area (e.g., conducting hearing tests) or may be broader in nature (e.g., someone who serves as the plant's program supervisor).

EDUCATION AND CERTIFICATION IN HEARING CONSERVATION

To provide education, information and guidance to industry and those serving industry regarding the successful implementation of an occupational HCP, the Council for Accreditation in Occupational Hearing Conservation (CAOHC) was established in 1973. A more comprehensive history and summary of CAOHC, as well as a description of the elements of the HCP, are found in the CAOHC Hearing Conservation Manual [4]. CAOHC is the major authority on the training and certification of occupational hearing conservationists (OHCs) in the United States, recognized by both the government and private sector.

The CAOHC Council consists of two representatives from each of the following organizations:

- American Academy of Otolaryngology-Head and Neck Surgery (AAO-HNS)
- American Association of Occupational Health Nurses (AAOHN)
- American College of Occupational and Environmental Medicine (ACOEM)
- American Industrial Hygiene Association (AIHA)
- American Speech-Language-Hearing Association (ASHA)
- Institute of Noise Control Engineering of the United States of America (INCE/USA)
- Military Audiology Association (MAA)
- National Safety Council (NSC).

The Council develops and monitors certification standards for occupational hearing conservation courses, as well as the certification of Course Directors who conduct these courses. All OHC courses must meet standards of course content, length, and faculty representation before being approved by CAOHC. Every year, approximately 550 courses are conducted nationally, with more than 7,000 students participating. Currently there are over 22,000 individuals who have attended these courses and have earned certification as an OHC.

A CAOHC-approved course is at least 20 hours in length and is conducted over a period of three days or more. The OHCs are trained in conducting audiometric testing, screening test results for referral to an audiologist or physician for review, recordkeeping, selecting and fitting hearing protection and educating employees. OHCs are NOT responsible (unless otherwise trained) for conducting noise measurement surveys, noise control measures, audiogram interpretation, diagnosis of hearing problems, administration or supervision of HCPs or training of other OHCs. CAOHC-approved training is provided by a faculty that must include representatives of at least three of the

professional disciplines represented on the Council. This diversity offers a confirmation to the students of the interdisciplinary elements of HCPs, as well as different viewpoints and approaches to working in hearing conservation. Nationwide, there are approximately 370 certified Course Directors who frequently seek guest speakers to serve on their course faculties.

NOISE MEASUREMENT AND CONTROL IN HEARING CONSERVATION

A required curriculum element of a CAOHC-approved course is a one-hour lecture in noise measurement and noise control engineering. There are several very practical reasons why an OHC should be familiar with the concepts, techniques and instrumentation associated with noise measurement and control. First, although the OHC may not be the person doing the noise measurements, he or she may be required to identify, select, pay for, or review the work of the person who is hired or contracted to actually conduct the measurements. Second, an OHC should have a basic familiarity with how noise exposure measurements are acquired and how the results of those assessments affect the other elements of the HCP. For example, this person is likely the one who recommends or distributes personal hearing protective devices, posts warning signs in "high-noise" areas, identifies employees for inclusion in the HCP, or provides hearing conservation training to employees. Finally, all OHCs can identify some "noise problems" through careful observation and listening. Although few people may be in a position to hire a noise control engineer and review that person's technical recommendations, some OHCs may find that they are able to recommend and solve minor noise problems, given the right information and access to appropriate materials. For instance, they might reduce unwanted sound transmission by replacing door seals and making repairs in structures.

Most students who attend a CAOHC-approved course are not likely to have either the opportunity, or the need, to conduct noise measurements themselves, nor will they be developing engineering solutions for industrial noise problems. In addition, some will have little, if any, education beyond high school. Nonetheless, it is still possible to deliver a one-hour lecture that is at an appropriate level and relevant to the needs of the majority of students in the course, yet is technically accurate. By aiming to convey the "whys" of noise measurement and control (e.g., why choose a particular measurement method, noise control approach, piece of equipment, etc.), a well-prepared lecturer can convey a good general understanding of the topics without overwhelming the students with cumbersome details. This qualitative approach can be implemented by employing a presentation style that focuses on concepts (rather than specifics), avoiding the use of equations and graphs as much as possible, and illustrating techniques and procedures with photos.

Anyone with an educational background and experience in *any* of the disciplines of hearing conservation may serve on the faculty or as a guest lecturer for a CAOHC-approved course. Typically, topics in noise measurement may be covered either by an engineer or an industrial hygienist, but a lecture that adequately covers *both* noise measurement and noise control engineering would most appropriately be taught by a noise control engineer. INCE members are uniquely qualified to contribute to the education of OHCs (and to the broader goal of reducing noise-induced hearing loss) by serving as guest lecturers for CAOHC-approved courses in their geographical areas.

TEMPLATE FOR A NOISE MEASUREMENT AND CONTROL LECTURE

If asked to serve as a guest lecturer for the first time, a noise control engineer might benefit from the availability of a template that will be described in this section. The need for a relatively non-technical approach not withstanding, this outline for a one-hour lecture in noise measurement and control looks surprisingly similar to what might be presented to a technical audience. In general, the hour can be split fairly evenly between the general topics of noise measurement and noise control engineering. The lecture should include a review of fundamental acoustics principles; the purposes, methods and procedures for noise monitoring; selection, use, calibration and care of noise measurement instrumentation; reasons and strategies for controlling noise exposure; and an explanation, with examples, of the major forms of engineered noise controls. The following is a suggested outline for a lecture that can be comfortably delivered in one hour with a fairly general treatment of most topics. More detailed information may be included in handouts that are distributed as part of the course materials, so that OHCs will have a comprehensive set of notes, to which they can later refer if they desire.

- Why OHCs should know about noise exposure monitoring and noise control engineering
- Lecture topics overview
- Review of fundamental acoustics principles [sound pressure level, frequency ("low" frequency vs. "high" frequency), spectra, broadband noise, tones, A-weighted sound level]

- Review of TWA and noise dose concepts and calculations
- Noise exposure measurement
    - Purposes of noise/exposure measurement.
    - When to conduct noise measurements
    - Methods for determining noise exposure (personal dosimetry, area or equipment noise level survey)
    - How to select a noise exposure assessment method
    - Area noise surveys (selecting a sound level meter, correct use of a sound level meter for hearing conservation measurements, calibration of sound measurement instrumentation, estimating employee exposure from area noise measurements, area noise survey procedure, information to record during a noise survey, noise survey report)
    - Personal noise dosimetry (selection of noise dosimeters, how to fit an employee with a dosimeter, procedures for conducting personal noise dosimetry, communicating with employees during dosimetry studies)
    - Communicating the results of noise exposure assessments
    - Good (conservative) practice concepts in noise measurement
    - Resources for purchasing and renting instrumentation
    - Resources for obtaining professional assistance with noise monitoring
- Noise control engineering
    - Benefits of engineered noise controls
    - Strategies for controlling noise exposure (retrofit engineered controls, purchase of quiet equipment and design of quiet systems)
    - Hierarchy of engineered controls (controlling noise at the source, path, and receiver)
    - Noise problems that may be easily corrected with simple repairs and maintenance
    - Resources for professional noise control engineering assistance
- Other noise control and acoustics resources
- Review of lecture topics

A variety of teaching aids may be employed to help illustrate concepts in noise measurement and noise control engineering. For instance, if students can physically hold a hand-held sound level meter, a dosimeter, and their respective calibrators, they can become familiar with the simple and lightweight instrumentation that is available for hearing conservation measurements. Finally, if time allows, acoustical demonstrations [5] may be employed to illustrate selected fundamental principles of acoustics, in particular: frequency, tonal and broadband noise, and A-weighting.

Although a lecture on noise measurement and control may be delivered successfully without illustrations, photos can demonstrate concepts that quickly become too complex for an audience of students with diverse educational backgrounds. For instance, photos are superior to word charts when communicating proper techniques for using a sound level meter and for fitting a dosimeter. Close-up photos of sound measurement instrumentation can especially illustrate important features (e.g., A-weighting filter, "slow" response selector, small size, etc.). Also, photos taken in an occupational setting may document the follow-on activities associated with noise measurement (like signs labeling "high noise" areas and equipment, noise exposure assessment reports posted visibly in the work area, employees being interviewed during an assessment, and so on). For a non-technical audience, noise control engineering concepts can be best illustrated through the use of photos that show noise control solutions in various stages of completion.

The guest lecturer will need to coordinate handout materials with the Course Director, who will either ask for a single paper or electronic copy of the lecturer's viewgraphs ahead of time or request that the lecturer bring multiple copies for distribution. Since an exam is required at the end of all CAOHC-approved courses, guest lecturers will also need to coordinate with their respective Course Directors to ensure that test questions pertaining to noise measurement and control are covered adequately in the lecture.

OPPORTUNITIES IN CAOHC-APPROVED COURSES

Clearly, a noise control engineer is the most appropriate and most qualified person to deliver a lecture on noise measurement and control for a CAOHC-approved course. Unfortunately, many Course Directors are typically audiologists who work in a clinical setting and may not have many colleagues who are trained or experienced in

noise measurement and control. Likewise, most noise control engineers are not familiar with CAOHC and are unaware of the need for guest lecturers who are willing to teach noise measurement and control. Because CAOHC's guidelines for the selection of course faculty are fairly liberal (requiring only that three disciplines of hearing conservation be represented), some Course Directors either teach the noise measurement lecture themselves or engage a guest lecturer whose background is in yet another area, but not in noise measurement or noise control engineering.

Because INCE is a component professional organization of CAOHC, the two organizations have established a collaborative referral service for the purpose of identifying interested noise control engineers who are interested and willing to serve as guest lecturers for CAOHC-approved courses in their geographical areas. INCE maintains a registry of these members, which was established during 1999, following a solicitation of all Board Certified INCE Members. Course Directors who are seeking a guest lecturer are encouraged by CAOHC to make use of this referral service by contacting the INCE Business Office [6] for the names of interested Board Certified INCE Members who reside in (or have indicated that they are willing to travel to) the geographical area where the course is being held. Board Certified INCE Members who would like to be added to the registry of guest lecturers are encouraged to contact the INCE Business Office [6] via email with their full contact information (mailing address, phone number, email address) and specify the major metropolitan areas where they are willing to teach. Those INCE Members who agree to be listed on the guest lecturer registry are under no obligation to accept any teaching opportunities, and all arrangements are strictly between the Course Director and the lecturer. Agreements may be as informal as a one-time lecture or as formal as becoming a permanent paid faculty member for a course with multiple offerings each year. Depending on the student population that a particular Course Director tends to target, guest-lecturing engagements may lead to business opportunities to become involved in industrial noise control projects for firms whose employees have attended the course. Often, a well-presented lecture can raise awareness of noise control opportunities that may have been previously overlooked or dismissed.

To make it easier for guest lecturers to participate in CAOHC-approved courses, a comprehensive PowerPoint presentation has been prepared by the authors and is available on request to any INCE Member. The presentation follows the outline presented above and may be used, as is, or modified (particularly with customized photos that illustrate specific noise control projects with which the lecturer is familiar). The slides may be printed as overhead transparencies or projected as a computerized PowerPoint slide show, depending on the audiovisual equipment available in the classroom. The presentation is available on compact disc by email request [7]. Although this presentation was developed specifically for a nontechnical audience and meets the requirements for a CAOHC-approved one-hour noise measurement and control lecture, it may be easily adapted for use in other teaching contexts and may be shortened (e.g., by eliminating the noise control section) or enhanced for more technical audiences. Paper copies of the slides may be distributed as handout materials by selecting the "handouts" option in PowerPoint's print menu. This presentation includes more detail than may be comfortably presented during a one-hour lecture; slides are marked to indicate whether they are intended primarily as backup material to be included in handouts, rather than discussed during the lecture.

SUMMARY

Serving as a guest lecturer in a CAOHC-approved course can provide an exciting opportunity for a noise control engineer to easily and conveniently contribute to a shared goal of reducing noise-induced hearing loss in the industrial workforce. Many noise control engineers are engaged in the design of low-noise products and noise control devices, equipment noise control, or the teaching of noise control engineering. However, they may lack familiarity with how their efforts relate to the goal of reducing industrial noise exposure and hearing loss. It is important for noise control engineers who are engaged in industrial noise control to understand and fully appreciate how important the profession of noise control engineering is to broader occupational hearing conservation goals. With this appreciation (and use of the tools described in this paper), such engineers have the capability to expand their roles into successful hearing conservation activities.

REFERENCES

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2. Occupational Noise Exposure; Hearing Conservation Amendment; Final Rule. 29 CFR 1910.95 Federal Register 46(162), 42622-42639 (Occupational Safety and Health Administration, 1983) (More information is available at http://www.osha.gov.)

3. Health Standards for Occupational Noise Exposure; Final Rule. 30 CFR Part 62 Federal Register 64(176), 49548-49634 (Mine Safety and Health Administration, 1999) (More information is available at http://www.msha.gov.)

4. Alice H. Suter, *Hearing Conservation Manual* (Council for Accreditation on Occupational Hearing Conservation, 1993) (More information is available at www.caohc.org or via email at info@caohc.org.)

5. Auditory Demonstrations in Acoustics and Hearing Conservation (National Aeronautics and Space Administration, Glenn Research Center, 1997) Available free by email request indicating full mailing address and intended use to beth.a.cooper@grc.nasa.gov.

6. Institute of Noise Control Engineering (Contact via email at omd@ince.org.)

7. *Noise Measurement, Noise Exposure Monitoring and Noise Control Engineering* (National Aeronautics and Space Administration, Glenn Research Center, 2001) PowerPoint lecture presentation is available free by email request (indicating full mailing address and intended use) to beth.a.cooper@grc.nasa.gov.